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Abstract Preference : **Oral**

High-entropy effects on phase transformation behavior of CuNiTiHfZr high-entropy shape memory alloys

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By incorporating the concept of high-entropy alloys into traditional Ni-Ti shape memory alloys (SMAs) through the addition of Cu, Hf, and Zr, it is possible to obtain high-entropy shape memory alloys (HESMAs) with higher operating temperatures and broader application ranges. The macroscopic behavior obtained through differential scanning calorimetry (DSC) can be compared with the microscopic behavior observed through in-situ X-ray diffraction (XRD), X-ray nano-diffraction (XND), and X-ray fluorescence (XRF). The influence of the core-shell structure formed by an uneven distribution of alloying elements on the phase transformation behavior of CuNiTiHfZr enables to explain the mismatch between the macroscopic and microscopic behaviors, providing a better understanding of the combined effects of high-entropy and shape memory.

Keywords : High-entropy shape memory alloys, in-situ X-ray diffraction, in-situ X-ray fluorescence (XRF), core-shell structure, gradient structure, phase transformation, thermodynamics.

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Abstract Preference : **Oral**

Theoretical and experimental approach study of plant-based of copper hydroxide composites and silver nanoparticles synthesis

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Nanomaterials represent a significant portion of the rapidly expanding field of nanoscience-nanotechnology, for which shape and size remain essential in nanoscale device manufacturing. Size reduction can lead to new physicochemical properties and a range of applications. Access to these nanoscale entities requires the development of suitable elaboration methods. Conventional procedures for synthesizing these nanomaterials are often harmful to human health and the environment but also require sometimes sophisticated and expensive equipment. Because of its ecological advantages, low time consumption and promising applications, the nanoparticles' synthesis using plants has attracted great interest in several research groups across laboratories. Here, we present the experimental results of Copper hydroxide composite and silver nanoparticles obtained via plant extracts as metal ion agent reductors. A numerical approach based on Mie scattering theory was also applied to evaluate the particles' size.

Keywords : Copper hydroxide composite, silver nanoparticles, green synthesis, Mie scattering approach

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Abstract Preference : **Oral**

Advancing Optical Applications through Crystal Engineering and Energy Manipulation in Lanthanide-Doped Nanomaterials

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Lanthanide-doped nanomaterials are renowned for their unique optical properties, driven by their complex, real-existing energy levels that facilitate nonlinear optical responses. However, large lanthanide-doped upconversion nanoparticles (UCNPs) with sizes exceeding 15 nm are often employed to ensure sufficient brightness for imaging, leading to issues such as accumulation and low targeting efficiency, severely limiting their practical applications at the subcellular level. To overcome this challenge, we employed crystal engineering to fabricate ultrasmall (sub-10 nm) and bright core-shell UCNPs through dynamic metal complex docking-induced volumetric lattice reconstruction. This innovative approach eliminated vacancies within the nanocrystal lattice, curbing lanthanide ion diffusion and minimizing surface quenching, thus making the UCNPs highly promising for practical bio-applications such as cell labeling, super-resolution imaging, and neuron tracking. Furthermore, we observed for the first time that efficient modulation of optical transitions and energy level populations in neodymium (Nd^{3+})-doped nanocrystals by mid-infrared (MIR) photons. This novel phenomenon resulted in remarkable ratiometric luminescence changes, enabling broadband (4-11 μm) MIR detection and imaging at room temperature, surpassing the efficiency of nonlinear processes with virtual energy levels by orders of magnitude. Rooted in the principles of crystal engineering and energy manipulation, our work significantly advances the field of lanthanide-based nanomaterials, paving the way for their diverse applications.

Keywords : Lanthanide-doped nanomaterial; Crystal engineering; Energy manipulation

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Abstract No. : **OR-S20-0866**
Symposia : **Flexible Thin Film Multi-junction Solar Cells**
Abstract Preference : **Oral**

Contemplation for hybrid perovskite precursors leading efficient photoactive films

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Hybrid perovskites have been extensively investigated owing to their inherent merits in terms of excellent optoelectronic properties, facile processing, and extensible mechanical properties. Since emerging the perovskites into the research field of next-generation optoelectronics, the quality of perovskite thin films has been significantly improved by exploiting various strategies. The improvement has been mainly developed by thermodynamical perspectives considering crystallization processes, grain nucleation/growth, and stabilized octahedral lattices. Although the precursors of the perovskites are the origination to fabricate the films, consideration for the precursor chemistry has rarely been brought up as well, and there are still no distinct strategies for the chemistry.

In this presentation, the chemistry of perovskite precursors will be discussed to ensure high-performance perovskite films. After dealing with various chemical properties in view of purity, synthetic methods, and dopants, I will introduce an eco-friendly solvent process for synthesizing perovskite microcrystals, offering deeper insights into future directions for the sustainable mass-production of perovskite materials with reliable quality, paving the way for the commercialization of next-generation perovskite technologies.

Keywords : Perovskites, precursor, chemistry

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Abstract No. : **IN-S04-0865**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

Development of Electronic and Chemical Devices through Biologically Templated Synthesis

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Biological systems are composed of over ten thousand distinct proteins. These proteins are intricately assembled in three dimensions, optimized over billions of years of evolution for specific functions. Mimicking these structures using conventional material synthesis and fabrication techniques remains a significant challenge. The exceptional functionalities and properties of biological systems derive from their unique structures. In this research, we introduce a novel method for synthesizing complex electronic and chemical devices by utilizing biological systems as templates. While previous studies have employed simpler biological systems, such as viruses or bacteria, as templates for material synthesis, the use of more complex systems, such as eukaryotic cells or even parts of animal bodies, has not yet been demonstrated. Additionally, prior efforts have typically utilized entire cells or organs as templates rather than targeting specific proteins within them. In our approach, we use antibody staining and selective material growth to leverage specific protein structures as templates for the inorganic material growth. We demonstrate that a variety of materials can be synthesized using this method, and numerous proteins can serve as templates. This technique allows us to create inorganic materials from specific protein structures within cells and tissues. We also show that these materials can function as catalysts or chemical sensors.

Keywords : biotemplating

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Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Oral**

The Role of hole transport Layers on Efficiency and Transparent of Organic Solar Cells

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The organic solar cells had been studied for decades with their wide possibility of application in many ways such as large area, flexibility, transparency, and solution processability. Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) is the most widely used as the HTL in p-i-n PSCs because of its optical and electrical properties. However, the way of deposition PEDOT:PSS is only solution-based process. Here, we report about the development of self-assembled monolayer based hole transport layers (SAM-HTLs), which is acceptable for vacuum-based evaporation techniques. With this device engineering, these materials will be benefical for the ability of optical and morphological parts, which should be an ideal strategy for semitransparent solar cells.

Keywords : Transparent, Organic Solar Cells, passivation, hole transport

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Abstract No. : **KN-S03-0863**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Keynote**

Biohybrid materials and devices for highly sensitive sensing

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As manufacturing advances, replicating biological functions like molecular recognition and self-organization remains challenging. In this talk, I will discuss biohybrid devices that combine biological materials and machines to address these challenges.

One example is biohybrid (BH) sensors, which use biological molecules to detect target substances in air and liquid with high sensitivity and selectivity. BH sensors can function as chemical sensors for specific odors or chemicals, or as bioresponse sensors for unknown or mixed substances, offering diverse applications.

This technology could enable robots to detect human sweat odor in disaster areas, airport systems to find trace drugs, and food safety inspection systems. Achieving this requires integrating engineering, biology, medicine, pharmacy, and science, creating a new interdisciplinary field.

Keywords : Biohybrid robotics, Olfactory receptor, Lipid bilayer membrane, Cell-based sensors

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Abstract No. : **PO-S02-0862**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Bright Colloidal Deep-blue-emissive Europium Halide Nanocrystals

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Halide perovskite nanocrystals (PNCs) are gaining significant attention as light-emitting materials due to their high color purity and facile color tuning, coupled with the ease of solution-based processing. However, a significant limitation for industrialization lies in the toxic nature of Pb-based perovskites. Additionally, the photoluminescence quantum yield (PLQY) and stability of blue-emitting PNCs have lagged behind compared to the red and green counterparts. To address these challenges, europium (Eu)-based nanocrystals, which emit deep-blue light, have been proposed as a key eco-friendly alternative. However, the inherent properties of Eu precursors: (i) low solubility and (ii) strong organic coordination, present significant obstacles for colloidal synthesis of Eu-based nanocrystals. So far, reported colloidal Eu-based PNCs have not achieved a high PLQY exceeding 6%. In this study, we present a systematic synthetic strategy of colloidal Eu-based nanocrystals with high PLQYs. We controlled the chemical interaction between the precursors and ligands, along with modulation of reaction temperature and duration. These controlled reactions led to successful synthesis of deep-blue-emitting Eu^{2+}-doped CsBr, Cs_4EuBr_6/CsBr and $CsEuBr_3$ nanocrystals. Notably, the synthesized colloidal $CsEuBr_3$ nanocrystals exhibited a high PLQY of ~40% and a narrow spectral linewidth. Furthermore, we investigated the chemical reactions between the precursors and ligands in-depth, suggesting the synthetic mechanisms of the colloidal Eu-based nanocrystals. This study introduces great potential of Eu-based nanocrystals for solution-processable non-toxic blue light emitters exhibiting both high PLQY and high color purity.

Keywords : colloidal europium perovskites, deep-blue emission, ligands, precursors, phase transformation

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Abstract No. : **OR-S12-0861**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Magnetic Removal of Micro-Nanoplastics Using Iron Oxide (Fe_3O_4) Nanoparticles: Effectiveness and Size-Dependent Removal Efficiency

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Micro-nanoplastics (MNPs) pose a significant environmental challenge due to their accumulation in aquatic ecosystems, caused by the frequent occurrence of heavy rain and floods due to climate change. Microplastics (MPs), smaller than 5 mm, present severe human health problems due to their possibility to enter the food chain. Recent attention has focused on nanoplastics (NPs), which carry even greater risk than MPs because of their relatively high specific surface areas and hydrophobicity. Hence, MNPs can strongly adsorb other pollutants, exacerbating their environmental impact. Therefore, the removal of MNPs in water is crucial, but the removal efficiencies of MNPs by current technologies are not high.

Recent studies have explored the use of magnetism as a method for MNP removal. The hydrophobic surface of MNPs can be magnetized by binding nanoparticles and magnetized MNPs can be separated and removed using magnetics. This study investigates the efficacy of iron oxide (Fe_3O_4) magnetic nanoparticles for this purpose. By synthesizing nanoparticles with diverse sizes and magnetic strengths, we assess their ability to remove MNPs from water. Our results demonstrated the high removal efficiency of magnetized Fe_3O_4 particles, particularly for smaller MNPs. We achieved removal efficiencies exceeding 80% for MNPs around 100 μm in size, with increasing removal for smaller particles. Furthermore, our findings confirmed that a substantial quantity of MNPs was effectively removed within a short reaction time.

Keywords : Climate change, Iron oxide, Microplastic, Magnetic, Nanoparticles

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Abstract Preference : **Oral**

In-situ transmission electron microscope investigation of the deformation mechanism in nano-pillared CoCrNi-(Si) alloys.

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In recent years, single-phase high- and medium-entropy alloys (HEA and MEA) have rapidly developed due to their extraordinary mechanical properties, for example, high strength with high ductility, especially at extremely low temperatures. However, as compared to low temperatures, HEA and MEA at ambient temperature possess a relatively low strength. Some previous works indicated that a proper addition of Si could significantly increase the overall mechanical properties, including yield strength, ultimate tensile strength, and total elongation. The enhancing mechanical properties could be attributed to the decrement of stacking fault energy via adding Si. The easier formation of twin and HCP structures in Si-containing CoCrNi MEA contributed to the tensile strength.

In this work, to investigate the strengthening mechanism with and without Si addition in CoCrNi medium entropy alloys, in-situ compression tests on nanopillars in a transmission electron microscope (TEM; JEOL ARM300F) were conducted for single-phase equiatomic CoCrNi and $CoCrNiSi_{0.3}$ medium entropy alloys. In the CoCrNi sample, dislocations dominated at the early-stage compression. With the continuing compression, the first slip band suddenly occurred on the (111) plane. While the strain was increased, several planar slip bands could be seen during the compression and then formed shear steps at the surface. The $CoCrNiSi_{0.3}$ sample showed a similar trend (dislocation glide) as the CoCrNi sample at the initial deformed stage. However, as the sample compression proceeded, some stacking faults occurred but disappeared immediately, indicating the addition of Si significantly lowered the stacking fault energy, leading to a different deformation mechanism. The following deformation was accompanied by both dislocation and deformation twin. This work provided direct evidence that adding Si could efficiently decrease the stacking fault energy, thus easily forming twin as deformation behavior. As compared to equiatomic CoCrNi MEA, $CoCrNiSi_{0.3}$ displayed a significantly higher strength due to the twinning mechanism.

Keywords : In-situ compression transmission electron microscopy; CoCrNi medium entropy alloy; Silicon addition; Deformation twin; Dislocation

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Abstract No. : **IN-S02-0859**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Atomic Level Modifications of Quantum Dots for Advanced Device Applications

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Semiconductor nanocrystal quantum dots (QDs) exhibit unique optical and electrical properties, which are depending on their size and shape. Recent advances have revealed that atomic-level structural modifications can significantly influence these properties. In this presentation, I will discuss my research on the atomic-level engineering of QDs for advanced device applications. Initially, I will address the controlled synthesis and post-treatment processes that enhance the optical and electrical performance of QDs. I will highlight strategies such as doping and defect engineering in various QD materials, including II-VI, I-III-VI, and perovskites. Additionally, I will explore the impact of these atomic modifications on applications in devices such as light-emitting diodes, photodetectors, and photoelectrochemical cells. Lastly, I will present insights gained from in-situ transmission electron microscopy, which elucidates the structural transformation mechanisms of QDs and their implications for device applications.

Keywords : quantum dots; synthesis; doping; mechanism; light-emitting diodes

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Abstract No. : **IN-S04-0858**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

Smart Environmental Monitoring by Low-Power / Self-Powered Gas Sensors and Artificial Intelligence

INKYU PARK[*1]

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With the advent of the 4th industrial revolution, there has been a significant rise in the use of Internet of Things (IoT) and advanced sensors in several sectors, including but not limited to smart factories, healthcare, environment, and entertainment. However, the deployment of an increasing number of sensors in IoT systems has made it crucially important but challenging to reduce their form factors and power consumption. Consequently, there is a growing need for sensors that are miniaturized, low-power, or self-powered. In particular, when it comes to environmental IoT, it is essential to decrease power consumption in gas sensors while simultaneously enhancing sensing performance factors, such as sensitivity, selectivity, and response speed. In this talk, we present some recent advancements in the development of environmental sensors that are miniaturized, low-power or self-powered. These sensors utilize functional nanomaterials, microfabricated sensor structures, and photo-activated sensing mechanisms, which were developed by our research group at KAIST. Additionally, we describe the implementation of deep learning-based signal processing techniques for ultra-low power environmental sensors. The following topics are covered in depth: (a) Low-power semiconductor metal oxide (SMO) based chemoresistive gas sensor array using localized hydrothermal synthesis, (b) Ultra-low-power SMO gas sensors monolithically integrated on a micro LED platform, (c) Self-powered gas sensors using chemo-optically modulating sensing films and photovoltaic cells, (d) Machine learning of gas sensor array for high performance electronic nose (e-nose) systems.

Keywords : low-power sensor, gas sensor, self-powered sensor, electronic nose, artificial intelligence

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Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Oral**

Flexible thin-film Cu(In,Ga)Se_2 solar cell having bifacial architecture

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Flexible bifacial Cu(In,Ga)Se_2 (CIGS) solar cells, with light incidence from both sides, increase photocurrent, enabling high-efficiency power generation. Their lightweight and flexible characteristics enhance installation convenience, making them suitable for future applications such as buildings and mobility. Tandem solar cells, combining bifacial CIGS solar cells with pin-structured Perovskite solar cells, can compensate for the photocurrent deficiency in the lower CIGS cell with rear light incidence, thus being free from the photocurrent matching condition between the upper and lower cells. Therefore, it is advantageous for achieving high efficiency, as it allows the selection of bandgaps that provide the best performance for both CIGS and Perovskite solar cells.

To enable light incidence from both sides, the opaque Mo back electrode in the flexible bifacial CIGS solar cell should be replaced with a transparent conducting oxide (TCO) electrode, and ultrathin glass (UTG) can be used as the transparent flexible substrate. In this structure, improving the carrier transport characteristics and recombination properties at the TCO/CIGS interface is essential, and it is crucial to secure processes that can implement CIGS thin-film solar cells on very thin substrates. In this presentation, we aim to share research results related to the interactions between various TCOs and TCO/CIGS interface characteristics, the achievement of high-efficiency cell processes on UTG substrates, and propose future research plans.

Keywords : bifacial CIGS solar cell, ultrathin glass, tandem

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Abstract No. : **IN-S20-0856**
Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Invited**

Advanced Device Processing for Flexible Triple-Junction Thin-film Solar Cells

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The combination of perovskite (PRV) and Cu(In,Ga)Se_2 (CIGS) solar cells has been recognized as effective for the demonstration of lightweight flexible multi-junction solar cells. Here, we discuss a comprehensive approach to fabricating highly efficient PRV and CIGS solar cells on flexible substrates and developing next-generation PV technology based on tandem configuration.
CIGS bottom subcells (Eg ~ 1.1 eV) on flexible substrates were fabricated using a three-stage process incorporating alkali metal elements (i.e. Na and Rb). By controlling the microstructure and extrinsic alkali incorporation, efficiencies of around 20% were demonstrated. PRV mid-subcells (Eg ~ 1.5 eV) were grown by a hybrid process consisting of sequential steps of vacuum and wet processing. By optimizing the processing conditions, PRV cells with an efficiency of approximately 18% were demonstrated. Finally, under illumination filtered by PRV of 2.0 eV, the mechanical stack of mid-PRV and bottom CIGS solar cells showed an efficiency of 14%, showing great potential for application in triple-junction thin-film solar cells.

Keywords : Tandem, CIGS, Perovskite, Solar Cells, Photovoltaics

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Abstract No. : **PO-S11-0855**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Amino-functional MXene nanoflakes to enhance the output performance of triboelectric nanogenerators.

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To date, researchers have found various ways to improve the performance output of triboelectric nanogenerators (TENG). In there, the find suitable filler for polymer triboelectric materials has an efficient strategy to boost the output performance of TENG. In this work, we introduce the new approach by modifying the surface to a suitable filler MXene ($Ti_3C_2T_x$) for the positive sides of TENG. Researchers use $Ti_3C_2T_x$ as the typical filler to improve the negative side of TENG, but very few apply it to the positive side. Significantly, the change original surface terminating group (-O and -H) of $Ti_3C_2T_x$ to an amino group ($-NH_2$), the NH_2- $Ti_3C_2T_x$, which can easily additionally be doped into the positive side, contributing to stronger interfacial interactions, better compatibility to the polymer matrix and thereby efficient dielectric modulation. Combined with modifying the surface of $Ti_3C_2T_x$ filler, it forms more dipoles and induces more surface triboelectric charges on the dielectric materials. The TENG device based on Nylon 11 composite/ PVDF-TrFE exhibits a higher maximum power density of 7 mW/cm^2 than the devices based on pristine Nylon 11/PVDF-TrFE. This finding can help easily design fillers for advanced triboelectric materials, which opens new ways to improve the output performance via efficient dielectric modulation.

Keywords : MXene, triboelectric nanogenerator, surface functionalization, positive filler

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Abstract No. : **PO-S06-0854**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Simple approach Janus structure for Electromagnetic Interference Shielding materials with conductive layer coated Polyvinylidene Fluoride Foam

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With the advent of 5G communication technology, electromagnetic wave contamination and secondary electromagnetic pollution have emerged as significant concerns for activity of electronic equipments. Among the conductive materials, MXene ($Ti_3C_2T_x$), known for its metallic electrical conductivity, two-dimensional nanoflake structure, extensive surface functionality, and hydrophilicity, has emerged as a leading candidate for electromagnetic interference (EMI) shielding applications. This study introduces a design featuring a polyvinylidene fluoride (PVDF) foam layer strategically coated over an MXene layer. The PVDF foam serves as an effective impedance matching layer, substantially enhancing the absorption of electromagnetic waves. The optimized thickness of the PVDF foam on top of the MXene layer promotes a predominantly absorption-driven EMI shielding mechanism. The inclusion of electrically conductive MXene nanoflakes forms a robust conductive network, efficiently dissipating absorbed electromagnetic waves and further elevating the EMI shielding effectiveness (SE). This structure shielding performance was rigorously assessed across both the X-band (8.2 GHz - 12.4 GHz) and the Ka-band (26.5 GHz - 40 GHz) frequencies. Demonstrating high EMI SE and power coefficient, the composite achieved an EMI SE of approximately 60 dB with high absorptivity (over 0.7) in the X-band and approximately 70 dB with high absorptivity (over 0.8) in the Ka-band. These findings underscore its potential as a route to develop the absorption dominant EMI shielding materials.

Keywords : EMI shielding materials, PVDF porous foam, MXene, impedance matching, high absorptivity

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Abstract No. : **OR-S20-0853**
Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Oral**

Development of In_2O_3 Based Transparent Conducting Oxides and Their Applications to Thin Film Solar Cells

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Transparent Conducting Oxide (TCO) is one of the most important materials used in various optoelectronic applications such as LEDs, solar cells, and transistors. Among them, the TCO layer must have a high optical transmittance to transmit light to the absorber layer and outstanding electrical characteristics to ensure smooth carrier movement. In the meantime, Perovskite-based solar cells show potential photovoltaic materials due to their low cost and excellent power conversion efficiency. Perovskite solar cells characterized by a wide bandgap are well-suited for integration into a tandem arrangement with CIGS solar cells, which possess a narrow bandgap. However, because of the parasitic absorption by the top cell, there is a decrease in power. Fabricating TCO with high conductivity and transmittance is crucial to producing high-efficiency cells. Furthermore, perovskite solar cells are temperature sensitive and cannot be manufactured at high temperatures, thus they must perform well at low temperatures. In this work, different components were added to In_2O_3 to synthesize TCO materials, and then the electrical and optical characteristics of each material were investigated and compared. The development of such transparent electrodes is likely to aid in the evolution of tandem solar cell technology. It is expected that further research on these Transparent Conductive Oxides (TCO) will lead to the development of tandem solar cell technology.

Keywords : Transparent Conducting Oxide, Perovskite, CIGS, In2O3, Tandem solar cell

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Abstract No. : **OR-S20-0852**
Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Oral**

Research on p-i-n perovskite solar cells for high-efficiency multijunction cells

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Perovskite solar cells (PSCs), based on cost-effective organic-inorganic hybrid semiconductors, are a fast-growing solar cell technology with great potential. Technical development of efficient and reliable mass production methods is necessary for the successful commercialization of these PSCs. From this perspective, it is clear that although solution-based techniques have been extensively studied due to their simplicity and cost-effectiveness, for process-sensitive multi-junction cells with multi-layer thin films, a vacuum-based approach is required to ensure precision, reproducibility and uniformity. Hence, the development of a proper vacuum deposition process is crucial for the realization of PSC-based high-efficiency multi-junction cells, requiring extensive consideration of perovskite composition as well as vacuum deposition equipment and process conditions. In this work, we present a p-i-n PSC technology based on vacuum deposition for the realization of high-efficiency multi-junction solar cells.

Keywords : perovskite solar cells, high-efficiency multijunction cells, vacuum deposition

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Abstract No. : **OR-S20-0851**
Symposia : **Flexible Thin Film Multi-junction Solar Cells**

Abstract Preference : **Oral**

Development of wide-bandgap perovskite via vacuum deposition process for multi-junction solar cells

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The necessity of developing large-area perovskite solar cells has brought worldwide research interests on vacuum-deposition processed perovskite solar cells (PSCs) which is capable of uniform and reproducible thin film formation. Recently, power conversion efficiency (PCE) over 26% has been reported in vacuum-processed PSCs, making them competitive with solution-processed counterparts.

The Shockley-Queisser limit efficiency of commercially available crystalline silicon solar cells is estimated to be 29.4%, and to overcome this limit further, photoactive layers with different bandgaps can be integrated in series to maximize the incident light absorption. In particular, perovskite/CIGS structure, which combines wide-bandgap perovskite as a top-cell and low-bandgap CIGS thin film as a bottom-cell, is attracting attention as a multi-junction flexible solar cell that can achieve ultra-light weight and high efficiency.

To form a uniform and compact thin film on top of the CIGS layer with a rough surface morphology, vacuum deposition technique offers reliable and continuous in-line process, which is expected to enable the realization of high-efficiency perovskite/CIGS-based multi-junction solar cells.

In this study, vacuum-processed wide-bandgap (1.9–2.0 eV) PSCs were investigated for triple-junction solar cell technology with a perovskite/perovskite/CIGS thin-film structure that can achieve high open-circuit voltage and wide versatility. Wide-bandgap perovskite thin film of $MAPbI_xBr_{3-x}$ composition was deposited using a sequential vacuum-process (PbI_2/MABr), and the process conditions were optimized to obtain a bandgap of 1.95 eV and a film thickness variation of less than 5%. Finally, an inverted-structure vacuum-processed wide-bandgap PSCs were fabricated achieving PCE of 10.5%.

Keywords : mixed-halide, perovskite solar cell, uniformity, vacuum-deposition, wide-bandgap perovskite

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Abstract No. : **PO-S13-0850**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Multifunctional passivation materials on electron transport layer for high efficiency perovskite solar module.

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Renewable energy has gained great interests from both academia and industry to simultaneously reduce greenhouse gas emissions and meet the increasing supply of energy demand. Perovskite solar cells (PSCs) have reported high efficiency and stability of 26% based on research on crystal growth and phase transition, showing great potential as an alternative energy resource.

SnO_2 layer has been proven to be one of the promising electron transport layers (ETL) for high-efficiency PSCs. However, it is still a challenge to fabricate highly efficient and reliable large-area perovskite modules by using a single SnO_2 layer structure with uniform coverage, desirable thickness, and low defect density. Therefore, the introduction of new materials/layers is needed to compensate for the power generation losses driven by defects and non-uniform coverage of ETL.

In this study, we incorporate a multifunctional passivation layer between ETL and the perovskite layer to improve the crystallization of the perovskite film and improve its interfacial properties. The multifunctional passivation layer protected the SnO_2 surface, improved the morphology of the perovskite photoactive layer, and reduced non-radiative recombination at the interface. As a result, the multifunctional passivated device showed improved efficiency at both small- and large-area devices, resulting in a over 18% efficient 15x15 cm^2 perovskite module.

Keywords : perovskite, solar-cells, solar module, interface

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Abstract No. : **IN-S14-0849**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

"Advancements in Sustainable Hydrogen Generation: Exploring Electrocatalysis and Photoelectrocatalysis Approaches"

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In the realm of sustainable energy research, particularly concerning hydrogen generation, two distinct methodologies, namely electrocatalysis and photoelectrocatalysis, have garnered significant attention. Our investigation focuses on two distinct schemes within these approaches for improving catalytic activity using appropriate material development strategies.

Firstly, electrocatalysis involves the utilization of catalysts to facilitate the electrochemical conversion of water into hydrogen and oxygen. We present a study focusing on the synthesis and characterization of a novel $NiSe_2$ nanoparticle-based catalyst supported on 2D g-C_3N_4 nanosheets via a cost-effective hydrothermal technique. This composite catalyst demonstrated exceptional performance in the hydrogen evolution reaction (HER) compared to individual g-C_3N_4 and $NiSe_2$ catalysts. The synergistic interfacial interactions between $NiSe_2$ nanoparticles and g-C_3N_4 facilitated efficient charge transport, while the abundance of active sites provided by 2D g-C_3N_4 nanosheets enhanced catalytic activity. The composite exhibited remarkable long-term stability and efficient HER kinetics, characterized by a substantially lower Tafel slope and sustained activity over extended durations.

Secondly, photoelectrocatalysis integrates the use of light to drive electrochemical reactions for hydrogen production. Our research focuses on a distinct approach, involving the synthesis of TiO_2 nanorod arrays (TNRs) grown on FTO substrates, followed by their transformation into nanotube arrays (TNTs) through acid-etching hydrothermal treatment. These TNTs exhibited superior photoelectrochemical (PEC) performance compared to TNRs. The conversion from nanorods to nanotubes significantly augmented the active surface area and facilitated efficient light absorption and charge transport, thus enhancing overall PEC performance. This study sheds light on the role of acid etching treatment in the formation of TiO_2 nanotube arrays and their potential applications in sustainable hydrogen generation.

Through these investigations, we aim to contribute to the advancement of sustainable energy technologies, particularly for hydrogen generation, by exploring innovative approaches within the domains of electrocatalysis and photoelectrocatalysis.

Keywords : Electrocatalysis, Hydrogen, Sustainability, Photoelectrocatalysis,

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Abstract No. : **IN-S05-0848**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Invited**

Triboelectric Potential Driven FETs for Interactive Neuromorphic Synaptic Devices and Systems

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Fully imitating functions of biological synapses or afferents is critical to the evolution of neuromorphic computation and artificial intelligence. Benefiting from recent progress in bioinspired sensors, artificial synapses and interactive systems, more intelligent neuromorphic devices (or systems) capable of processing sensing signals and delivering interactive feedback are urgent to be developed and have been rapidly emerging recently. Different types of electronic devices (e.g., memristor, ionic devices, floating-gate transistor) have been demonstrated to successfully mimic synaptic functions assisted with electrical, optical and mechanical plasticization. Integration with sensory, processing, and actuating components further endows the traditional neuromorphic devices with more complete bionic somatosensory ability. The seamless and adaptive interactions between neuromorphic synaptic devices and external environment is believed to be essential in establishing future brain-like computers and artificial intelligent systems. This presentation will introduce interactive neuromorphic synaptic devices and systems based on our recent research work of artificial afferents, bioinspired analogous nerves, myoelectric-mechanical interface, etc.

This talk will mainly cover the significant progress concerning on artificial synapses correlated with mechanical, optical, pressure and strain trigger-signals. Based on our researches of artificial afferent, mechanoplastic neuromorphic devices, and bioinspired mechano-photonic synapses, “interactive neuromorphic device” will be the core in this presentation. This talk will start from the principle of neurosynaptic devices activated by different sensing signals and introduce the influence of external signals on synaptic plasticity. It will also introduce the research progress of interactive neuromorphic synaptic devices/systems inspired by pressure, touch, displacement, light, heat, and mixed signals, and look forward to the future applications of interactive neuromorphic synaptic devices/systems. The interactive neuromorphic synaptic device will involve electronic devices, neuromorphic computation, sensors, and human-machine interactions, which is highly promising for revolutionary artificial synapse and neuromorphic systems.

Keywords : Triboelectric potential, FET, Interactive, Synaptic Devices, Neuromorphic Systems

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Abstract No. : **PO-S14-0847**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

"Advanced Electrochemical Pathways in Urea Electrolysis: Exploiting Nickel based materials as Novel Catalytic Materials"

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Urea electrolysis presents a promising pathway for sustainable hydrogen production, boasting a significantly lower electrolytic cell potential of 0.37 V compared to the 1.23 V required for ordinary water electrolysis. This paradigm shift not only aims for a cleaner energy synthesis process but also addresses the reduction of urea-rich wastewater contamination. Recent research has focused on nickel-based materials, including nitrides, phosphides, Ni-alloys, chalcogenides, oxides/hydroxides, and metallic nickel, for their roles as mono- and bifunctional electrocatalysts in alkaline settings for urea electrolysis.

This study begins with an in-depth exploration of the fundamental principles controlling urea electrolysis, and then digs into the technical details of the urea oxidation reaction (UOR) and the hydrogen evolution reaction (HER). The authors propose strategies for developing electrocatalysts for HER, bifunctional applications, and UOR, as well as discussing the roles of nickel-based materials in these electrochemical processes. Systematic assessments of catalytic performance, mechanistic insights, and the influence of morphological, compositional, and electrode/electrolyte kinetic variables are reported for a wide range of nickel-based electrocatalysts.

Finally, the paper discusses the challenges, future opportunities, and commercial scale up of electrocatalysts for urea-based energy conversion. Furthermore, the catalytic mechanisms driving urea oxidation on nickel-based materials are investigated, including major reaction routes and active sites. Insights into the elements impacting catalytic activity, such as nickel loading, morphology, and support materials, are thoroughly examined, resulting in a comprehensive understanding of catalyst structure-performance correlations.

Keywords : Electrolysis, Hydrogen generation, Ni based, Urea oxidation, Sustainability

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Abstract No. : **PO-S13-0846**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Enhancing performance of perovskite solar cell via dual additive management

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When considering the efficiency of the Shockley-Queisser limit, photoactive layer with 1.34 eV is beneficial for single-junction solar cells. From this point of view, formamidinium (FA)-based is promising photoactive layer for single junction perovskite solar cells (PSCs) due to its optimal band-gap. However, the transformation from α-phase to δ-phase in ambient air is accelerated by defects in FA-based films, leads to significant losses in open-circuit voltage (V_{oc}) losses. To address this problem, additive engineering has been widely employed to improve the phase stability of FA-based by passivating the bulk defects. Nevertheless, single-additive engineering has limitations for simultaneously achieving the improved phase stability and device performance. Herein, we report dual-additive management by introducing methylammonium chloride (MACl) and cesium chloride (CsCl) into the perovskite precursor solution. We found that simultaneous introduction of MACl and CsCl was more effective for improving the phase stability and photovoltaic performance of FA-based devices compared to introducing each individually. By optimizing the ratio of MACl to CsCl in the precursor solution, the device exhibited a significant increase in V_{oc}, which led to improved power conversion efficiency (PCE).

Keywords : perovskite, solar cell, additive

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Abstract No. : **PO-S19-0845**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Poster**

A model to understand the buckling and switching in self-oscillation behavior of suspended Al/Cr/Nb trilayer mirror during red to blue detuning

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We investigated optomechanical behavior of the cavity where suspended Au/Cr/Nb doubly clamped trilayer beam serve as a mirror. The beam showed unusual behavior i.e. self-oscillations when it was red detuned. The mechanical properties of the beam were tuned to simulate switching of self-oscillations from red to blue detuning. Effect of high laser power on period doubling and intermode coupling of these beams was investigated. Also a theoretical model is developed to understand the competition between bolometric force and radiation pressure in these beams.

Keywords : Optomechanical Cavity, Suspended MEMS, Radiation Pressure, Bolometric force

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Abstract No. : **IN-S09-0844**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Invited**

Interfacial Properties of MIM Capacitors with High-k Thin Films

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Recent advancements in DRAM capacitor technology have addressed challenges related to the low-k layer at the electrode-dielectric interface. These developments include transitioning to TiN for electrodes and employing ZrO_2-based multilayers as dielectrics. However, as device scaling continues, a thin low-k TiO_xN_y layer at the ZrO_2/TiN interface remains a critical factor affecting effective permittivity. Despite pre-/post-deposition treatments and layer interposition, the persistent low-k layer poses challenges in maintaining acceptable capacitance density. Therefore, next-generation capacitors are exploring electrode/dielectric fabrication process combinations that prevent harmful interfacial layers, thereby mitigating capacitance degradation and minimizing defect-induced leakage current. This presentation will discuss the atomic layer deposition techniques for current dielectric, ZrO_2, and the potential future dielectrics such as TiO_2 and $SrTiO_3$, along with strategies to enhance their interface properties.

Keywords : DRAM, capacitor, ALD, high-k, ZrO2, TiO2, SrTiO3

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Abstract No. : **PO-S10-0843**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Bio-inspired Chitosan-based Hydrogels as Wound Dressing Materials

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In recent years, adhesive materials have garnered significant attention in biomedical applications due to their versatile properties such as adhesiveness and biocompatibility, achieved through the synthesis of diverse materials. Among these, gallic acid-conjugated chitosan has emerged as a notable example, offering advantages in promoting wound healing, adhesive properties, and biocompatibility. However, challenges such as cytotoxicity and limitations in mechanical strength have been observed. In response, this study introduces a novel approach to address these issues by developing a biodegradable chitosan-gallol/hyaluronic acid/calcium (CHI-G/HA/Ca2+, CHC) patch.

The CHC hydrogel combines the beneficial properties of chitosan for blood clotting and tissue regeneration, hyaluronic acid for inflammation reduction and tissue protection, and calcium for tissue homeostasis maintenance and wound healing facilitation. Notably, the CHC patch exhibits significantly enhanced mechanical properties, as confirmed by rheological analysis. In an in vivo rat model of wound healing, the CHC patch group displayed a remarkable over 90% wound healing rate after 14 days post-surgery, showcasing superior efficacy compared to the control group with a 76% wound healing rate.

These findings highlight the potential of the CHC patch as a promising candidate for wound healing applications. By addressing the challenges associated with existing adhesive materials, the CHC patch offers a comprehensive solution with enhanced biocompatibility, mechanical strength, and wound healing efficacy. This research contributes to the advancement of biomedical materials, offering new opportunities for improved wound care and patient outcomes. Further exploration and validation of the CHC patch's effectiveness in clinical settings hold promise for its widespread adoption and impact in the field of wound healing.

Keywords : Chitosan, Gallic Acid, Hyaluronic Acid, Calcium Chloride, Wound Healing

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Abstract No. : **IN-S09-0842**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Invited**

Materials Exploration for Advanced Interconnects

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Electrically connecting the semiconductor devices with high integrity allows efficient data transferring as the signals coherently operates with high-demand functionalities. Recent researches alongside the materials criteria have been performed and evaluated for a variety of metallic wires, hence the interconnect technology is now about to transform from conventional metal elements expanding materials candidates, seemingly accessible to further reduced line widths, *e.g.*, sub-10nm, since the devices get smaller down to atomic length scale. For such reduced dimensions, metal wire suffers and results in increasing resistivity due to significant contributions of grain boundaries and interface states. This presentation will address detailed design rules and specifications depending on device applications in order to take appropriate materials and structures candidates in the course of development. With such knowledges, capacitively decoupled new narrow metal lines carrying high carrier densities, therefore, will significantly support continuous scaling of semiconductor technology with respect to the power and integration capability.

1. IEDM (2020), The overview of current interconnect technology challenges and future opportunities.
2. *MRS Bulletin*, **46**, 959 (2021), D. Gall, Materials for interconnects.
3. *J. Appl. Phys.*, **128**, 080903 (2020), Opportunities and challenges of 2D materials in back-end-of-line interconnect scaling.
4. *Unpublished* (2024), Reduced resistivity size effect and cobalt-palladium thin films via grain boundary modification.

Keywords : Interconnect, Resistiviy Size Effect, Electron Transport

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Abstract No. : **PO-S10-0841**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Bio-Inspired Double-Layered Patches for Intestinal Anastomosis Integrity

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In our prior research, we developed adhesive patches utilizing chitosan to address the challenge of intraperitoneal fluid accumulation leading to post-surgical anastomotic leakage. However, these chitosan patches exhibited unwanted adhesion at the surgical site. To tackle both leakage and adhesion issues simultaneously, we introduced a novel solution - the Double-Layered Patch (DLP). This DLP, composed of chitosan-gallic acid (CHI-G) and hyaluronic acid (HA), aimed to prevent anastomotic leakage while minimizing post-surgical adhesions. Our study, conducted on thirty rats divided into five groups, evaluated the effectiveness of DLP compared to chitosan patches, PGA patches, HA alone, and suture-only control groups. Following a 2cm linear bowel resection, bursting pressures and adhesion scores were assessed at 7 and 21 days post-surgery. Results demonstrated that DLP exhibited multi-pathway crosslinking between CHI-G chains, coupled with slow degradation kinetics, distinguishing it from chitosan patches. DLP also displayed significantly higher swelling capacity compared to chitosan patches, indicating its suitability for fluid-rich environments. Notably, the bursting pressure of the DLP group (159.01 ± 24.53 mmHg) surpassed that of the control group (129.39 ± 5.70 mmHg), indicating effective prevention of postoperative anastomotic leakage. Moreover, DLP yielded lower adhesion scores (4.52) compared to the control group (4.78), highlighting its ability to mitigate post-surgical adhesions. In conclusion, our findings underscore the utility of DLP as a promising biomaterial for preventing anastomotic leakage and adhesion formation in fluid-rich environments. This research signifies a significant advancement in surgical techniques, offering potential benefits for patient outcomes and recovery.

Keywords : Anastomotic Leakage, chitosan, gallic acid, adhesion, hyaluronic acid

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Abstract No. : **PO-S13-0840**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Increasing open-circuit voltage in perovskite solar cell via insulating layer

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To reach high power conversion efficiency (PCE), perovskite solar cells (PSCs) have minimum open-circuit voltage (Voc) losses, which indicates reducing the non-radiative recombination. Non-radiative recombination in PSCs may occur within the perovskite bulk material or at the interface between charge transport layer and perovsktie layer, and is typically quantified by the photoluminescence quantum yield (PLQY). Therefore, the various strategies such as compositional engineering, interface engineering, and surface passivation have been implemented to increase the PLQY and reduce Voc losses. Especially, the incorporation of an insulating layer between the absorber layer and charge transfer layer has emerged as a crucial strategy for mitigating surface recombination. However, while the strategy enhances Voc via reducing surface recombination, it concurrently presents a challenge by diminishing the fill factor (FF). Herein, We introduced bathocuproine (BCP) as an insulating layer between SnO_2 and Perovskite layer using spin-coating. Compared with control indicating FTO/SnO_2/perovskite without BCP, PLQY value of target, which was FTO/SnO_2/BCP/perovskite, was increased from 1.32 to 9.93%. In addition, the full device stack of target showed an improved PCE of 24.5 % with the Voc of ca.1.18 and FF of 84.0%. As a result, employing BCP as an insulating layer between the electron transport layer and perovskite layer not only effectively reduced non-radiative recombination, but also successfully mitigated the trade-off between Voc and FF.

Keywords : perovskite solar cell, PLQY, isulating lyaer, Voc

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Abstract No. : **OR-S14-0839**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

A promising MoS_2/ C_3N_5 composite in a hole scavenging system for Photoelectrochemical Water Splitting

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Photoelectrochemical (PEC) water splitting has true potential of becoming the flag bearer of producing green hydrogen. Being a thermodynamically non-spontaneous reaction, presence of an efficient photocatalyst is inevitable . The bottleneck though is the fast recombination of charge carriers, in photocatalysts, which are created on illumination.

Our research focusses on both these frontiers, developing a robust photocatalyst as well as diminishing the electron-hole recombination in the system. Nitrogen rich carbon nitride, C_3N_5 is a promising catalyst for PEC reactions however, it suffers with high recombination rate. To overcome this challenge, we prepared MoS_2/ C_3N_5 nano-composites with different MoS_2 loading percentages. UV-Vis absorption and photoluminescence study makes it evident that MoS_2 is an effective cocatalyst, resulting in higher visible light absorption and lower electron-hole recombination.

PEC studies as conducted under the illumination of an LED based solar simulator in Na_2SO_4 electrolyte for all the MoS_2/ C_3N_5 samples establishes its photoactivity. The photocurrent response of the composite showed a significant increase in the linear sweep voltammetry study. 5% MoS_2/ C_3N_5, exhibited 10 times enhanced photocurrent response than pure C_3N_5 catalyst. Interestingly, when the electrolyte was added with hole scavengers (Na_2S + Na_2SO_3) the photocurrent value boosted 5 times. The transient light experiment with respect to time showed an immediate switching response in the current flow without any time delay demonstrating a sturdy composite system. In addition, the onset potential also reduces in case of the composite as compared to C_3N_5. The impedance is also decidedly low in case of the composite, exhibiting a better current flow due to reduction in the recombination of

charge carriers and thereby exhibit superior H_2 evolution reaction rates. The MoS_2/ C_3N_5 composite can thus be a promising electrode material for photoelectrochemical H_2 generation devices.

Keywords : Photoelectrochemical Water splitting. Hydrogen evolution reaction, hole scavenger, photocurrent

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Abstract No. : **IN-S06-0838**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Development Status of High-Entropy Alloys for Commercialization and Machine Learning-Based Webpage Construction

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Over the past decade, various series of high-entropy alloys have been proposed, with attempts being made to commercialize FCC and BCC series alloys in various industrial fields. For example, FCC series alloys have been applied in extreme cryogenic environments such as liquid hydrogen, offering a new perspective that could expand the market boundaries of high-manganese steels previously used for LNG storage. Additionally, BCC series alloys are being explored as potential materials for components in high-temperature environments, such as generators and engines. However, which is equipped with a mass production system for metal manufacturing, alloys enriched with Fe in the FCC high-entropy alloy series are seen as the most promising candidates for commercialization. Therefore, it is necessary to understand the relationship between existing high-entropy alloys, low-carbon steel, stainless steel, and high-manganese steel to propose new commercially viable alloy systems. Our research team has conducted various studies to understand these relationships and has successfully built a database of phase stability data through machine learning and AI. The system has been made available on a webpage for all researchers to enhance the use of machine learning in high-entropy alloy design. This can be used at the initial stages of developing new alloys through very simple mouse operations. Even without thermodynamic background knowledge or commercial software, the phase stability of new alloys calculated based on existing literature databases and multiple statistical models can be confirmed in a short time, making it a milestone that many researchers can easily use.

Keywords : High-Entropy Alloys; Alloy Design; Database; Machine Learning; Webpage Construction;

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Abstract No. : **PO-S14-0836**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

High-efficiency anion exchange membrane water electrolysis through the reduction of the activation energy barrier and onset potential of oxygen evolution reaction

Yoo Sei Park[*1], Jun Seok Ha[1]

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Anion exchange membrane water electrolysis (AEMWE) using non-platinum group metals (PGMs) is gaining significant attention as an advanced technology for sustainable and clean hydrogen production. However, achieving high-efficiency AEMWE has been delayed due to the low performance of non-PGM-based electrodes, especially the anode, which is involved in the oxygen evolution reaction (OER) and has become a bottleneck for improving efficiency of AEMWE. In this study, we developed a high-performance anode (nickel-iron-cobalt-(oxy)hydroxide) for AEMWE through corrosion engineering at room temperature. Incorporating cobalt into nickel-iron-(oxy)hydroxide significantly reduced the activation energy barrier for the oxygen evolution reaction (OER) and lowered its onset potential, leading to enhanced AEMWE efficiency. Moreover, the AEMWE single-cell equipped with nickel-iron-cobalt-(oxy)hydroxide as the anode demonstrated superior performance compared to AEMWE single-cells equipped with nickel-iron-(oxy)hydroxide anode and those with PGM catalysts.

Keywords : anion exchange membrane water electrolysis; oxygen evolution reaction; hydrogen energy; electrocatalysis; water splitting

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Abstract No. : **IN-S03-0835**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Invited**

Wafer-Level Patterning of Metal Oxide Nanomaterials for MEMS Gas Sensors

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In the past few decades, gas sensitive nanomaterials are usually deposited on specific area of the wafer by drop-casting or inkjet printing for application in gas sensor fabrication. Wafer-level patterning of sensing materials with satisfactory reproducibility still encounters challenge. In this talk, we propose a facile ‘top-down’ strategy to manufacture wafer-scale gas sensing chips with high-throughput by photolithography using a well-mixed photoresist-nanomaterial suspension, followed by calcination. The fabricated gas sensors based on the proposed approach yield excellent reproducibility and uniformity of sensing response to ethanol detection with a good relative standard deviation. Besides, we have proved the feasibility of this method for patterning different materials onto various electrodes structure. This method provides a potential for mass production of MEMS gas sensors where high efficiency and throughout are crucial.

Keywords : MEMS gas sensor; nanomaterials; pattern; wafer level fabrication

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Abstract No. : **IN-S12-0834**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

MOF water harvester extracts drinking water from Death Valley desert air only using sunlight

Woochul Song*[1]

[1]*POSTECH*

Ever increasing water stresses have been one of the greatest challenges of the world. To address this global crisis, water in air is expected to be promising alternative water sources, but atmospheric water harvesting (AWH) has not been practical, especially in arid areas. However, recent developments of reticular materials such as metal-organic frameworks (MOFs) and covalent-organic frameworks (COFs) stimulated the sorbent-assisted AWH research. In this talk, recent progress on MOFs and COFs chemistry for AWH will be briefly introduced. Then, the most recent study of integrating MOFs into scalable AWH device will be presented that can produce water only using natural sunlight and ambient temperatures. This study showed that >75% of theoretical water harvesting capacity of MOFs could be achieved at device scale through the field tests in the Death Valley without any footprints left in the environment. This sorbent-assisted AWH could usher in a new strategy of securing water against global water scarcity.

Keywords : MOF, atmospheric water harvesting

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Abstract No. : **KN-S06-0833**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Keynote**

Mesoscopic nature of serration behavior in high-Mn austenitic steel

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We have thoroughly clarified the mesoscopic nature of serration behavior in a high-Mn austenitic steel in connection with its characteristic localized deformation. A typical high-Mn steel, Fe-22Mn-0.6C (wt. %), with a face centered cubic (FCC) single-phase structure was used in the present study. After 4 cycles of repeated cold-rolling and annealing process, a specimen with a fully recrystallized microstructure having a mean grain size of 2.0 μm was obtained. The specimen was tensile tested at room temperature at an initial strain rate of 8.3×10^{-4} s^{-1}, during which the digital image correlation (DIC) technique was applied for analyzing local strain and strain-rate distributions in the specimen. Obtained results indicated that a unique strain localization behavior characterized by the formation, propagation and annihilation of deformation localized bands, so-called Portevin–Le Chatelier (PLC) bands, determined the global mechanical response appearing as serration on the stress-strain curve. In addition, the *in-situ* synchrotron XRD diffraction during the tensile test was utilized to understand what was happening in the material with respect to the PLC banding. Lattice strain of (200) plane nearly perpendicular to the tensile direction dropped when every PLC band passed through the beam position, which indicated a stress relaxation occurred inside the PLC band. At the same time, the dislocation density increased drastically when the PLC band passed the beam position, which described that the material was plastically deformed and work-hardened mostly within the PLC band. All the results obtained consistently explained the serration behavior in a mesoscopic scale. The serration behavior on the stress-strain curve totally corresponded to the formation, propagation and annihilation of the PLC band in the 22Mn-0.6C steel, and the localized deformation, i.e., the PLC banding, governed the characteristic strain hardening of the material.

Keywords : deformation localization; Portevin–Le Chatelier (PLC) band; digital image correlation (DIC); in-situ synchrotron XRD diffraction; work hardening

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Abstract No. : **IN-S10-0832**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Invited**

Engineering 3D Human Heart Tissues for Modeling Cardiac Development and Disease

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Any problems during heart development due to genetic mutations or abnormal environmental factors can lead to life-threatening congenital heart defects. To investigate these cardiac developmental processes and mechanisms of congenital cardiac malformations, we have developed a novel human fetal heart model. Specifically, we emulated the actual cardiac development process by providing the necessary mechanical and chemical conditions for human pluripotent stem cells to differentiate along the cardiac development trajectory. This approach has allowed us to successfully obtain a new human fetal heart model that recapitulates the 3D cardiac morphogenesis vital to the formation of a thick heart wall. By examining these novel fetal heart models, known as cardiac organoids, we discovered that mechanical forces significantly contribute to heart wall formation via mechano-sensing genes. Additionally, we have developed a model of cardiac chamber malformation triggered by genetic mutations, using induced pluripotent stem cells from patients with congenital abnormalities in heart chamber formation. This novel human heart model will help expand our future understanding of cardiac development and congenital heart diseases.

Keywords : Tissue Engineering, Stem Cell, Heart Development, Organoids

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Abstract No. : **PO-S13-0831**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

SOLID-STATE LIGAND EXCHANGE OF TIN OXIDE NANOPARTICLES ELECTRON TRANSPORT LAYER FOR INVERTED PEROVSKITE SOLAR CELLS

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The SnO2 electron transport layer is currently the most commonly chosen material as an electron transport layer in perovskite solar cells due to its excellent thermal and light stability. In addition, in inverted structures, it is gaining attention as a better alternative to BCP(Bathocuproine) in inducing ohmic contact between C60 and the metal electrode. Furthermore, to realize tandem structures, SnO2 plays a crucial role as a buffer layer to prevent perovskite damage during the deposition of the top transparent electrode. However, in current inverted structures, SnO2 is predominantly fabricated using the ALD (Atomic Layer Deposition) process. Although ALD can produce a compact SnO2 layer, it has the disadvantages of slow processing speed and increased cost. To form the SnO2 layer on top of the perovskite via solution processes, a solvent suitable for SnO2 nanoparticles must be carefully chosen to avoid perovskite degradation, and the issue of removing the long alkyl chain ligands used in the synthesis of the nanoparticles needs to be addressed to ensure high charge transport ability. To overcome these challenges, we developed techniques for selecting solvents for SnO2 nanoparticles and strategies for solid-state ligand exchange to achieve high-performance and uniform SnO2 layers on top of the perovskite. Through this approach, we fabricated high-performance inverted perovskite solar cells without fullerene-based electron transport layers.

Keywords : Perovskite solar cells, SnO2, Ligand, Tandem solar cells

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Abstract No. : **PO-S12-0830**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

"CuS 3D Yarn ball Structures as Promising Photocatalysts for Environmental Remediation and Solar Fuel Generation"

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The present study involves a one step conversion of CuO to CuS forming 3D urchin structures. The structural and morphological properties have been investigated using X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), and Scanning Electron Microscopy/Transmission Electron Microscopy (SEM/TEM) analysis. The photocatalytic degradation studies under visisble light by CuS in assistance with H2O2 exposure for Rhodamine B (RhB) dye and Tetracycline (TC) antibiotic were carried out. To understand the active radicals present in the degradation mechanism, scavenger tests were conducted and it was found that hydroxyl radicals served as the main contributors to the improved photocatalytic efficiency. In order to understand the charge transfer behavior and transient current response, the Photoelectrochemical (PEC) characterization of the CuS was carried out which revealed that the CuS exhibitied photocathode behavior ana was suitabile for PEC water splitting. Finally, a proposed mechanism clarifies the factors behind the enhanced effectiveness of CuS photocatalysts. Thus, the present work underscores the promising potential of CuS structures in advanced photocatalysis and sustainable energy conversion, offering insights for addressing environmental challenges and advancing solar-driven fuel production.

Keywords : RhodamineB, Tetracycline, Photocatalysis, PEC, water splitting

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Abstract No. : **OR-S07-0829**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

Useful Web-service for Enhanced Search and Analysis of Calculation Data: Calculation Data eXplorer

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Calculation results based on the Density Functional Theory(DFT) provide fundamental insights into the relationship between material structure and properties, aiding in the discovery of novel materials. The increasing focus on FAIR (Findable, Accessible, Interoperable, and Reusable) data principles has enhanced the sharing of such computational data. In this context, platforms like NOMAD have emerged as pivotal in distributing this data within the computational materials science community. Utilizing these shared datasets, researchers have developed methodologies that integrate AI technologies, such as machine learning, to predict properties of interest in materials.

CalcDX (Calculation Data Explorer, https://calc.chemdx.org) is a newly developed tool designed to process and extract meaningful data and information from calculation results. This tool provides web-based services for searching, visualizing, analyzing, and statistical processing of data, complete with detailed views. A comprehensive materials ontology, which includes material names, compositions, compound types, and structures, facilitates the integration and classification of calculation data and its linkage to corresponding experimental results. On CalcDX, users can identify specific material candidates suitable for surface electrochemical reactions, particularly for applications like water electrolysis and fuel cell electrodes. Additionally, formation energy data from PubDX (Public Data Explorer, https://pub.chemdx.org) can be utilized to construct phase diagrams that include thermodynamic information, crucial for evaluating material states.

Keywords : DFT, Materials Informatics, Machine Learning, Database, Ontology

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Abstract No. : **IN-S09-0828**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Invited**

Characterization of microstructures of metal thin film for flexible electronics based on TKD and ASTAR

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Nanostructure of cupper thin film on polyimide flexible substrate is revealed by novel orientation imaging techniques. Copper and polyimide thicknesses play critical roles on what technique is successful in acquiring diffraction patterns while avoiding electron beam damage and blistering. Conventional electron back-scattered diffraction as well as emerging higher resolution transmission orientation imaging were employed to resolve the grain structure. Spatial resolution is compared in terms of minimum detectable twin width. Experiments and simulations indicate that polyimide thicknesses below 1000 nm allow the electrons to scape; resulting in acceptable reflective or transmission patterns and lack of blistering.

Keywords : Characterization, Metal thin film, Microstructure, Deformation mechanism

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Abstract No. : **IN-S02-0827**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Perovskite Nanocrystal Lasers

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Recently, the study of halide perovskites has attracted enormous attention due to their exceptional optical and electrical properties. As a result, this family of materials can provide a prospective platform for modern nanophotonics [1] and metaphotonics [2,3], allowing us to overcome many obstacles associated with the use of conventional semiconductor materials. Resonant halide perovskite micro- and nanocrystals is a rapidly developing research area driven by its potential applications for lasers, nanophotonics, and optoelectronic devices.

Here, we overview the recent progress in the field of halide perovskite lasers starting from record-small plasmon-free single-particle lasers [4] to the larger designs where the perovskite microlasers [5, 6] are coupled with waveguiding systems [7,8,9]. Finally, we report new results on halide perovskite nanolasers based on exciton-polariton condensation and mirror-image Mie modes at a visible wavelength of approximately 0.53 μm with an ultra-small nanocavity volume ($\lambda^3/20$) [10]. Additional opportunities for lead-free and up-conversion small perovskite lasers is discussed as well.

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Keywords : halide perovskite, laser, nanocrystals

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Abstract No. : **OR-S12-0826**
Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Oral**

Solar light driven effective degradation of cationic and anionic dye using oxygen-deficient SnO_2.

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Oxygen-deficient SnO_2 nanoparticles were synthesized via a facial solvothermal method, yielding crystallite sizes ranging from 6 to 8 nm. Morphological analysis indicated microparticle formation through the aggregation of spherical nanoparticles, as confirmed by SEM and TEM observations. HRTEM analysis revealed that these nanoparticles were not single crystalline but rather composed of randomly oriented nanoparticles. Elemental analysis via EDS and XPS confirmed the presence of Sn and O without any detectable impurities. UV-vis spectroscopy indicated band gap values varying between 2.76 and 3.16 eV for the SnO_2 nanoparticles. Photoluminescence (PL) studies at ambient temperature suggested contributions from band edge emission, interstitial defects, and homogeneous oxygen vacancies. The S0.15 sample exhibited a red shift compared to other samples and possessed a surface area of approximately 45.2 m^2/g, large pore size (5.82 nm), and high pore volume (0.081 cm^3/g). These characteristics of the S0.15 (30 mg) sample facilitated the rapid degradation of methylene blue (MB), methyl orange (MO), and eriochrome black T (EBT) within 3 min under sunlight irradiation.

Keywords : SnO2, Dyes, Wastewater treatment, Sunlight exposure.

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Abstract No. : **OR-S16-0825**
Symposia : **ICYRAM Young Researcher Symposium**

Abstract Preference : **Oral**

A sunlight-assisted 2D/2D Lewis Base Enriched interface formation of g-C_3N_4-Graphene oxide composite as an Efficient Electrocatalyst

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Developing cost-effective and highly active oxygen reduction reaction (ORR) electrocatalysts is crucial for advancing fuel cell (FC) technology, but current efforts face challenges due to high costs and complex synthesis procedures. This study presents a rapid and cost-effective synthesis method utilizing solar radiation to prepare ORR electrocatalysts. The approach involves reducing a composite of 2-dimensional graphene oxide (SRGO) and 2D porous graphitic carbon nitride (g-C3N4) under solar radiation. This process creates Lewis base centers and a hierarchal porous structure with a high surface area, facilitating O2 molecule diffusion and adsorption. The resulting electrocatalyst exhibits an onset potential of 0.85 V, follows a four-electron pathway for ORR, and demonstrates excellent methanol tolerance and stability compared to Pt/C. The catalyst's outstanding performance is attributed to abundant Lewis base active centers from g-C3N4 on SRGO sheets, optimized surface area, porosity, and a strong interface between electroactive Lewis centers and conductive graphitic domains. Density functional theory (DFT) results confirm the lower limiting potential of the Pyridinic N site, supporting ORR activity. This novel strategy, using sunlight for synthesis, provides insights into structural properties, Lewis basicity, and enhanced electrochemical activity of high-performance N-doped carbon ORR catalysts.

Keywords : Solar light, Lewis base centers, CO2 adsorption, Pyridinic N, DFT

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Abstract No. : **OR-S06-0824**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

N-doped Norbornane sp^2 carbon structure: An efficient electrocatalyst for energy conversion reaction

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At present, the development of Pt-free bifunctional electrocatalysts for the energy conversion reactions like oxygen reduction reaction (ORR), hydrogen-oxygen evolution reaction (HER-OER) are necessary for the advancement of sustainable and cost-effective solutions for energy conversion system (ECS). In this direction, herein we report N doped sp^2 hybridized carbon framework (N-CF) as a metal-free electrocatalyst for ECS. This work inspects the effect of N doping that converts a hybrid advanced structure of CF {Norbornane or bicyclo [2, 2, 1] heptane structure} into planar N-CF. A series of N-doped CF with different doping concentrations has been prepared using a facile and cost-effective technique. This robust electrocatalysts exhibits a promotional effect in the activity, porosity, thermal and electrochemical stability for the ORR and HER reactions. A rich delocalized electronic density of the sp^2 bounded N species helps in modulating antibonding state of molecular oxygen and facilitates the breakage of O=O bond in ORR. It also promotes proton adsorption via bonding between proton and valence electron rich catalyst surface to aid HER. The research sought to investigate the employability of N-CF for fabricating sustainable energy devices with electrocatalyst possessing multiple electrocatalytic activities for ORR and HER.

Keywords : sp2 carbon framework, nitrogen doping, oxygen reduction reaction, hydrogen evolution reaction, EELS

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Abstract No. : **PO-S13-0823**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Cation-modified P3CT Hole Transport Layers for High Efficiency Inverted Perovskite Solar Cells

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Poly[3-(4-carboxybutyl)thiophene-2,5-diyl] (P3CT) is used as an hole transporting material for organic-inorganic hybrid lead halide perovskite solar cells (PSC) due to its high hole mobility and excellent stability. Combined with metal cations such as K, Cs, and Rb, properties of P3CT can be improved to serve as an efficient hole transport layer (HTL) for PSCs. Modification of P3CT by doping with cations affects crystallization of perovskite materials and interfacial properties, and it has been used to improve the performance of inverted PSCs. In this study, P3CT was tuned by organic functional cations. Compare with K cation-tuned P3CT, organic cations-tuned P3CT suppressed the PbI_2 formation on the perovskite surface and reduced the surface roughness of the HTL by mitigating the aggregation. As the hole collection properties are improved and recombination loss at the HTL/perovskite interface is reduced, a power conversion efficiency (PCE) of 20% was achieved in the 1.68 eV-band gap perovskite solar cells.

Keywords : perovskite; solar cells; hole transport materials

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Abstract No. : **PO-S14-0822**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Optimizing Photoelectrocatalytic Water Splitting with Z-Scheme Charge Transfer in $BiVO_4$/g-C_3N_4 for Sustainable Hydrogen Production

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The application of light-responsive semiconductor materials in photoelectrocatalytic (PEC) water splitting holds great promise for hydrogen production. Artificial photosynthesis employing the Z scheme, incorporating various semiconductor combinations, emerges as a promising avenue for green hydrogen generation. Particularly, for this scheme, bismuth vanadate ($BiVO_4$) and graphitic carbon nitride (g-C_3N_4) are promising for their favorable bandgaps, cost-effectiveness, large surface area, facile synthesis, and robust stability. In the present study, $BiVO_4$, in its stable monoclinic phase with a bandgap of 2.42 eV, was synthesized, while pristine g-C_3N_4 was synthesized by thermal polymerization. The $BiVO_4$/g-C_3N_4 Z scheme enhanced charge transfer efficiency, and reduced electron-hole recombination, thereby improving PEC performance. X-ray diffraction (XRD) and Fourier-transform infrared (FT-IR) spectroscopy analyses were employed to confirm the phase purity and structural composition of the materials under investigation. Morphological studies conducted using scanning electron microscopy (SEM), provided detailed imaging of surface structures and morphology. PEC measurements were conducted to gain insights into the intrinsic properties of the materials, particularly focusing on parameters such as photocurrent density and transient behavior during solar water splitting. The PEC response observed from the $BiVO_4$/g-C_3N_4 composite was notably superior compared to that of the individual bare materials. This indicates the potential of $BiVO_4$/g-C_3N_4 for sustainable hydrogen generation, suggesting that this composite could be a promising candidate for efficient and eco-friendly hydrogen production methods. Furthermore, for a deeper understanding of the $BiVO_4$/g-C_3N_4 Z scheme and its implications for hydrogen generation, additional study into electrocatalytic (EC) hydrogen evolution reaction (HER) was studied. This provided further insights into the mechanisms underlying the enhanced performance of this composite material system. This study significantly advances the efficient and sustainable hydrogen production technologies by deeper understanding of charge transfer mechanisms, tunable properties, and improved PEC performance.

Keywords : Hydrogen, Photoelectrocatalysis, Sustainability, Water splitting, Z-scheme

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Abstract No. : **PO-S13-0821**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Fabrication of High-Efficiency Indoor Perovskite Devices via Antisolvent Engineering

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Perovskite solar cells (PSCs) exhibit distinctive characteristics that render them potentially efficacious materials for deployment within indoor environments. Nevertheless, the utilization of solar cells in such settings presents a distinctive challenge attributable to the reduced carrier densities observed under relatively weak artificial illumination, particularly emanating from sources such as light-emitting diodes (LEDs). To address this challenge, the effects of various antisolvents on trap density within the perovskite film to control. By optimizing the interplay between intermediate phases and DMSO, formation of PbI2 and its subsequent passivation could be effectively controlled, leading to a substantial reduction in trap states within the perovskite film. This strategic intervention has yielded substantial enhancements in PSC efficiency. Moreover, the remarkable efficiency levels achieved by both small-area perovskite cells and larger-area mini-modules underscore the scalability and versatility of antisolvent engineering in improving PSC performance across different form factors. Under 1000 lux illumination, small-area perovskite cells with an active area of 0.14cm^2 have demonstrated exceptional efficiency levels exceeding 43%, while larger-area perovskite mini-modules, with an active area of 25cm^2, have achieved efficiency levels surpassing 40%. By mitigating the adverse effects of trap states and enhancing device performance, antisolvent engineering holds promise for unlocking the full potential of PSCs in various applications, thereby contributing to the transition towards sustainable and renewable energy sources.

Keywords : Perovskite solar cells, Indoor photovoltaic devices

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Abstract No. : **OR-S14-0820**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

"Exploring Visible Light-Driven Photoelectrochemical Water Oxidation with $Bi_2(S,Se)_3$-Sensitized TiO_2 Nanotube Array Thin Films"

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In an effort to mitigate the expenses associated with hydrogen production and employ environmentally benign materials in the construction of electrode components for photoelectrochemical (PEC) cells, titanium dioxide (TiO_2) emerges as a promising candidate. However, its efficacy is hindered by limited absorption of visible light and rapid recombination of charge carriers. In this study, we systematically address these challenges by, 1) the transformation of TiO_2 nanorods into nanotubes (to improve surface area), and 2) the exploration of $Bi_2(S,Se)_3$ role in improving the PEC water oxidation performance of TiO_2 nanotube array thin films through the establishment of a p-n heterojunction.

Herein, we undertake a systematic design of experiments to facilitate the in-situ growth of facet-controlled, vertically aligned rutile TiO_2 nanorod (TNR) arrays, followed by their conversion into nanotubes (TNT) arrays via hydrothermal approach. The resulting nanotubes exhibit increased exposed active surface area contributing to their improved response compared to nanorods. Subsequently, a cost-effective SILAR method was utiilized to decorate $Bi_2(S,Se)_3$ onto TNTs. The synthesized thin films were characterized using XRD, SEM, and UV-visible spectroscopy to analyze their structural and optical attributes. The PEC performance was assessed through a range of techniques including LSV, CV, chronoamperometry (CA), and EIS under visible light irradiation.

Thus, the results demonstrate a significant enhancement in the PEC response of $Bi_2(S,Se)_3$-sensitized TNT array thin films as compared to pristine TNTs, under one-sun illumination (AM1.5G) in a neutral 0.5M Na_2SO_4 electrolyte. This improvement is ascribed to synergistic interactions between the $Bi_2(S,Se)_3$ sensitizer and TiO_2 nanotubes, facilitating visible light absorption and efficient separation of charge carriers. This study offers valuable insights into the advancement of efficient visible light-driven photoelectrochemical water oxidation systems for renewable energy applications.

Keywords : Green hydrogen, Nanotubes, PEC, TiO2, Water splitting

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Abstract No. : **IN-S02-0818**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Overcoming Doping Challenges in Metal-Halide Perovskites

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Doping has been one of the most essential methods to control charge carrier concentration in semiconductors. In metal halide perovskite (MHP), which have revolutionized the field of solar cells and light-emitting diodes due to their favorable optoelectrical properties, extensive electrical doping via conventional substitutional doping still remains challenging due to their structural stability limited by tolerance factor and compensation of intentionally introduced defects by mobile halide ions[1]. As an alternative non-invasive approach, molecular doping has been previously reported for tuning the electrical properties of MHPs[2]. However, most of the reports have been focused on charge transfer at the interface or grain boundaries which have limited the attainable doping range. In this study, we first demonstrate molecular doping with a strong p-dopant (magic blue) for significantly improving the electrical conductivity of low-dimensional lead perovskites[3]. We identify that dopant incorporation into the bulk of the film as the structural origin of the improved conductivity and propose the solvent selection criteria for achieving an effective bulk molecular doping. Our efficient doping methods developed will open up a controllable route towards tuning electronic structure for optimizing perovskite-based electronic and optoelectronic devices).

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Keywords : Doping, Metal-halide perovskites, Molecular doping,

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Abstract No. : **IN-S02-0817**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Colloidal Quantum Dots-based Shortwave Infrared Optoelectronics for Long-range Communications

Se-Woong Baek[*1]

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The detection of infrared (IR) light is crucial for realizing various future applications, including recognition, bio-imaging, spectroscopy, and object inspection. In particular, utilizing photons beyond the silicon absorption band-edge (i.e., 1550 nm) becomes important to demonstrate long-range communications and quantum technologies. Colloidal quantum dots (CQDs), semiconducting nanocrystals, are promising alternative materials due to their quantum-confined bandgap tunability across visible to shortwave-infrared (SWIR) wavelengths. However, CQD-based IR optoelectronics currently face two challenges: the use of toxic elements such as Pb, Cd, and Hg, and lower performance compared to epitaxial semiconductors.

This talk showcases how to build IR devices using non-toxic CQD materials, including III-V, I-VI, and beyond. Various short-ligand passivation strategies enable stable CQD ink, thereby rendering high-quality conductive solids. We reveal that the extent of ligand passivation yields a surface-mediated photomultiplication effect, boosting the responsivity of devices. Furthermore, we have demonstrated an efficient avalanche breakdown in the CQD multiplication layer, achieving a fast response time below the nanosecond level with a notable gain of up to $\sim 10^4$. This represents a record gain x bandwidth product among all prior solution-processed IR photodetectors operated at 1550 nm.

Keywords : infrared, optoelectronics, colloidal quantum dot,

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Abstract No. : **IN-S18-0816**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Invited**

Single-crystalline nanomembranes for flexible/stackable electronics

Jeehwan Kim[*1]

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In the context of the future of electronics, encompassing fields like bioelectronics, 3D integrated electronics, and bendable electronics, the demand for flexibility and stackability in electronic products has significantly increased. However, conventional wafer-based single-crystalline semiconductors find it challenging to keep pace with these trends due to their inherent attachment to thick, rigid wafers, rendering them inflexible and non-stackable. While polymer-based organic electronic materials offer mechanical compliance and cost-efficiency advantages, their electronic and photonic performance lags substantially behind that of single-crystalline inorganic materials. Over the past half-decade, our research group at MIT has been dedicated to addressing this performance-mechanical compliance dilemma. We have focused on developing methods to create cost-effective, flexible, and stackable single-crystalline inorganic systems. In today's presentation, I will delve into the strategies we have developed to realize this dream electronic system, and how these strategies introduce innovative approaches to advanced electronic manufacturing. I will particularly highlight our groundbreaking remote epitaxy technique, capable of producing single-crystalline freestanding membranes from various compound materials with exceptional semiconducting performance. Additionally, I will showcase an unprecedented flexible and stackable system enabled by the stacking of these freestanding, flexible membranes.

Keywords : Single-crystalline nanomembrane, Flexible/stackable electronics, Remote epitaxy

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Abstract No. : **KN-S01-0815**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Keynote**

Innovating layered cathode materials through the mechanistic understanding of its disorders

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Irreversible phase transformations of layered oxide cathodes during charging have been detrimental for most of them. Even if a lot of efforts have been made to relieve this highly irreversible phase transformation, there have been just a few successful results, which definitely limit the amount of extracted alkali ions and thereby the available capacities of the layered oxides. So, this presentation will suggest couple of strategies to get over the saturated cathode technology.

As an inverse conceptual strategy, we first observed the possibility to make this irreversible phase transformation extremely reversible by utilizing crystal water as a pillar. Although we found a few cyrstal structures working with this reversible phase transition, the works using Na-birnessite (NaxMnO2•yH2O; Na-bir) or Li-birnessite (Li-bir) as basic structural units will be highlighted here. The crystal water in the structure contributes to generating metastable spinel-like phase, which is the key factor for making this unusual reversibility happen. The reversible structural rearrangement between layered and spinel-like phases during electrochemical reaction can activate new cation sites and enhance ion diffusion with higher structural stability. This unprecedented reversible phase transformation between spinel and layered structure is affected by the steric coordination or amount of crystal water in the lattice as well as the low crystallinity of pristine layered materials. Hence, this research may be correlated with the mechanism behind DRX(disordered rocksalt) cathodes. Pseudo Jahn-Teller effect (Pseudo JTE) will be also stressed out as a fundamental reason behind lattice distortion of layered oxide cathodes. Even though Jahn-Teller effect (JTE) has been regarded as one of the most important determinators of how much stress layered cathode materials undergo during charge and discharge, there have been many reports that traces of superstructure exist in pristine layered materials and irreversible phase transitions occur even after eliminating the JTE. A careful consideration of the energy of cationic distortion using a Taylor expansion indicated that second-order JTE (Pseudo JTE) is more widespread than the aforementioned JTE because of the various bonding states that occur between bonding and anti-bonding molecular orbitals in transition metal octahedra. As a model case, some of layered oxide cathodes will be dealt with in this presentation. In order to manipulate more Li from layered cathodes, oxygen redox should be stabilized because the capacity from cationic redox has been already saturated. Herein, by investigating more fundamental reasons for oxygen redox which can be valid for not only Li-rich layered cathodes but also conventional ones with rhombohedral symmetry, we will suggest the realistic solution to stabilize oxygen redox toward higher energy density and safety.

The aforementioned strategies will provide deep insight into novel class of intercalating materials, and thus it can break up some typical prejudices which we have about the layered cathodes for alkali ion (Li or Na) secondary batteries.

Keywords : Alkali ion batteries; Layered cathodes; Disorder

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Abstract No. : **IN-S12-0814**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Dual Resistance Janus PDA/Patterned PVDF Membrane for Membrane Distillation with Early Wetting Detection using Electrochemical Impedance Spectroscopy

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Membrane distillation (MD) stands out as a promising separation technology due to its high efficiency and minimal energy requirements. However, issues like membrane fouling and wetting persist, particularly when dealing with low surface tension substances such as oil and surfactants. To tackle these challenges, researchers have developed novel MD membranes with asymmetric wettability, known as Janus membranes, featuring a hydrophilic layer atop a hydrophobic layer. This configuration allows the hydrophilic side to remove hydrophobic contaminants while the hydrophobic side exhibits remarkable resistance to wetting. In this study, a Janus polydopamine (PDA)/patterned polyvinylidene fluoride (PVDF) membrane was fabricated using non-solvent- and vapor-induced phase separation methods. This membrane, with its hydrophobic patterned PVDF layer, effectively delayed membrane wetting without significantly compromising flux (12.50 to 11.42 LMH) or permeate conductivity (up to 2.37 $\mu S\ m^{-1}$). Additionally, the hydrophilic PDA layer prevented oil from interacting with the membrane surface, enabling stable operation for over 10 h. The membrane's performance was evaluated in direct contact MD (DCMD) setups using both a 3.5 wt.% NaCl feed solution with hourly sodium dodecyl sulphate injection and a 3.5 wt.% NaCl feed solution containing 1000 mg L^{-1} oil. Notably, the wetting of the membrane was systematically monitored in real-time using electrochemical impedance spectroscopy (EIS). The Janus membrane exhibited decreasing normalized impedances corresponding to different wetting stages, ranging from 0.99 to 0.45 during partial wetting and eventually reaching 0.00 during full wetting. Simultaneously, wetting fronts gradually increased from 0% to 82% and ultimately to 100% with membrane wetting. Compared to conventional electrical conductivity measurement methods, EIS with impedance and wetting front analysis provided more precise detection during DCMD operation. This study showcases the effectiveness of Janus membranes in mitigating membrane wetting and highlights the real-time monitoring techniques like EIS for understanding membrane performance under dynamic conditions.

Keywords : Membrane distillation (MD); Anti-wetting; Anti-fouling; Janus membrane; Polydopamine (PDA), Polyvinylidene fluoride (PVDF)

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Abstract No. : **IN-S03-0813**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Invited**

Colorimetric Hydrogen sensor for smark window display

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Palladium is the most prominent material in both scientific and industrial research on gas storage, purification, detection, and catalysis due to its unique properties as a catalyst and hydrogen absorber. Advancing the plasmonic optical phenomena of palladium reacting with hydrogen, transduction of the gas-matter reaction into light-matter interaction is attempted to visualize the dynamic surface chemistry and reaction behaviors. The simple geometry of the metal-dielectric-metal structure, Fabry-Perot etalon, is employed for a colorimetric reactor, to display the catalytic reaction of the exposed gas via water-film/bubble formation at the dielectric/palladium interface. The adsorption/desorption behavior and catalytic reaction of hydrogen and oxygen on the palladium surface display highly repeatable and dramatic color changes based on two distinct water formation trends: the foggy effect by water bubbles and the white-out effect by water film formation. Simulations and experiments demonstrate the robustness of the proposed Fabry-Perot etalon as an excellent platform for monitoring the opto-physical phenomena driven by heterogeneous catalysis.

Keywords : Hydrogen sensor, Colorimetric display

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Abstract No. : **PO-S01-0812**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Characteristics of Li_2O-B_2O_3-Al_2O_3 Green Sheet using thick film lamination process

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Currently, research is being actively conducted on all-solid-state batteries that use solid electrolytes instead of liquid electrolytes like existing lithium-ion batteries. All-solid-state batteries are popular due to their low risk of ignition or explosion and high energy density. Among various types of solid electrolytes, oxide-based solid electrolytes such as oxide-based solid electrolytes that can replace organic liquid electrolytes are attracting attention. They exhibit chemical stability in air and water and are relatively easy to synthesize and handle. However, since loss occurs during the pellet polishing process after sintering, a method for manufacturing the oxide-based solid electrolyte in the form of a thin sheet is needed. Although research is being actively conducted on the manufacture of solid electrolyte sheets using wet processes, there are many cases where the solid content content exceeds 50%.

In this study, a Li_2O-B_2O_3-Al_2O_3 solid electrolyte sheet with a solid content of 60% was manufactured using a coating process. However, when only LBS powder and binder were used, a uniform sheet could not be obtained. Afterwards, a slurry was prepared by controlling the surface condition of the powder using a silicone coupling agent and then formed into a sheet, thereby successfully producing a uniform sheet. Afterwards, the sheet characteristic evaluation and ionic conductivity analysis using Green Chip showed an ionic conductivity value of 10^{-7}S/cm.

Keywords : Solid-state batteries

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Abstract No. : **IN-S05-0811**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

Laser-Driven Synthesis of 2D Material-Based Electronics on Arbitrary Substrate

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Two-dimensional (2D) materials are increasingly valued for their pivotal role in flexible electronics, providing substantial benefits over traditional materials. These materials are highly sensitive, enabling the accurate detection of specific analytes and various physical forces, which makes them perfect for advanced sensors on flexible bases that support various shapes and sizes. Traditional methods for producing 2D materials involve high-temperature techniques (exceeding 750°C) and often damage the films during transfer to the desired substrates, leading to contamination, wrinkles, and inconsistencies. These defects are especially troublesome in sensor arrays, where they can cause operational inaccuracies.

In response to these issues, we present a new approach for directly synthesizing 2D material-based sensor arrays on flexible substrates using a laser-driven selective heat treatment process. This method involves the thermal decomposition of precursor compounds to create the 2D materials, specifically forming a MoS_2 sensor array on a stretchable substrate. A critical feature of this technique is the use of a fiber laser with a 1.06 μm wavelength, which selectively heats the precursor without significantly affecting the MoS_2, allowing for rapid heating and decomposition into MoS_2. We also showcased the creation of Laser-Induced Graphene (LIG) with tunable morphology on a polyimide substrate. By adjusting the laser's focus, we varied the LIG structure from porous to fibrous, with the latter resembling carpet fibers and exhibiting enhanced sensitivity to fine mechanical changes. This method not only improves the accuracy but also streamlines the manufacturing process of stretchable devices that incorporate 2D materials.

Keywords : Laser-driven synthesis, Selective treatment, Photothermal effect, Flexible electronics,

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Abstract No. : **PO-S11-0809**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Autonomous Resonance-Tuning Mechanism for Environmental Adaptive Energy Harvesting

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With the advent of the era of the fourth industrial revolution, the Internet of Things (IoT) combined with big data analytics will play a variety of roles in a wide range of applications. The biggest obstacle to the expansion of IoTs is that they are not free from power sources. Energy harvesting technology that captures unused ambient energy and converts it into useful electrical energy can provide the most feasible solution for this problem. The piezoelectric method has been the most extensively investigated for energy harvesting due to its high-energy conversion efficiency, high energy density, and simple integration with vibrating platforms. To maximize the power generated from vibrations, the energy harvester must operate at resonance since the displacement significantly reduces in off-resonance. However, energy harvester typically exhibits narrowband natural frequencies and thus it is difficult to couple with broadband vibrations. For this reason, operating in resonance at actual environments with various frequencies is one of the biggest issues in energy harvesting research. In this research, we will introduce novel strategies to achieve broadband operation through autonomous resonance tuning (ART) mechanisms that can automatically adjust their resonance frequencies by adapting to environments. The ART mechanism using the adaptive clamping system will be introduced, and discussed its operation mechanism and experimental validation in detail. The ART mechanisms were implemented only with mechanical principles without any additional energy consumption or human intervention and demonstrated that they can operate even in an actual frequency variant environment.

Keywords : energy harvesting, piezoelectric, self-resonance tuning, adaptive clamp

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Abstract No. : **PO-S06-0808**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

The synthesis of colossal permittivity materials utilising multiphase TiO_2 with a core-shell structure

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The advent of the 4th Industrial Revolution, which encompasses a plethora of AI-based technologies, has precipitated a rapid societal shift towards the future. This has necessitated the development of electronic products that require high-voltage and high-performance components. Multi-Layer Ceramic Capacitors (MLCC), a passive element that is indispensable for electronic products, is also in need of high performance. This has led to the necessity for research and development of supermassive dielectric materials, which have a dielectric constant of 10^4 or more and a dielectric loss of 10^{-3} or less. While the mechanism of colossal permittivity has not been clearly identified, it has been reported that the formation of oxygen vacancies caused by Ti^{3+} ions in dielectric materials containing Ti ions leads to colossal permittivity.

In this study, it was observed that when anatase TiO_2 and rutile TiO_2 form an interface, electrons from the rutile migrate to the anatase, resulting in the formation of Ti^{3+} and oxygen vacancies. This process was induced by forming a rutile shell on the anatase TiO_2 through heat treatment.

The controlled synthesis of Barium Titanate Zirconate ($Ba(Ti,Zr)O_3$, BZT) from TiO_2 was employed to confirm the mechanism by which the large dielectric constant is realized by the formation of oxygen vacancies due to metal ions. Furthermore, XRD analysis and microstructure analysis were conducted to confirm that the grain growth is promoted by the decrease in step free energy due to the lower synthesis temperature and the lower critical driving force (Δg_c).

Keywords : colossal permittivity, MLCC, BZT, Metalic Ion

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Abstract No. : **IN-S07-0807**
Symposia : **Computational Materials Science**

Abstract Preference : **Invited**

Computational insights into novel low-dimensional materials for next-generation semiconductor applications

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Low-dimensional materials such as two-dimensional materials, novel metal-halide crystals with internal low-dimensional polyhedrons, and colloidal quantum dots attract great attention due to their exceptional tunability of electrical and optical properties. These materials are expected to be important building blocks in the development of next-generation semiconductor devices. In this presentation, several computational studies based on density functional theory (DFT) will be introduced for the application of low-dimensional materials to various functional semiconductor devices. In particular, it will be highlighted that the material engineering parameters revealed by electronic structure calculations can act as key components toward seamless collaborations with experiments.

References
[1] *Nano Today* 55, 102184 (2024)
[2] *Adv. Funct. Mater.* 32, 2202207 (2022)

Keywords : Density functional theory, low-dimensional materials, semiconductor devices,

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Abstract No. : **IN-S13-0806**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Development of Organic Semiconducting Materials for OPV

Yun-Hi Kim[*1]

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Organic solar cells have attracted great attention as next-generation wearable power generators due to their merits of light-weight, low cost, and potential stretchability. One of the most successful advances in improving the power conversion efficiency (PCE) of OSCs has been recently achieved with the advent of non-fullerene small molecule acceptors (NFSMAs). A highly fused backbone structure of the NFSMAs incorporated with strong dye molecules allow to a high absorption coefficient compared to conventional fullerene-based acceptors, leading to the drastic improvement of the light absorption and the PCE of OSCs to 19%. In this presentation, I will discuss the design strategies of Non-fullene acceptors for good stability as well as high efficiency. Despite recent successes of the NFSMA-based OSCs, morphological instability and sharp domain interfaces caused by strong crystalline and high diffusion properties of the NFSMA can limit long-term stability and mechanical reliability for their practical applications. In this regard, all-polymer solar cells (all-PSCs)—consisting of a polymer donor (*P*D) and a polymer acceptor (*P*A)—are a particularly attractive class of the PSCs due to their excellent morphological stability and mechanical robotness . Here, we report a new series of NFSMA-based *P*A materials containing the same building blocks of *P*D to enhance the molecular compatibility between *P*A/*P*D, achieving high mechanical robustness and efficiency of all-PSCs.

Keywords : OPV, non-fullerene acceptor, stability

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Abstract No. : **PO-S10-0805**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Enhancing bacterial detection sensitivity through thermal responsive MNAGA-coating on PANI nano-structured substrate.

Yeonwoo Jeong[1], Eun-Kyung Lim[*1]

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Due to the global warming, the risk of pathogenic bacterial infection increases with each passing year. Therefore, early-stage detection of pathogenic bacteria is important. Past to present, numerous efforts have been conducted, and recently, a 3D hierarchically structured polyaniline (PANI) substrate was developed to enhance the bacterial capture ability for sensitive bacterial detection. However, the captured bacteria were not easily released, limiting the detection sensitivity. In this study, thermal responsive poly(methacryloyl glycinamide) (MNAGA) was co-polymerized with benzyl acrylate onto the urchin-like PANI nanostructured substrates vis SI-SRGET-ATRP method. The MNAGA coated PANI nanostructured substrates exhibited thermal responsiveness at 37 °C, altering surface hydrophilicity and facilitating the release of captured bacteria. The surface properties were characterized using XPS spectra, static water contact angle measurement and FT-IR spectra. Finally, the enhanced bacterial detection sensitivity of MNAGA coated PANI substrate was confirmed through RT-PCR analysis on real kitchenware and food samples. While further optimization is necessary, our study highlights the potential of thermal-responsive coatings in enhancing bacterial detection methods.

Keywords : Bacteria, PANI, Nanostructured

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Abstract No. : **IN-S14-0804**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

Solar Catalysts for Transforming Sunlight into Green Hydrogen and Beyond

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The development of sustainable materials using scalable methods that can enable high-efficiency solar energy conversion devices to produce hydrogen fuel is critical for better utilizing the world‘s abundant solar resources and accelerating the much-needed renewable energy transition. Chalcogenide and chalcogenide-halide materials possess environmentally friendly, non-toxic, inexpensive, and earth-abundant constituent elements and exhibit a band gap in the range of (~ 1.0 to ~ 2.0 eV) and a high absorption coefficient (~ 10^4 cm^{-1}), making them promising in these sustainable energy technologies.

In this talk, I will talk about our recent research advances in the development of chalcogenide and emerging chalcogenide-halide materials and their applications in solar hydrogen production. In addition to this, I will also talk about our recent developments in PV-driven electrolysis using earth-abundant catalysts for producing hydrogen and value-added chemical products. Current bottlenecks and future, promising directions will also be discussed.

Keywords : Solar catalysts, chalcogenide, chalcogenide-halide, semiconductors, electrocatalysts

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Abstract No. : **PO-S06-0803**
Symposia : **Advanced Structural Materials**
Abstract Preference : **Poster**

The effect of beam modes on melting behavior and microstructural evolution in conduction mode laser welding of Al-Si coated boron steel

Ok-Hyun Park[2], Hyun-Uk Jun[1], Jaehun Kim[1], Hong-Kwang Kim[3], Changwook Ji*[1]

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High-strength steel is becoming increasingly prominent in the automotive industry as a material that meets the demands for lightweight and high durability to address energy shortages and environmental pollution. As cold forming cannot produce complex-shaped parts, hot stamping processes that operate at austenitizing temperature have been developed. To prevent surface oxidation and decarburization of steel at high temperatures, the Al-Si coating with excellent high-temperature oxidation resistance and anticorrosion ability are widely used. However, the Al-Si coating on the steel surface acts as a strong ferrite stabilizer and is mixed into the fusion zone during laser welding, reducing the stability of austenite and expanding the dual-phase region. This significantly reduces weld performance and makes it difficult to achieve excellent mechanical properties. To address this, a next-generation ARM laser has been developed with independently adjustable ring modes. The objective of this study is to investigate the ARM laser welding properties, specifically focusing on the melting behavior, weld microstructure, and the effects of segregation and phase transformations in Al-Si coated hot-stamped boron steel to enhance weldability.

The ARM laser offers many advantages such as reduced spatter and improved weld quality due to uniform temperature gradient. Initial findings confirm that the temperature gradient effects of the ring beam improve the flow of the molten pool, effectively suppressing the formation of ferrite phases that negatively impact weld quality. Yet, research on the mechanism and process development is still lacking. In particular, the independent adjustment of the core and ring in each beam mode is expected to greatly influence weld efficiency and lead to significant changes in the shape and microstructure of the weld.

Keywords : High-strength steel (HSS), Ferrite stabilizer, ARM (Adjustable ring mode) laser, Ring beam, Segregation

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Abstract No. : **IN-S13-0802**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Invited**

High-Performance Perovskite/Organic Tandem Solar Cells with Mixed Self-Assembled Monolayers

Jin Young Kim*[1], Jung Geon Son[1], Shahid Ameen[1], BongSoo Kim[1], Dong Suk Kim[1]

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Perovskite/organic tandem solar cells offer a promising avenue to surpass the Shockley-Queisser limit by mitigating thermalization losses. However, wide bandgap perovskite solar cells (WBG PSCs) face challenges, particularly in open-circuit voltage losses. Herein, we propose a novel approach employing a mixed self-assembled monolayer (mSAM) as a hole-selective layer (HSL). This strategy facilitates efficient hole extraction by homogenizing the surface potential of the HSL. Furthermore, the modification of indium tin oxide with mSAM enhances perovskite crystallinity, reducing lattice strain and phase segregation. We have significantly improved the device efficiency, achieving a power conversion efficiency of 18.85% for WBG PSCs and 24.73% for perovskite/organic tandem cells. These results demonstrate the potential of the mSAM strategy to advance both the performance and stability of perovskite-based tandem solar cells for practical renewable energy applications.

Keywords : Mixed self-assembled monolayers, hole-selective layers, perovskite/organic tandem solar cells,

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Abstract No. : **PO-S06-0801**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Influence of Cooling Effects on the Mechanical Properties of Low Cost High-Strength Steel Wire Fabricated by the WAAM Process

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Wire Arc Additive Manufacturing (WAAM) is one of the metal 3D printing processes using an electric arc as a heat source to melt metal wire and build up products layer by layer. WAAM has significant benefits over other methods such as Laser-Directed Energy Deposition (L-DED) and Powder Bed Fusion (PBF), particularly for producing large components or molds with superior mechanical properties, and is well-suited for fast production of diverse, small-batch items. Given these advantages, the WAAM process has attracted considerable interest across various industries including aerospace, Shipbuilding, and automotive. However, WAAM can introduce high heat input from the arc, resulting in residual stress and molten metal flowdown within the layers. Such characteristics often lead to larger grain sizes compared to those in PBF and L-DED processes, which can reduce the precision, mechanical properties, and stability of the final part. Therefore, research into cooling methods to refine grain size is crucial. Additionally, for the industrial application of WAAM, considering the cost-effectiveness of the layered material is essential, leading to the use of commercialized low-cost high-strength solid wires.

In this study, three types of commercial low-cost high-strength solid wires were selected, and layering was conducted under different conditions of current (200, 250, and 300 A) and feed speed (30, 40, and 50 cm/min), to compare and analyze the resulting defects and mechanical properties. Subsequently, using the selected high-strength solid wire, the effects of cooling during the layering process on mechanical properties were compared and analyzed based on optimized layering conditions.

Keywords : Additive Manufacturing, Wire Arc Additive Manufacturing, High-Strength Steel, Mechanical Properties

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Abstract No. : **IN-S02-0800**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

3D printing of inorganic nanomaterials by photochemically bonding colloidal nanocrystals

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3D printing has been a transformative technology for building porotypes and various functional devices. However, from the materials perspective, direct 3D printing is typically restricted to metals and photocurable polymers. Important inorganic materials, especially the semiconductors and metal oxides, can only be printed with nanoscale resolution in the presence of polymeric or other matrices. The material limitation stems from incompatibility of conditions required for forming atomic bonds in these inorganic materials and the conditions used in regular 3D printing apparatus. To address this issue, we develop an approach for 3D printing of inorganic nanomaterials, or abbreviated as 3D Pin. 3D Pin uses 1) preformed, colloidal inorganic nanocrystals with various compositions as “artificial atoms” or building blocks, and 2) the photochemically bonding between nanocrystals via their native ligands with bisazide linkers. The broad library of colloidal nanocrystals and the nonspecific bonding chemistry of these nanocrystals render 3D Pin universal, as exemplified by over 10 semiconductors (II–VI, InP, $CsPbBr_3$), metals (Au), metal oxides (In_2O_3, TiO_2), and their mixtures. The printing process, triggered photochemically in the solution of nanocrystals with a femtosecond laser, allows for the formation of 3D objects in arbitrary forms and with nanoscale resolution (~150 nm). The printed structures show high materials purity (inorganic mass fraction over 90%), low porosity, and high mechanical strength. These features also allow the printed structures to preserve the original optical properties of the nanocrystal building blocks and show emergent behaviors, such as chiroptical response, owing to the structural designs. We expect 3D Pin to expand the material library of 3D printing techniques and unlock the designer space for combining inorganic material–structure for emergent applications.

Keywords : 3D printing; colloidal nanocrystals; quantum dots; surface chemistry

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Abstract No. : **IN-S05-0799**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

Giant 2D Single-Crystalline Metallic Nanosheets: Synthesis and Applications

Tae-Wook Kim[*1]

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In this study, we report hierarchical porous Cu film via assembly of single-crystalline, nanometer-thick, and micrometer-long copper nanosheets and their use in EMI shielding. Layer-by-layer assembly of Cu nanosheets enabled formation of a hierarchically-structured porous Cu film with features such as multi-layer stacking; 2D networking; and a layered, sheet-like void architecture. The hierarchical-structured porous Cu foil exhibited outstanding EMI shielding performance compared to the same thickness of dense copper and other materials, exhibiting EMI shielding effectiveness (SE) values of 100 and 60.7dB at thicknesses of 15 and 1.6 μm, respectively. In addition, the EMI SE of the hierarchical porous Cu film was maintained up to 18 months under ambient conditions at room temperature and showed negligible changes after thermal annealing at 200°C for 1 hr. These findings suggest that Cu nanosheets and their layer-by-layer assembly are one of the promising EMI shielding technologies for practical electronic applications. And also, we will discuss on monolayer assembly of metallic nanosheets and their applications.

Keywords : Single crystal, metal nanosheet, electronic ink, EMI shielding

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Abstract No. : **OR-S13-0798**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Oral**

Overcoming stability limitations of efficient, flexible perovskite solar modules

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Despite the remarkable growth of perovskite photovoltaic technology, the performance and stability of flexible perovskite solar modules (f-PSMs) are still below the commercial level, and even the clear reasons for this have hardly been elucidated. Here, we found that flexible perovskite solar cells (f-PSCs) suffer from a trade-off between efficiency and stability due to the off-balance between surface coverage and the charge-transporting property when conventionally using colloidal SnO_2 nanoparticles as an electron-transport layer (ETL). To resolve this trade-off, we newly designed an ETL that enhances the charge transport properties and mitigates the shunt sites, resulting in improved efficiency and operational stability. Therefore, we succeeded in achieving a certified efficiency of 21.8% in f-PSC (22.92% in-house) and 16.4% in f-PSM (900 cm^2). Furthermore, we discovered that incomplete coverage gives rise to the formation of a shunt pathway, causing the current crowding effect, which could have a significant impact on long-term operational stability.

Keywords : perovskite, flexible, large-area, solar cells, trade-off

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Abstract No. : **IN-S04-0797**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Invited**

Intelligent Medical Solution using Multimodal Electronics and Control Networks

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Despite recent strides in medical diagnostic systems, cardiovascular diseases (the leading global cause of death) and respiratory diseases (ranking 3rd and 6th) continue to claim 43 lives per minute worldwide. Conditions like acute cardiac arrest or respiratory failure often arise suddenly, lacking warning symptoms, posing challenges for immediate treatment and response. With an alarming 8% survival rate, these issues represent significant societal concerns. Furthermore, sudden infant death syndrome (SIDS) contributes significantly to infant mortality within the first five years, underscoring the pressing need for continuous monitoring of cardiovascular and respiratory functions, along with the development of rapid response systems.

While wireless biosignal detection systems offer a promising solution for continuous health monitoring, the current emphasis primarily revolves around heartbeat detection. This leaves the technological landscape for detecting various biosignals, such as respiration and blood pressure, underdeveloped. Enhancing sensor sensitivity to subtle biosignals introduces susceptibility to external physical or electrical noise, complicating the task of obtaining reliable vital signals. Additionally, the development of medical solutions transitioning seamlessly from diagnosis to immediate therapeutic assistance demands a convergence of knowledge from medicine, electronic engineering, and control engineering, rendering it a futuristic technology.

The seminar introduces advances in three key areas that overcome the limitations of existing wireless monitoring systems: 1) the development of reliable high-performance biosignal sensors and biosignal separation algorithms, 2) the utilization of sensor networks for spatiotemporal information of biosignals, and 3) a real-time stimulation therapy system.

Keywords : Continuous Medical System

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Abstract No. : **IN-S03-0796**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Invited**

Nanoribbon Yarns with Versatile Metal/Ceramic Materials for High-Performance Transducer

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Nanomaterial-based yarns have been actively developed owing to their advantageous features, namely, high surface-area-to-volume ratios, flexibility, and unusual material characteristics such as anisotropy in electrical/thermal conductivity. The superior properties of the nanomaterials can be directly imparted and scaled-up to macro-sized structures. However, most nanomaterial-based yarns have thus far, been fabricated with only organic materials such as polymers, graphene, and carbon nanotubes. This paper presents a novel fabrication method for fully inorganic nanoribbon yarn, expanding its applicability by bundling highly aligned and suspended nanoribbons made from various inorganic materials (e.g., Au, Pd, Ni, Al, Pt, WO_3, SnO_2, NiO, In_2O_3, and CuO). The process involves depositing the target inorganic material on a nanoline mold, followed by suspension through plasma etching of the nanoline mold, and twisting using a custom-built yarning machine. Nanoribbon yarn structures of various functional inorganic materials are utilized for chemical sensors (Pd-based H_2 and metal oxides (MOx)-based green gas sensors) and green energy transducers (water splitting electrodes/triboelectric nanogenerators/supercapacitor/thermoelectric generator). This method is expected to provide a comprehensive fabrication strategy for versatile inorganic nanomaterials-based yarns.

Keywords : Nanoyarn, sensor, metal, ceramic, nanomaterials

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Abstract No. : **IN-S02-0795**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Invited**

Application of Direct Lithography in Ultrahigh-Resolution Display

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Colloidal quantum dots (QDs), as a class of zero-dimensional semiconductor materials, have generated widespread interest due to their adjustable band gap, exceptional color purity, near-unity quantum yield, and solution-processability. With decades of dedicated research, the potential applications of quantum dots have garnered significant recognition in both the academic and industrial communities. Furthermore, the related quantum dot light-emitting diodes (QLEDs) stand out as one of the most promising contenders for the next-generation display technologies. In recent years, driven by new concepts such as smart healthcare and "metaverse", the next generation of displays have set higher standards for pixel resolution to meet the ever-increasing demands of applications such as massive information and near-eye displays. However, the resolution of mainstream displays currently remains at the level of tens or hundreds of micrometers, and entering the submicron and nanometer scales faces many serious challenges. Ultrahigh-resolution displays are crucial for future near-eye virtual/augmented reality displays. QLED uses extremely small nanocrystals as emitters, and theoretically the light-emitting performance of the device is not limited by size, thus it has unique advantages in the field of high-resolution displays.

Different from OLEDs and micro-LED (in which shadow masking and massive transfer are usually applied to achieve full-color display, respectively), the pixilation techniques of QLEDs are mainly based on the manipulation of QD solutions or films. However, taking into account the droplet size and alignment accuracy of the industrial nozzle, it remains difficult for ink-jet printing to produce ultra-small QD pixels with well-defined boundaries. In order to meet the demands of high-resolution display, an alternative technology is needed to deliver delicate display effects and high fabrication efficiency. As a cornerstone technology in the modern semiconductor industry, photolithography is recognized as one powerful approach for the preparation of QD arrays.

For the QLED process, we have developed direct lithography processes for quantum dot layer and functional layer materials, which can realize the preparation of<5 μ m pixel arrays. Moreover, we propose and develop the first direct photolithography of EC WOx nanomaterials via an in situ ligand exchange reaction under UV radiation. A novel high-resolution EC display with precise WOx patterns (<4 μm, the highest resolution of inorganic EC materials and one of the highest resolutions of EC field) was fabricated.

Keywords : QLED;photolithography; ultrahigh-resolution display,

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Abstract No. : **OR-S11-0794**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

ECRAM for Neuromorphic Computing via Lithium Insertion Electrodes

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ECRAM devices stand out as a promising solution for implementing artificial synapses in neuromorphic computing systems, as they require much less energy for computation. Yet, the demonstrated conductivity change remains limited. Here, we choose lithium insertion electrodes as the channel and Li reservoir layer. Since the material exhibits conductivity change up to 6 orders of magnitude, we explore the device as a potential artificial synapse. We test two different method of transferring Li ion, specifically vertical type and planar type. The two Li transfer methods differs in the type of electrolyte, with solid electrolyte for vertical type and ionic liquid for planar type.
We will discuss the electrochemical lithiation profiles and the resultant conductivity change according to lithium insertion for each Li transfer method, along with the optimization attempts. Also, the device geometry and performance in terms of resistance changes and retentions will be discussed.

Keywords : ECRAM, Neuromorphic

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Abstract No. : **PO-S07-0793**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Exploring Synergistic Interactions in Metal-Oxide Electrocatalysts for Water Electrolysis

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As the global push for sustainable energy sources continues to intensify, technologies such as renewable water electrolysis and fuel cells will play a critical role in the transition away from fossil fuels. It is widely accepted that developing more active and durable catalysts for water electrolysis remains a major research focus. Traditional strategies have been to increase the intrinsic activity of known materials or to discover new materials through intensive experimentation. However, the complex relationship between the structure of a material and its properties during the electrocatalytic reaction presents a significant challenge. In recent years, computational materials science has become an essential tool for the mapping of these relationships, leading to the development of innovative materials with enhanced functionalities. This progress highlights the essential role of computational materials science in the development of renewable energy technologies, and is marked by numerous breakthroughs in energy materials facilitated by computational research.

In this talk, I will discuss our recent research on how hybrid catalysts combining metal nanoparticles with metal oxide supports enhance catalytic performance [1,2]. We have found that oxygen vacancies in the oxide support reduce the energy required for charge transfer and enhance the interaction between the metal nanoparticles and both the oxide support and the electrolyte through density functional theory, comprehensive electrochemical analysis, and operando X-ray absorption spectroscopy. Furthermore, there will be a discussion on how we can further improve these hybrid catalysts. These results highlight the importance of the interactions between the metal and the metal oxide and represent an innovative approach to the design of highly efficient electrocatalysts.

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Keywords : Density Functional Theory, Water electrolysis, Electrocatalysts

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Abstract No. : **KN-S12-0792**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Keynote**

Microbial CO_2 Conversion to Value-added Chemicals using Carbon-negative and Sustainable Microbial Electrosynthesis Cell

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Microbial electrosynthesis (MES) is a promising strategy for the conversion of CO_2 to useful chemicals. Nevertheless, the characteristics of electrode-associated cells in MES and their metabolic pathway regulation in CO_2 fixation have not been elucidated. This work presents the electrode-driven hydrogen and polyhydroxybutyrate (PHB) production from CO_2 in Rhodobacter sphaeroides. Under an applied potential of - 0.9 V vs. Ag/AgCl to the cathode and glutamate as nitrogen source, Rhodobacter sphaeroides produced hydrogen (328 mL/L/day) with CO_2 as the sole carbon source under illumination. The initial planktonic cells decreased rapidly in suspension, whereas biomass formation on the cathode surface increased gradually during MES operation. With ammonium chloride as nitrogen source, the electrode-associated cells produced PHB at concentrations up to 23.50 ± 2.8% of the dry cell weight (DCW), whereas the suspended cells grew faster but with a lower cellular PHB content. The electron uptake and regulation of the metabolic pathways differed in electrode-associated and suspended R. sphaeroides. Gene expression analyses showed that phaA expression was upregulated in electrode-associated R. sphaeroides, whereas phaB expression was downregulated in suspended cells. The electrode-associated cells expressed unconventional CO_2 fixation enzymes, such as isocitrate dehydrogenase and formate dehydrogenase, with more PHB synthesis. These results show that CO_2 can be upcycled to polymeric substances and provide novel insights into the genetic regulation of electrode-associated cells in MES.

Keywords : CO2; microbial electrosynthesis cell, bioelectrochemical cell, microbe-electrode interaction

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Abstract No. : **OR-S11-0791**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Effect of Electrolyte Concentration Difference on Thermogalvanic Engergy Harvesting Performance

KIHOON RYU[1], Sangtae Kim[1], Kihoon Ryu[*1]

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Harvesting low-grade heat (below 100℃) via thermogalvanic devices from wasted energy has received a large amount of research attention, yet efficient thermogalvanic devices by employing electrodes with their melting points difficult to achieve a high output voltage and power performance. In this work, a remarkable finding shows that the control of adding a fluorinated solvent, 1,1,2,2-tetrafluoroethyl-2,2,3,3-tetrafluoropropyl ether (TTE) concentrations in electrolytes significantly alters the thermopower and current of the thermogalvanic device. The model systems based on Na2K alloys are employed to test the thermopower and current by shifting the concentration of TTE. The measured results show that the thermopower gets notably increased containing 5 v% TTE, significantly strengthened to 63.6 mV/K. The implications of this work in terms of electrolyte concentration change of thermal energy harvesting will be further discussed.x

Keywords : Energy harvesting, Low-grade heat

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Abstract No. : **IN-S18-0790**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Invited**

Bio-to-Byte: Stealthy Neural Recorder for primates

Kyung-In Jang[*1]

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It is highly challenging to develop a single integrated neural interface system that can record realtime brain neural signals, store data on a server, analyze signals, and combine different device functions including signal measurement, wireless powering, wireless communication, and device control into a single implantable device in primates for the study of brain neuronal dynamics of natural instinct. Also, the brain volume of NHPs is more than 100 times larger than that of rodents.

Due to the large size of the brain, it is difficult to insert a long-length neural probe with low bending stiffness by mimicking the brain's softness (a few kPa). Additionally, NHPs naturally sit, stand, and hang in a flexible posture with their four limbs, adding a layer of obstacles to stably supply wireless power due to their freedom of movement and ability to change their head height and angle. Several researches have reported brain neural interface technology in non-human primates. However, due to aforementioned large-animal specific technical challenges, there is no neatly integrated wireless, battery-free, fully implantable neural interface for monitoring brain neural activity of NHP's natural instinctive behavior in an unrestricted, wild-like environment.

We introduce a comprehensive set of material and engineering strategies focused on brain neuroscience research in untethered, conscious and freely-moving NHPs, covering (1) wireless, battery-free, fully implantable neural interface device with multichannel real-time neural signal recording and user-friendly device control schemes; (2) multielectrode flexible neural probe coated with mechanically transient, bioresorbable sucrose needle; (3) sub-meter scale wireless power transfer by precisely organized repeater-antenna system; and (4) AI modeling for brain neuroscientific analysis of natural instinctive behavior of NHPs.

Keywords : brain machine interface, neural probe, implant, wireless electronics

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Abstract No. : **OR-S12-0789**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

GOLD NANOSPHERES-ENCAPSULATED YOLK-SHELL STRUCTURE: APPLICATIONS AS ENVIRONMENTAL CATALYST

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Water scarcity due to population growth and climate change has emerged as a paramount global environmental issue, therefore effective water treatment technologies are continuously required to solve them. Hence, in this study, we newly developed gold nanospheres encapsulated mesoporous silica nanocapsules (AuNS@ySiO2) and evaluated its catalytic performance. The AuNS@ySiO2 was synthesized using the seeded growth method and selective etching process, and its characteristics were thoroughly analyzed. To confirm the catalytic performance of the AuNS@ySiO2/peroxydisulfate (PDS) system, we conducted comparative experiments with various structured control groups, using phenol as a target compound. The AuNS@ySiO2/PDS system exhibited outstanding phenol degradation performance compared to the control groups, which have identical amounts of AuNS, owing to the enhanced colloidal stability of AuNS. Through several experiments, the phenol degradation mechanism in the AuNS@ySiO2/PDS system revealed a non-radical pathway in which electrons were transferred from phenol to PDS through AuNS as an electron mediator. Phenol degradation in the presence of humic acid exhibited higher performance than the results for the control groups, attributed to the molecular sieving effect of the mesoporous silica shell. In addition, we fabricated a functional membrane using AuNS@ySiO2 (AuNS@ySiO2 membrane) through pressurized filtering and evaluated its characteristics, flux, and phenol degradation performance. The AuNS@ySiO2 membrane exhibited improved flux owing to the photothermal effect of AuNS present in AuNS@ySiO2 by irradiation of 808 nm laser. Moreover, it effectively degraded phenol contained in the feed water by the nano-confinement effect as the phenol passed through the AuNS@ySiO2 membrane, showing thousands of times higher rate constants than batch conditions. Based on these results, the newly developed yolk-shell structure AuNS@ySiO2 is expected to be effectively applied as an environmental catalyst with its unique structural characteristics and high catalytic activity.

Keywords : Yolk-shell structure, Gold nanoparticle, Advanced oxidation process, Photothermal, Nano-confinement

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Abstract No. : **OR-S11-0788**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Tunable Thermogalvanic Thermopower via Controlled Lithiation/Sodiation of TiO_2 Anatase Electrodes

Eunho Choi[1], Dongwook Lee[2], Sangtae Kim*[1]

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Thermogalvanic devices provide a promising solution for efficiently harvesting low-grade waste heat (below 100°C). However, mechanistic design strategies on tailoring the thermopower of solid-state electrode materials remain to be unveiled. Here, we demonstrate tunable thermopower from +2.1 mV/K to –4.7 mV/K by inserting alkali (lithium and sodium) ions into TiO_2 anatase insertion electrodes. The size-dependent pseudo-capacitance/intercalation capacity among Li-inserted TiO_2[1] and crystal/amorphous transformation among Na-inserted TiO_2[2] provide a platform for exploring a range of physical mechanisms potentially contributing to thermopower. The results show that the thermopower changes from +1.7 mV/K to –4.7 mV/K upon sodiation, as the material transforms from crystalline to amorphous TiO_2[2]. This tunable thermopower offers potential design strategies towards developing n-type and p-type thermogalvanic electrodes based on solid-state materials, which has been scarce for practical p-n leg device construction.

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Keywords : Thermogalvanic, TREC, Alkali ions, Tunable thermopower

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Abstract No. : **PO-S14-0787**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

"Enhanced Photoelectrochemical Water Splitting with Doped and Acid-Treated g-C_3N_4 Synthesis, Characterization, and Mechanistic Insights"

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Hydrogen is one of the cleanest source of energy. As the world transitions toward a more sustainable energy future with reduced dependence on fossil fuels, technologies that can directly harness solar energy for chemical reactions, like water splitting, become increasingly important. Visible light-driven hydrogen production aligns with this transition by enabling a clean and efficient way to generate hydrogen. The unique properties of g-C_3N_4 (GCN) that make it an excellent catalyst, include visible light activity, low cost, non-toxicity, high stability, simple synthesis, and narrow bandgap, for photo-electrochemical (PEC) water splitting. Here focus is on synthesis of g-C_3N_4 by thermal polymerization method and studying the effect of doping and acid treatment on g-C_3N_4. The introduction of boron heteroatom into the g-C_3N_4 (BCN) structure can modify its electronic properties and enhance its catalytic performance. Acid treatment on g-C_3N_4 turns it into the protonated g-C_3N_4 (PCN) which leads to enhancement into the PEC performance. Here, phase purity and structural composition confirmation were studied through X-ray diffraction (XRD), and Fourier-transform infrared (FT-IR) spectroscopy analyses. Morphological characterization was conducted via scanning electron microscopy (SEM). PEC measurements provided insights into the materials nature, photocurrent density, and transient behaviour during solar water splitting. The observed substantial increase in PEC response of BCN over their bare materials; highlights its potential for sustainable hydrogen generation. Thus, the current research can contribute to advancement of efficient and sustainable technologies for hydrogen production thorough understanding of underlying mechanisms of charge transfer, electrode/electrolyte interfacial processes in PEC studies.

Keywords : Hydrogen, Photoelectrocatalysis, g-C_3N_4, Water splitting, Sustainability

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Abstract No. : **OR-S11-0786**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Search for corrosion-resistant alloy coatings for molten chlorides

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Thermal energy storages employing molten chloride salts have recently attracted significant research attention due to their economical and scalable nature. However, the strong corrosion attacks by molten chlorides on structural materials impede their commercialization efforts. Recent research efforts led to a search for alloy elements and potential alloy coatings that slow down the molten chloride-induced corrosion. Yet, the search has been limited to several refractory elements. This study aims to predict the corrosion tendency of the alloying elements and intermetallic compounds through thermodynamic stability analysis and determine potential alloying elements that effectively improve corrosion resistance in molten chlorides. Specifically, we study Cr, Fe, and Ni as the base metals and Al, Co, Mn, Ti, Zr, W, and Mo as the alloying elements and study all potential intermetallic compounds for their corrosion resistance. The thermodynamic stability is analyzed via atomistic simulations in terms of the enthalpy of formation and vibrational entropy for the intermetallic and metal-oxide compounds. We find that almost all the intermetallic compounds considered exhibit lower corrosion resistance than the base metals, except for the Ni-Mo compound, with an increased corrosion potential of +0.024 V than pure Ni. These results systematically outline the limited opportunities in protective coatings based on intermetallic compounds and also point to the search among other chemical spaces such as ceramics.

Keywords : Molten salt, Thermal energy storage, Corrosion, Alloy, Thermodynamic analysis

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Abstract No. : **IN-S12-0785**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Chloride-mediated ion separation for CO2 removal from seawater

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The concentration of CO2 in the atmosphere is on the rise, prompting widespread efforts to extract CO2 from various sources including power plant exhausts, chemical processes, and directly from the atmosphere. Historically, efforts have primarily focused on capturing CO2 from localized sources such as power plants. However, there is increasing interest in negative emission technologies, which aim to remove CO2 that has already been released into the environment. These strategies largely focus on direct air capture, but the relatively low atmospheric CO2 concentration (about 420 ppm) presents challenges due to the slow absorption rates and the energy demands of regenerating capture agents.

The ocean, which has absorbed approximately 30% of anthropogenic CO2 emissions, presents a significant opportunity for CO2 separation due to its higher CO2 concentrations—about 120 times that of the atmosphere. By extracting CO2 from ocean water, we can indirectly lower atmospheric CO2 levels, as the CO2-depleted water can then reabsorb CO2 from the air, potentially reducing overall atmospheric concentrations. A critical aspect of this technology is the environmentally responsible reintroduction of treated water back into the ocean, which involves minimizing chemical additives and avoiding the production of harmful byproducts. The electrochemical method offers distinct advantages here, eliminating the need for external chemicals and providing fine control over the reaction through voltage adjustments.

In this presentation, a new electrochemical system composed of two different chloride-capturing electrodes will be introduced to modulate the alkalinity of seawater and extract CO2 as a gas phase. This system could successfully remove carbon dioxide from seawater without introducing an ion exchange membrane.

Keywords : CO2 capture, oceanwater, electrochemistry, pH swing

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Abstract No. : **IN-S12-0784**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Operando Spectroscopic Analysis for Photo/Electrocatalytic Processes

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Observing key intermediates directly on the catalyst surface poses a significant challenge in various photo/electrocatalytic processes, including CO_2 reduction and O_2 reduction reactions. To gain a comprehensive understanding of the reaction mechanisms, it is essential to conduct combined studies utilizing complementary tools such as electrochemical characterization, computational calculations, and operando spectroscopies. Among these, time-resolved attenuated total reflection-surface enhanced infrared absorption spectroscopy (ATR-SEIRAS) stands out as particularly suited for investigating electrochemical CO_2RR due to its ability to observe interfacial processes in real-time with high surface sensitivity. Time-resolved analysis offered by ATR-SEIRAS allows for the exploration of the kinetic relevance of intermediates and their dynamics in relation to reactants and products during the reaction. Furthermore, integrating operando spectroscopic studies with material characterization enables the correlation of intermediate behavior with catalyst conditions. In this context, I will introduce in situ time-resolved FT-IR (or ATR mode) spectroscopic techniques to capture isotopically labeled products and key intermediates generated during the photoreduction of carbon dioxide.

Keywords : operando analysis, photocatalysis, electrocatalysis

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Abstract No. : **KN-S14-0782**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Keynote**

Highly stable and crystalline semiconductor quantum dot glassy materials for energy genration and storage.

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Major advances have been made recently in exploring new kinds of Quatum dots (QDs)-embedded glasses for variety of optial applications. These QD-glasses demonstrtaed efficient and stable luminiscence in the visible to mid IR range and showed many competitive applications such as phosphors and optical fibre applifiers. However, this is the first time, we have used such unique glass for energy and energy storage applications. It is well known that semiconductor quantum dots are unstable at ambient conditions and hence it is very difficult to study their size quantization and functionality, precisely. In view of this, the semiconuctor quntaum dots of different size (2-7 nm) are grown in the glass matrix and studied the optical properties. These Q dot semiconductor glasses are highly stable and can be used for optical applications.The CdS, CdSSe, bismuth quantum dots grown in glass matrix have shown fantastic optical properties and used for solar light harvesting to produce hydrogen. More significantly, the oxide semiconductor Ag_3PO_4 quantum dots of size (1-5 nm) have been grown in glass matrix which shows an excellent optical property. The dodecahedrons of Ag_3PO_4 are also been seen at nano phase state in glass matrix which is quite unique. The uniform distribution of very tiny quantum dots have been observed in glass matrix which are quite stable up to 300 °C. The fabrication of variety of quantum dot glasses have been demonstrated for hydrogen production. The hydrogen generation using such systems has been demonstrated for the first time. More significantly, these quantum dot glasses have also been used for the lithium-ion battery applications for the first time. There will be huge potential for these glasses to explore them further for energy applications.

Keywords : Semiconductors, Quantum dots, Hydrogen , Lithium ion battery

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Abstract No. : **OR-S06-0781**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Study on the microstructure and mechanical properties of adjustable-ring-mode laser welded and hot-stamped Al–Si coated boron steel joints

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The automobile industry is current focused on the development of high-strength steels (HSS) to produce lightweight vehicles and increase crashworthiness and passenger safety. However, the press formation of HSS suffers from spring-back behavior due to insufficient ductility during hot-stamping. Hot metal formation of the 22MnB5 steel is characterized by surface oxidation and decarburization, which can be prevented by applying various coatings. Among them, the Al-Si coating is generally used because of its better high temperature oxidation resistance and anticorrosion ability. However, boron steel with an Al–Si coated surface deteriorates the weld quality depending on the microstructure and strength of the steel during laser welding. However, boron steel with an Al–Si coated surface deteriorates the weld quality depending on the microstructure and strength of the steel during laser welding. Meanwhile, A next-generation adjustable ring mode (ARM) laser that adds an independently adjustable ring mode to fiber laser systems is currently being developed. In particular, the energy-density distribution can be tuned using different beam modes in an ARM laser, and this tunable distribution influences the microstructural evolution and mechanical properties of the fusion zone (FZ).

In this study, the microstructure and mechanical properties of ARM laser-welded, hot-stamped 22MnB5 steel joints were analyzed and compared with those of Al–Si coated 22MnB5. Al segregation into the FZ was suppressed by a ring beam introduced via ring-beam-mode (RBM) and dual-beam-mode (DBM) laser welding. Dilution of the Al–Si coating in the FZ induced α-ferrite formation during hot stamping. The tensile strength and elongation of the TWB joint in the CBM were ~989 MPa and 1.1 %, respectively, which were significantly lower than those of the RBM (1245 MPa and 1.96 %, respectively) and DBM (1321 MPa and 2.12 %, respectively). The relationship between microstructure and mechanical properties was further clarified via the XRD and EBSD analysis.

Keywords : high-strength steel (HSS), Hot-stamping, Al-Si coating, Adjustable ring mode (ARM) laser, Microstructure

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Abstract No. : **OR-S06-0780**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

nfluence of cooling temperature on microstructure and mechanical properties during WAAM process of steel wire

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The WAAM (Wire Arc Additive MAnufacturing) process is a type of 3D-printing technology that uses arc heat to melt supplied metal wire and deposit it in a three-dimensional form. The advantage of the WAAM process is that it has a relatively faster deposition rate than PBF (Powder Bed Fusion) and L-DED (Laser-Direct Energy Deposition) processes. These advantages can effectively reduce deposition time and cost. The WAAM process can be applied to various industries such as Aeronautical & Space, shipbuilding, and automobiles, but it has the disadvantage of low mechanical properties because the deposited metal has a large grain size. Therefore, research on cooling effects and cooling methods in the WAAM process is very necessary to compensate for low mechanical properties.

In this study, three commercially available low-cost steel solid wires were selected. The optimal deposition conditions and wire were selected based on the range of current (250 and 300 A) and travel speed (30, 40, and 50 cm/min). The microstructure and mechanical properties of steel solid wire deposited under optimal conditions were analyzed, and the microstructure and mechanical properties were compared and analyzed in detail to compare the effects of cooling temperature during the WAAM process.

Keywords : Additive Manufacturing, Wire Arc Additive Manufacturing, Steel, Mechanical Properties, Microstructure

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Abstract No. : **IN-S18-0779**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Invited**

Fiber-based electronics for advanced brain-machine interfaces

Taeyoon Lee[*1]

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The advent of wearable electronic devices designed for seamless integration into daily textiles heralds a new era of personal healthcare and bio-monitoring technologies. These devices, characterized by their lightweight, weavable, and stretchable properties, offer unprecedented opportunities for monitoring health parameters and delivering therapeutic interventions in real-time, addressing the complex spatial and temporal needs of modern medical treatments. Recent research has made significant strides in developing one-dimensional (1D) stretchable electrodes that are fundamental to the operation of wearable and textile electronics. These advancements encompass a variety of conductive materials and fabrication techniques aimed at enhancing the electrical performance and stretchability of electrodes to support the diverse applications of wearable devices.

Pivotal development in the field is the creation of implantable neural probes for brain-machine interfaces, which require a delicate balance between mechanical flexibility and electrical conductivity to minimize tissue damage while ensuring high-quality neural signal acquisition. The introduction of fiber neural probes, featuring core polymers coated with gold nanoparticles, marks a significant advancement in achieving long-term, stable signal recording with minimal foreign body responses. This approach not only advances the understanding of neural circuits but also opens new avenues for the treatment of chronic neurological disorders.

In conclusion, the field of fiber-based electronics for advanced brain-machine interfaces stands at the cusp of a revolution, offering solutions that promise to transform the landscape of personal healthcare, diagnostics, and therapeutic interventions. By addressing the challenges of integrating electronics with textiles and the human body, researchers pave the way for a future where wearable devices not only monitor health in real-time but also provide timely medical interventions, enhancing the quality of life and opening new horizons in medical science.

Keywords : Neural probes, implantable, brain-machine interfaces, minimal foreign body responses

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Abstract No. : **KN-S01-0778**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Keynote**

How interfaces control lithium (de)insertion pathway: Comparing liquid and solid electrolytes

Jongwoo Lim[*1]

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In the realm of lithium-ion batteries, the process of lithium (de)insertion follows a two-fold pathway, encompassing (1) charge transfer occurring at the electrolyte-electrode interface and (2) solid-state lithium diffusion within electrode. Conventionally, these two transport mechanisms have been regarded as distinct and investigated separately due to their sequential occurrence during battery cycling. However, our recent research demonstrates that the kinetics of charge transfer can excert control over the spatial distribution of lithium on the surface, consequently influencing the entire lithium (de)insertion pathway.

In addition, in the field of all-solid-state batteries (ASSBs), the interface between solid-electrolytes and electrodes further modulates the surface charge transfer kinetics, active surface areas, and local stresses. Chemo-mechanical properties in ASSBs complicate interfacial charge transfer and further affect lithium diffusion within the electrodes. In this talk, I will present how our synchrotron-based operando X-ray diffraction and imaging could help understand such phenomena.

Keywords : lithium-ion batteries, all-solid-state batteries, imaging, synchrotron

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Abstract No. : **PO-S05-0777**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

In Situ TEM Investigation of Nickel Catalytic Graphitization

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The Ni is known as an important catalyst for growing multilayer graphene. Its graphitization process plays a very important role in controlling the thickness of the grown graphene film. Therefore, the elucidation of the graphitization mechanism becomes an essential issue. Traditionally, Ni is considered to be a metal with high C solubility. And its C solubility is influenced by the thickness of the grown film. However, a few studies suggested that the intermediate phase is related to the graphitization. Because it has various suggestions on its catalytic graphitization mechanism, it is valuable to study with *in situ* TEM. In this study, it shows the graphitization on Ni and amorphous carbon by *in situ* TEM experiment. To detect the reaction between Ni and C, the *in situ* experiment is built in vacuum annealing with stacked thin film of Ni and C. As a result, we can reveal the graphitization of a-C/Ni directly in real-time observation. From the in situ experiment, we found that the graphitization includes the carbide phase, which becomes unstable at 450 °C. The carbide phase is difficult to detect directly due to its similar structure to Ni. This study shows that the carbide phase coexists with Ni in certain plane which can be distinguish the small difference in *d* spacing by TEM. And different with the common idea, the graphitization on thin film system did not progress in layer-by-layer growth. This study determines the graphitization mechanism and the behavior of thin film a-C/Ni during reaction by in situ TEM experiment.

Keywords : in situ TEM, graphene growth mechanism, nickel catalyst, solid carbon source, graphitic layers

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Abstract No. : **PO-S05-0776**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

In Situ TEM Study on Growth of Carbon Nanofiber and Nanotube from Ethanol Vapor

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Carbon nanofibers (CNFs) and carbon nanotubes (CNTs) are utilized across various fields such as energy storages, chemical sensors, photonics, thermal interfaces, and wearable electronics due to their remarkable physical and chemical properties. However, the controlled synthesis of CNFs/CNTs has been hindered by the lack of nanoscale experimental evidence on how the growth temperature affects the growth process under real growth environment. This study presents the first *in situ* transmission electron microscopy (TEM) experiments to directly observe the growth of Ni-catalyzed CNFs/CNTs from an ethanol vapor at near atmospheric pressure. We thoroughly examine the impact of growth temperature on the structure of the resulting nanofibers or nanotubes. To introduce ethanol vapor into a micro-electromechanical system (MEMS) based closed cell, we designed and implemented a homebuilt bubbler system. This system enables precise control of flow rate and pressure, ensuring highly reproducible results across multiple *in situ* TEM experiments.

Keywords : carbon nanofiber, carbon nanotube, active state, activation energy, ethanol vapor, in situ TEM

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Abstract No. : **OR-S03-0775**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Oral**

Synthesis of La:MnMoO$_3$ perovskite oxide nanostructures for fluorescence detection of indoxacarb in food samples

Suresh Kumar Kailasa[1], Nirav Vajubhai Ghinaiya[2], Dr. Yoojin Choi[1], Prof. Tae Jung Park[*1]

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Indoxacarb is widely applied as an insecticide that poses a risk of environmental contamination, indicating a facile and selective probe is need to be developed for indoxacarb assay in environmental and food samples. In this work, fluorescent La:MnMoO$_3$ perovskite oxide nanomaterials are synthesized and used as a rapid fluorescent probe to detect indoxacarb in vegetable and fruit samples. The La:MnMoO$_3$ perovskite oxide showed blue fluorescence upon the excitation at 330 nm, however the fluorescence of La:MnMoO$_3$ perovskite oxide can be efficiently quenched by indoxacarb through the inner filter mechanism. The sensor showed a satisfactory linear relationship with increasing amounts of indoxacarb in the range of 2.5-60 μM (R^2 = 0.99) with a limit of detection (LOD) of 62.99 nM, displaying good recoveries in the range of 97.35 – 99.61%. The developed La:MnMoO$_3$ perovskite oxide-based fluorescent sensor could electively be applied for on-site assaying of indoxacarb in agricultural and environmental samples. Scheme 1 represents the preparation of La:MnMoO$_3$ perovskite oxide for fluorescence assay of indoxacarb.

Keywords : Perovskite oxide, Fluorescence spectroscopy, Indoxacarb, Inner filter effect.

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Abstract No. : **IN-S12-0774**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Heterogeneous catalysis for oxyanion and ozone activation

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Low-valent metal- and carbon-based materials catalyze the redox reactions involving oxyanions (e.g., persulfate and hydrogen peroxide) and ozone to enable the radical and non-radical oxidative degradation of organic compounds in water. Treatment efficiency and major degradative pathway are sensitive to the type of activator and radical precursor. Specifically, the high-yield production of radical oxidants, such as sulfate and hydroxyl radicals, was achievable with reduced transition metals that initiated the heterolytic dissociation of peroxide bonds through the one-electron reduction of oxyanions. Nickel sulfides served as the key species in the catalytic conversion of ozone into hydroxyl radicals whereas contributing to a marked increase in the capability of nickel-carbon composites for non-radical persulfate activation. Low-valent nickel oxide/hydroxide oxidatively transformed into the high-valent counterparts as non-radical oxidants upon the addition of diverse oxyanions, including persulfate and hypochlorite, which contrasted with the observation that reduced cobalt-derived catalysts performed the radical-induced oxidation of organics through the selective activation of peroxymonosulfate. Nanostructured carbons and carbon-encapsulated metals mediated the transfer of electrons from organic compounds as electron donors to persulfate molecules as electron acceptors, which led to the carbocatalytic treatment processes with substrate-specific efficiency and minimal sensitivity to the presence of background organic and inorganic constituents.

Keywords : Heterogeneous catalysis, water treatment, oxyanion, ozone, radical and non-radical oxidation

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Abstract No. : **OR-S04-0773**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Influence of Reaction Time on the Energy Storage Capabilities of Sonication Synthesized $BiVO_4$ Nanoparticles

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This study presents the synthesis of Bismuth Vanadate ($BiVO_4$) nanoparticles (NPs) using a cost-effective, single-step sonication method. The simplicity and affordability of this method make it suitable for large-scale production. The synthesis process was conducted at different reaction times (15, 30, and 60 minutes), resulting in the formation of spherical structures composed of tightly packed, cube-like morphologies. These structures were characterized using various techniques, including X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Raman spectroscopy, and electrochemical analyses. The XRD pattern revealed tetragonal crystal structures in all the prepared $BiVO_4$ samples, irrespective of the reaction time. Electrochemical properties of the $BiVO_4$ NPs were evaluated using techniques such as galvanostatic charge-discharge, cyclic voltammetry, and Electrochemical Impedance Spectroscopy (EIS) study. Notably, the $BiVO_4$ NPs synthesized over 60 minutes exhibited superior electrochemical properties, achieving a maximum specific capacitance of 869 Fg^{-1} at a current density of 1 Ag^{-1}. This research introduces a simple and efficient approach for synthesizing highly active $BiVO_4$ nanostructures, paving the way for their further exploration in energy applications

Keywords : Bismuth Vanadate; Nanoparticles; Sonication method; Cube-like morphologies; Specific capacitance.

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Abstract No. : **PO-S13-0772**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Optimizing the sheet resistance of monocrystalline Si wafers for high-efficiency crystalline silicon solar cells

Seongmin Lee[1], Yebin Ahn[1], Deokkyu Yoon[1], Inkyeong Park[1], Handon Um*[1]

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Due to accelerating global warming, the world is implementing various policies to reduce carbon emissions, and in recent years, the demand for energy other than fossil energy has ascended due to the surge in crude oil and commodity prices caused by the chaotic international situation. Renewable energy is steadily increasing its share to meet this demand, and in Korea, solar energy accounts for about 53% of total renewable energy (Korea Energy Agency, 2022). Crystalline silicon is a very commonly available element and has long been used as a material for semiconductors due to its abundance in nature, suitable bandgap of 1.12eV, non-toxicity, high stability, and mature technologies. A conventional crystalline silicon solar cell requires a p-n junction layer to separate the electron-hole pairs generated by light absorption. The p-n junction layer is formed by injecting the opposite type of dopant into the silicon substrate at an abnormal concentration of the dopant. This injection of dopants into the silicon is called the counter doping process.

When the amount of doping in the p-n junction layer becomes excessive, the concentration of carriers in the doped layer becomes higher and a lower sheet resistance is measured, which can reduce the series resistance of the solar cells. However, low sheet resistance promotes Auger recombination induced by high dopant concentration and adversely affects the energy conversion efficiency of the final produced solar cell. In this paper, we carried out the doping process using spin-on dopant, and measured the sheet resistance as a function of temperature and time during the doping step. By analyzing the efficiency of the solar cell according to the sheet resistance, we optimized doping conditions based on the sheet resistance.

Keywords : Silicon doping process

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Abstract No. : **PO-S13-0771**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Study of Metal Oxide-Silicon Hetero-junction formed by Plasma-Enhanced Atomic Layer Deposition for Dopant-free Silicon Solar Cells

Geon Hwi Kim[2], Sang Beom Hong[1], Han Don Um[*1]

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As the global movement towards achieving carbon neutrality gains momentum, there is a corresponding surge in demand for renewable energy sources. Among these, solar energy stands out, with crystalline silicon-based solar cells representing a significant proportion of renewable energy production due to their high efficiency and long-term stability. However, the conventional fabrication process for these solar cells involves doping process, necessitating high-temperature thermal treatments. This presents significant drawbacks in terms of energy consumption and processing time. In this abstract, we propose alternative fabrication method of crystalline silicon solar cells without high-temperature doping process. The focus lies on enhancing solar cell efficiency through the creation of a fixed charge within the metal oxide film, thereby inducing an inverse charge layer at the metal oxide-silicon interface. This novel approach mimics the behavior of a conventional p-n junction without the need for doping. By using plasma-enhanced atomic layer deposition (PE-ALD), a uniform Al2O3-Si junction with superior passivation effect can be achieved. Through control of process parameters such as plasma power, temperature, and pulse/purge time, the optical and electrical properties of the metal oxide film would be systematically characterized. This endeavor aims to unlock the full potential of undoped-based solar cells, thereby contributing to more efficient and sustainable energy solutions in the quest for carbon neutrality.

Keywords : dopant-free, Atomic Layer Deposition, solar cell

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Abstract No. : **PO-S15-0770**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Wrapped Core-Shell $BaTiO_3$-$Ca_2Nb_3O_{10}$ (BT-CN) dielectric ceramic for High-Temperature Multilayer Ceramic Capacitors

TaeYeong Song[1], Sangun Park[1], NaYeon Kwon[1], Do-kyun Kwon[*1]

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The development of Multilayer Ceramic Capacitors (MLCCs) with ever-thinner dielectric layers has driven the need for improved stability across a wide range of temperatures. A common strategy to achieve this involves incorporating Barium Titanate ($BaTiO_3$, BT) with other perovskite materials to create complex perovskite compounds. This study focuses on $KCa_2Nb_3O_{10}$ (KCNO), a particularly promising member of the Dion-Jacobson layered perovskite family. KCNO's layered structure allows for its conversion into two-dimensional (2D) nano-sheets via a top-down approach, including an exfoliation process. This process results in the formation of $Ca_2Nb_3O_{10}$ (CN) with a 2D nano-sheet structure. We successfully fabricated CN nano-sheets using a combination of ion exchange and exfoliation with TBAOH, achieving an impressive 92% exfoliation rate confirmed by UV-visible (UV-vis) analysis.

Furthermore, we incorporated CN nano-sheets into BT nanoparticles. This led to the formation of a fascinating core-shell structure observed by Transmission Electron Microscopy (TEM), where BT nanoparticles formed the core and CN nano-sheets wrapped around them like a protective shell.

Sintering the fabricated BT-CN composites significantly improved their temperature stability compared to conventional BT-based MLCCs. This enhancement can be attributed to the substitution of certain atoms within the BT structure by Calcium (Ca) and Niobium (Nb) atoms originating from the CN nano-sheets. This strategic substitution strengthens the BT structure, making it more resilient to temperature variations.

Finally, we explored the application of a fast firing technique to the BT-CN composites. This rapid heating process serves to further enhance temperature stability by minimizing the diffusion of Ca and Nb atoms from the CN shell towards the BT core. By restricting this movement, the core-shell structure remains intact, maximizing its effectiveness in stabilizing the MLCC material.

Keywords : Multilayer Ceramic Capacitors (MLCCs), Ca2Nb3O10 (CN), BaTiO3 (BT),Perovskites, 2D nano-sheets, Fast Firing

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Abstract No. : **PO-S13-0769**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Enhanced Catalyst Stability and Uniform Nanostructure Formation via Metal-Assisted Chemical Etching with Gold Catalyst/Metal Bilayers

Yejin Han[1], Hyein Cho[1], Han-Don Um[*1]

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Metal assisted chemical etching (MACE) is a wet etching technique using noble metals as catalysts to etch silicon surfaces selectively. Compared to conventional wet etching process showing the isotropic etch behaviors, MACE allows for anisotropic etching, offering a cost-effective fabrication of silicon nanostructures. Although MACE stands out for its simplicity and low processing costs compared to the dry etching processes, a limitation arises from the relatively poor adhesion between and silicon surfaces and the commonly used noble metal catalysts such as silver and gold. This weak adhesion can hinder the formation of uniform nanostructures by causing detachment or damage to the noble metal catalysts during the etching process, particularly when etching nanostructures with high aspect ratios. Therefore, enhancing the adhesion between the catalyst and the silicon surface to facilitate uniform reactions is crucial. To prevent catalyst deformation and promote the formation of uniform nanostructures, we introduced titanium (Ti) and chromium (Cr) as thin film layers, known for their superior adhesion to both noble metal catalysts like gold (Au) and silicon surfaces. In this abstract, we focus on stabilizing the catalyst and achieving uniform nanostructure formation through metal assisted chemical etching based on noble metal catalyst/metal bilayer systems.

Keywords : Novel-metal/metal layer, Metal assisted chemical etching, Nanostructure

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Abstract No. : **PO-S13-0768**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Characterization of Al_2O_3 Film Deposited by Thermal Atomic Layer Deposition

Sang Beom Hong[2], HanDon Um[*1]

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Global movement toward transitioning from fossil fuel energy to sustainable renewable energy sources has been gaining momentum. As a result, the global solar energy market continues to grow, with regulations in countries like South Korea mandating a certain percentage of electricity production from renewable sources or requiring green certifications, further emphasizing the importance of renewable energy.

Solar cells, however, suffer from defects such as dangling bonds within their interfaces and internal structures, leading to decreased efficiency due to induced recombination of generated charge carriers. Therefore, it is imperative to reduce interface defect density by removing dangling bonds through deposition processes of a passivation layer.

Among various deposition processes, thermal atomic layer deposition (ALD) stands out for its excellent step coverage, uniformity, and high stability. In this study, we utilized thermal ALD to deposit Al_2O_3 films on silicon substrates. We optimized deposition conditions to enhance surface passivation properties and evaluated intrinsic characteristics such as fixed charge and interface defect density of the films under different temperature conditions.

Keywords : ALD, Al2O3, Fixed charge, Dit, lifetime

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Abstract No. : **PO-S13-0767**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Superior light absorption of tapered Si micro-hole structures for high-efficiency silicon solar cells

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[1]*Kangwon National University*

The increase in fossil fuel consumption due to the continuous increase in energy demand is a major cause of worsening air pollution and climate change. There is an emerging movement to switch from fossil fuel energy to renewable energy, which is sustainable energy, to reduce carbon emissions worldwide. Solar energy, one of the renewable energy, can be efficiently generated mainly through crystalline silicon based solar cells. Crystalline silicon is one of the most abundant elements in nature and is excellent in lowering the manufacturing cost of silicon solar cells due to its mature technologies. In addition, crystalline silicon solar cells have the advantage of having long-term stability compared to other solar cells. In order to improve the efficiency of crystalline silicon solar cells, a method of increasing the absorption rate of light by forming structures such as a pyramid structure, wire structure, and hole structure on a silicon substrate has been continuously researched and reported. Among them, in the case of micro hole structure, it is difficult to increase the light absorption efficiently due to a large amount of light reflection in flat areas between the hole patterns. In this abstract, we proposes a funnel-shaped microhole structure that can absorb light effectively compared to the conventional microhole structure, increasing efficiency of solar cells.

Keywords : Microhole structure

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Abstract No. : **IN-S11-0765**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Invited**

Electrochemically driven Thermal Energy Harvesting

Sangtae Kim[*1]

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Thermogalvanic cells offer scalable low-grade waste heat recovery using tunable electrode-dependent thermopower and electrolyte-dependent thermal conductivities. However, the use of single-phase electrodes thermodynamically curb the entropy difference, limiting the thermopower enhancement. Here, we show that phase transforming electrodes achieve significantly enhanced thermopower using the melting phase transition of bulk Na_xK alloys. Under both temporal and spatial temperature gradients, the electrodes exhibit significantly increased thermopower up to 26.1 mV/K across the melting point and the generated voltages of 261 mV under 10 K temperature gradient. We also show that stabilizing the liquid metal electrode-electrolyte interface plays a critical role in evaluating the thermopower associated with the phase transition. The strategies demonstrated in this work suggest potential design guidelines towards optimizing thermogalvanic cells to specific temperature ranges.

Keywords : thermogalvanic devices, phase transition

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Abstract No. : **PO-S11-0764**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Redox Active Material Pillared Graphene based Micro-supercapacitors for Self-powered Environment Monitoring System

Vishwanathan Ravichandran[1], Swapnil Shital Nardekar[1], Jyoti Prakash Das[1], Sang Jae Kim*[1]

[1]*Jeju National University*

Miniaturized electrochemical energy storage systems are critical for the development of future electronic devices. Although on-chip micro-supercapacitors (MSC) have large power capacities and extended cycle lives, they suffer from limited energy density that is not enough to meet the energy demands. Herein, we report a strategy to solve these problems by the redox type p-phenylene diamine (PPD) into a reduced graphene oxide electrode. The aforementioned structure is achieved by a solvothermal reaction process and resulting materials (rGO@PPD) confirmed by physicochemical characterizations. Finally, the charge storage properties were investigated by symmetric rGO@PPD MSC device, which demonstrated superior device capacitance and energy density. As proof of concept, we successfully integrated the rGO@PPD MSCs with the electromagnetic anemometer. This integration enabled us to efficiently harvest regenerated wind energy and self-charge the MSC devices, which is further utilized to empower the environmental monitoring station, establishing it as a potential option for the near future.

Keywords : rGO@PPD; Solvothermal; Micro-supercapacitor; Self-powered; Sensory system

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Abstract No. : **PO-S09-0763**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Surface passivation of 2D Piezoelectric Materials via Atomic Layer Deposition of Al_2O_3 Thin Films

Sangwoo Lee[1], Joonbong Lee[1], A young Cho[1], Dae Haa Ryu[1], Hyunbin Chung[1], Taekjib Choi[*1]

[1] *Sejong University*

In the semiconductor applications, a passivation layer is a thin film that protects the material from environmental influences that can affect its properties. Our research focus is on passivation layers in semiconductor products to protect 2D piezoelectric materials from environmental influences. These layers must have high chemical resistance and low surface recombination rates in order to effectively protect the semiconductor surface. Aluminum oxide has proven to be a suitable material for these layers due to its excellent chemical resistance, etch selectivity, and density. We study the properties of alumina through parameter control of atomic layer deposition (ALD) and post-treatment methods such as rapid thermal annealing (RTA) and UV treatment.

Keywords : ALD, Aluminum oxide, Passivation, 2D piezoelectric material

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Abstract No. : **OR-S19-0762**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Properties of SnO_x thin films for EUV MOR at low temperatures

Hyunbin Chung[1], Sangwoo Lee[1], Joonbong Lee[1], A Young Cho[1], Dae Haa Ryu[1], Heeseo Yun[1], Taekjib Choi[*1]

[1]Sejong University

As the size of semiconductor devices decreases, the importance of lithography has led the semiconductor industry to introduce extreme ultraviolet (EUV, λ~ 13.5 nm) as the main next-generation lithographic technology. The metal oxide photoresist (MOR) is a promising type of non-chemically amplified resist (Non-CAR) for use in extreme ultraviolet lithographic patterning. Compared to CARs, MORs exhibit higher EUV absorptivity and shorter blur lengths. Tin-based MORs are considered for application as EUV photoresists due to its relatively high absorption cross section at 92 eV. Tin-based MORs can increase absorbance for EUV radiation and enable higher resolution patterning. In this study, amorphous SnO_x thin films were deposited by plasma-enhanced chemical vapor deposition (PECVD) using the tin isopropoxide precursor at varying temperatures. The films have been characterized as-deposited and after patterning. As deposition temperature increases, refractive index increases. Deposited below 50 ℃, SnO_x thin films show an amorphous phase, while SnO_x thin films deposited over 100 ℃ show crystalline phases. In chemical properties, as the temperature increases, the intensity of the Sn-O bonding peak increases. Tin-based MOR can enable finer patterns to be formed, but can also lead to development in lithographic technology.

Keywords : EUV, MOR, PECVD, Lithography

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Abstract No. : **KN-S04-0761**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Keynote**

Graphene-Based Biosensors for Body Temperature and Brain Activity Monitoring

Jong-Hyun Ahn[*1]

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Biosignals, such as body temperature and ECoG, provide valuable information about the overall condition of the human body and facilitate the diagnosis of various diseases. In this presentation, I will introduce two innovative devices: a wearable thermal patch with dual functionality, providing continuous body temperature monitoring and thermotherapy for effective self-care treatment, and an ECoG sensor with clinical diagnostic capabilities for monitoring abnormal brain rhythms in patients. The thermal patch is composed of a graphene-based capacitive sensor, a graphene thermal pad, and a flexible read-out board equipped with a wireless communication module. This wearable sensor continually tracks temperature variations over a broad skin area with high resolution and sensitivity. It also delivers thermotherapy through a graphene-based heater located at the device's base. Furthermore, the ECoG sensor comprises graphene electrodes and read-out circuits with a wireless communication module. This sensor is directly attached to the brain cortex, enabling continuous monitoring of ECoG signals. Animal studies have confirmed the system's effectiveness in diagnosing various diseases. This technology holds promise for the development of convenient and wearable healthcare devices.

Keywords : graphene, biosensor, wearable electronics

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Abstract No. : **IN-S15-0760**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Tailoring memristors through metallization on amorphous thin films

Hanwool Yeon[*1]

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The origin of memristive switching lies in the dynamic modulation of the conduction channel in nanometer-thick resistive mediums, and promising properties of memristors (e.g., analog switching) have been reported over 15 years. However, it should be highlighted that a single memristor, exhibiting all the promising performances simultaneously, does not exist due to a paradox in the switching dynamics. To address the performance dilemma and produce application-tailored memristive devices, material innovations for engineering the conduction channel are indispensable. In this talk, I will introduce my group's strategies to engineer the switching channel through metallization technologies, thereby addressing the dilemmas.

Keywords : Memristor, electrochemical metalliation, amorphous thin films

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Abstract No. : **PO-S15-0759**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Improvement of plating pretreatment by UV irradiation on ABS resin surface

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ABS resin possesses mechanical properties from three different substances and has excellent mechanical strength and heat resistance, making it widely used as a 3D printing material as it can be easily formed during the printing process

In convention, chemical substances were used to improve the adhesion strength of the metal thin film to the surface of ABS resin before plating. Our research group is studying surface modification by UV irradiation.

When UV light is irradiated onto the surface of ABS resin, the chemical bonds on the surface change, and the surface hydrophilicity is improved. As a result, the metal thin film adheres better to the surface of the ABS resin during plating, improving its adhesion.

We improved low-pressure mercury lamps to increase the ozone concentration, which made it possible to irradiate 185 nm and 254 nm UV rays on the surface of 3D-printed ABS samples under certain distances and temperature conditions. Therefore, it was found to be effective as a pre-treatment for electroless copper and nickel plating on ABS 3D-printed samples.

Ozone generated by UV light oxidatively decomposes the organic matter on the surface of ABS, which is expected to improve the hydrophilicity and strengthen the adhesion of the plating film.

In this study, our research group investigated UV irradiation conditions for better adhesion. In the future, we plan to examine irradiation conditions for polypropylene and as a pretreatment for surface coating.

Keywords : ABF resin, UV irradiation, Surface Modification, Electroless Plating

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Abstract No. : **OR-S06-0758**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Investigation of Austenite Grain Refinement and Precipitation Behavior of AlN in 1020 carbon steels.

Tzu Ching Tsao[1], Yu Ting Tsai[2], Jer Ren Yang*[1]

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Abnormal grain growth occurs when steels are subjected to high-temperature carburizing, and micro-alloyed precipitates are used to prevent excessive grain growth by pinning austenite grain boundary. However, as the carburizing temperature increases, pinning force may decrease, resulting in bimodal grain size structure, which consists of huge grains and surrounding fine grains. Abnormal grain growth is closely related to the size, distribution and evolution of precipitates, and in this project, the precipitation behavior of AlN in 1020 carbon steels and the effects of AlN on pinning austenite grain boundary at high temperature will be clarified.

The process of carburized cold-forged gears includes hot rolling, spheroidizing, cold working, and carburizing. The size of austenite grain during carburizing is affected by the distribution of AlN, which is strongly related to hot rolling stage, spheroidizing stage and the temperature increasing stage after cold working. In this project, we will focus on these three stages. By using dilatometer, the precipitation of AlN after hot rolling-isothermal heat treatment, hot rolling-continuous cooling, reheating treatment and austenitization will be simulated. The evolution of AlN precipitation at each stage and the pinning effect of AlN on austenite grain boundary at high temperature are expected to be clarified.

Keywords : AlN precipitate, abnormal grain growth, grain refinement

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Abstract No. : **OR-S08-0757**
Symposia : **Advanced Materials Imaging Technique**
Abstract Preference : **Oral**

Enhancing Mechanical Properties of Al-Cu-Li Alloys Through Creep Aging and Atomic-Scale Analysis of Precipitates by iDPC-STEM

HUNG-JEN LIN[1], JER-REN YANG[*1]

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My research focuses on age-hardening Al-Cu-Li alloys, investigating the evolution of nanoscale precipitates and their effects on mechanical properties by introducing dislocations before aging heat treatments. Precipitates were observed forming preferentially at heterogeneous nucleation sites such as dislocations, secondary phases, and grain boundaries during aging. I conducted a detailed analysis of how these nucleation sites affect material properties and proposed using an innovative creep aging treatment to enhance yield strength by 21 MPa without reducing ductility, benefiting subsequent material processing. Additionally, I employed TEM's iDPC imaging technique to observe Li-containing precipitates at the atomic level, accurately determining their crystal structures. This technique also captured atomic-level interactions between precipitates and dislocations, providing deeper insights into the material's micro-level strengthening mechanisms.

Keywords : iDPC STEM

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Abstract No. : **PO-S08-0756**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Air-Free Electron Microscopy Analysis of All-Solid-State Lithium Batteries

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All-solid-state lithium batteries (ASSBs) has brought a large advancement in energy storage technologies, offering significant benefits over traditional lithium-ion batteries with liquid electrolyte systems. These batteries leverage solid electrolytes that are inherently safer and more stable, eliminating risks associated with flammable liquid components. Additionally, ASSBs facilitate higher energy density and enhanced cycle life, which are critical factors for applications in electric vehicles (EVs) and energy storage systems (ESSs). However, ASSBs still suffer from several problems such as low ionic conductivity, interfacial instability and inferior mechanical property.

Electron microscopy (EM) offers many advantages for analyzing all-solid-state lithium batteries, providing essential insights for their development and optimization. This technique allows visualization of the microstructure and chemical composition of solid electrolytes and electrode interfaces at nanometer resolution, revealing characteristics which are critical for understanding ion transport mechanisms, interfacial phenomena, and degradation process. Ultimately, EM will provide with detailed information needed to tailor material compositions and structures for improved battery stability and efficiency.

While EM can provide valuable information about ASSB materials, the primary challenge is protecting ASSB materials safe from air and moisture. Conventional EM analysis is typically performed in open air, as most of conventional materials are less affected by air and moisture. However, as ASSB materials are extremely sensitive, air-free specimen preparation and air-free EM observation is necessary. Herein, we demonstrate EM analysis of solid electrolyte and cathode/solid electrolyte interface using air-free technique, which effectively preserving the original condition of the specimen.

Keywords : electron microscopy, all-solid-state lithium battery, solid electrolyte, interface

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Abstract No. : **OR-S09-0755**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Oral**

Impacts of heat treatment time on the electrical characteristics of phase change memory based $Ge_2Sb_2Te_5$(GST)

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With the emergence of the memory-centric computing systems like neuromorphic (brain-inspired) computing, the necessity of storage-class memory (SCM) has been on the rise since it can fill the performance gap between DRAM and 3-D NAND flash. Based on these demands, cross-point (X-point) memory has emerged, since it has not only an ultimate areal density of 4F 2 and 3-D stackability for the cost effectiveness but also a low read latency.[1] In addition, X-point memory is based on phase change memory (PCM) and ovonic threshold switch (OTS), which are made using chalcogenide materials. In general, Ge 2 Sb 2 Te 5 (GST) is mainly used material, the superlattice and doping based on the composition GST are a potential candidate for X-point memory fabrication. [2] The problems are that PCM unit cells based on GST have issues that are low reliability and are vulnerable to heat, because current values for SET and RESET pulse are changing in every operating sequence. These could be resolved by annealing PCM devices. However, despite the progress of research on thin film heat treatment consisted of phase change materials, the relationship to PCM device characteristics according to annealing condition is not clear yet. In this study, PCM devices-based on GST were annealed with respect to different treatment time in N 2 flow. The memory characteristics were evaluated with conventional PCM cell. Current-voltage (I-V) curves of devices according to each condition were observed, voltage of resistance change about was appeared around 1 V. Resistance-current (R-I) curves of devices according to each condition were observed. Furthermore, the physical properties of the GST phase change material according to the heat treatment time were investigated through X-ray photoelectron spectroscopy (XPS) and Transmission electron microscopy (TEM) analysis. Our results improved the reliability characteristics of PCM measurement and confirmed its cause through analysis.

Keywords : Phase change

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Abstract No. : **IN-S18-0754**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Invited**

Soft and flexible bioelectronics for brain-machine interfaces

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Large-scale brain mapping through brain-machine interfaces is important for deciphering neuron dynamics, addressing neurological disorders, and developing advanced neuroprosthetics. Ultimately, brain mapping aims to simultaneously record activities from millions, if not billions, of neurons with single-cell resolution, millisecond temporal resolution and cell-type specificity, across three-dimensional (3D) brain tissues over the course of brain development, learning, and aging. In this talk, I will first introduce flexible and soft bioelectronics with tissue-like properties that can track electrical activity from the same neurons in the brain of behaving animals over their entire adult life. Specifically, I will discuss the fundamental limitations of the electrochemical stability of soft electronic materials in bioelectronics and present our strategies to overcome these limitations, enabling a scalable platform for large-scale, long-term, stable brain mapping. Then, I will discuss the creation of "cyborg organisms", achieved by embedding stretchable mesh-like electrode arrays in 2D sheets of stem/progenitor cells and reconfiguring them through 2D-to-3D organogenesis, which enables continuous 3D electrophysiology during the development of human stem cell-derived brain organoids and animal embryonic brains. Next, I will highlight our current efforts that merge 3D single-cell spatial transcriptomics, machine learning, and electrical recording, enabling cell-type-specific brain activity mapping. In conclusion, I will envision the fusion of soft and flexible electronics, spatial transcriptomics, and AI for a comprehensive brain cell functional atlas to enhance future brain-machine interface applications.

Keywords : Flexible electronics, brain-machine interfaces

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Abstract No. : **OR-S11-0753**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Efficient Thermal Management Strategy via Oriented Heat Transfer by Passive Cooling Material with Thermoelectric Generator

Da Seul Kim[1], Jeong Min Baik[*1]

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With the rapid advancement of science and technology, the integration of internal circuits in electronic products has led to overlapping hot spots, decreasing their reliability and stability. Research on solar heat absorption, conversion, and transfer systems is essential to improve the low energy conversion efficiency of heat sources.

Here, a metal-based photothermal converter is manufactured to contribute to the improvement of heat absorption characteristics, and a heat transfer layer is combined with the lower part of the light absorber to form a photothermal absorption, conversion, and heat transfer layer structure, which plays a role in the high-efficiency transfer of captured energy. A polymer-nanoparticle composite thermal management material is attached to the low-temperature part to form an overall heat flow system, and the temperature difference generated by this is managed to increase the stability of the system.

W-MgF_2 and PMMA-C were utilized as selective absorber and thermal conductive layer, respectively. For thermal management, a composite material comprising a phase change material paraffin, thermal fillers (Al_2O_3, SiO_2), and ferroelectric particles was prepared. These fillers exhibit selective absorption and emission of infrared radiation, enhancing cooling efficiency. The inclusion of ferroelectric nanoparticles promotes the thermoelectric effect, generating an electric current as charge carriers move from hot to cool zone due to material polarization.

Keywords : Passive Cooling, Thermoelectric Generator

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Abstract No. : **OR-S04-0752**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Integrating Processing and Material Technologies for Enhanced Security: PUF and Anticounterfeiting Tag

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The integration of Processing and Material technologies presents a significant advancement in bolstering security measures beyond conventional electronic systems both Physically Unclonable Function (PUF) and anticounterfeiting tag. This presentation delves into novel approaches focusing on materials and methods for extracting keys, rather than conventional electronics aspects.(from the definition to comparing the conventional electrical based methods.) PUF leverages unique material properties or fabrication variations to generate device-specific keys, ensuring secure authentication and data protection. Similarly, anticounterfeiting tags utilize innovative materials and manufacturing techniques to authenticate products and combat counterfeit goods. Exploring advancements in materials and key extraction methods promises to revolutionize security protocols, enabling robust protection for a wide range of electronic devices and systems.

Keywords : PUF, Anticounterfeiting tag

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Abstract No. : **PO-S07-0751**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Fabrication of over 6 % efficient CZTS absorber layer using sulfurization of sequentially electroplated stacked Cu/Zn/Sn layers

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A quaternary indium- and gallium-free kesterite (KS)-based compound, copper zinc tin sulfide (Cu_2ZnSnS_4, CZTS), has received significant attention for its potential applications in low cost and sustainable solar cells. In the present study, kesterite Cu_2ZnSnS_4 thin films have been prepared by sulfurizing sequential electroplated of Cu/Zn/Sn layers. Careful studies were focused on identifying the role of preparative parameters such as absorber composition, soft annealing temperature and sulfurization temperature. The optimized CZTS absorber layer has shown Cu-poor Zn-rich composition with band gap energy 1.45 eV. The best solar cell device fabricated using an electrodeposited CZTS absorber exhibits a power conversion efficiency of 6.1 %, with V_{oc}- 641mV and J_{sc}- 18.5 mA/cm^2.

Keywords : CZTS, Kesterites, electrodeposition, thin film solar cells

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Abstract No. : **PO-S14-0750**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Electrochemical synthesis of Nickel–Cobalt bimetallic hydroxide for efficient urea oxidation

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The urea oxidation process (UOR) serves dual purpose of efficient hydrogen (H_2) production and mitigation of urea-rich wastewater. Nickel based electrocatalyst are widely explored for urea oxidation. Furthermore introducing Co in Ni based electrocatalyst enhances electrocatalytic activity. In this study, we report electrochemical synthesis of amorphous Nickel–Cobalt bimetallic hydroxide (NiCoBMHs) electrocatalyst for urea electrolysis. The synergism between Ni and Co greatly reduces the overpotential of urea oxidation and improves the reaction rate. At optimal Co precursor concentration in NiCo BMHs exhibits the lower overpotential 1.32 V vs. RHE at 10 $mAcm^{-2}$ and exhibits maximum current density of 208 $mAcm^{-2}$ at 1.8 V vs. RHE, suggesting the excellent electrocatalytic activity of NiCoBMHs.

Keywords : Nickel–Cobalt bimetallic hydroxide (NiCoBMHs), Electrodeposition, UOR, Electrocatalyst, Overpotential.

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Abstract No. : **PO-S09-0749**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Impact of Silver Incorporation on CZTSe Absorber for Flexible Monolithic CZTSe/Perovskite Tandem Solar Cell

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Kesterite-based $Cu_2ZnSn(S_xSe_{1-x})_4$ (CZTSSe) solar cells have been considered as one of promising photovoltaic materials because of non-toxicity and low-cost availability of the material system. Their theoretical efficiency limit has been calculated to be 32.4%, which is much lower than the record efficiency of the CZTSSe PV devices. Among various strategies to improve the performance of CZTSSe solar cells, there is a plausible way to maximize kesterite-based device performances such as a tandem structure which is effectively utilized a full-spectrum of light by stacking a narrow band-gap CZTSe bottom cell with a wide bandgap perovskite top cell. Currently, one of the challenges to realize a high-efficiency monolithic kesterite-based tandem solar cell is to make robust heterointerface and conformal integration between top and bottom cells. In this regard, it is critical to form a smooth surface of CZTSe because its roughness determines the performance of tandem solar cells.

In this study, we demonstrate a flexible monolithic CZTSe/perovskite tandem solar cell by growing high-quality CZTSe film on a flexible polyimide substrate at low temperature. To form high-quality CZTSe film with smooth surface, the effects of Ag doping was explored on microstructure of CZTSe film. Basically, a nominal Ag layer was prepared by the thermal evaporation method on the Mo film before CZTSe film deposition. Indeed, the microstructure of the CZTSe films was significantly enhanced after Ag doping and all the photovoltaic (PV) parameters were improved compared to the control device. Through process optimization, a record efficiency of 7.3% for a flexible CZTSe solar cell on PI was achieved. Moreover, a monolithic CZTSe/perovskite tandem solar cell has been successfully demonstrated with the perovskite top cell with a bandgap of 1.63 eV, prepared using a solution process. The CZTSe/perovskite tandem PV devices exhibited the power conversion efficiency of 16.1% for glass and 11.35% for flexible substrate. The obtained results suggest substantial potential to be utilized for chalcogenide/perovskite tandem solar cells.

Keywords : Cu2ZnSnSe4, Flexible, Polymer, Low growth temperature, Ag doping, defects, Monolithic, Tandem

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Abstract No. : **PO-S05-0748**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Open porous, highly electric conductive, edge-rich graphene nanoribbon hydrogels via interfacial self-assembly for high performance electrochemical devices

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Customized assembly of nanomaterials into three-dimensional macroscopic objects may offer versatile functional nanostructures. Gelation is a common route to this end, but unstable assembly of typical one-dimensional nanomaterials arising from their non-flat geometry of weakly interacting building blocks has remained a significant challenge. We report versatile reliable open nanoporous graphene nanoribbon hydrogel formation via straightforward interfacial layer-by-layer self-assembly. Atomically flat surface of graphene nanoribbon enables a stable gelation, overcoming the geometrical penalty of one-dimensional building blocks. The resultant hydrogel readily provides compact open porous web-like gel framework along with a wide range of controllability in the engineering of surface functionality, composite preparation and three-dimensional customized morphology formation. Large surface area and open porosity of the synergistic hydrogel structure simultaneously attain fast responsivity and high sensitivity in enzymatic biosensor application as well as fast rate capability and high capacitance in supercapacitor application.

Keywords : graphene nanoribbon hydrogels

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Abstract No. : **PO-S02-0747**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Enhanced Red-Emitting InGaN Quantum Particles with InAlN Buffer-layer on GaN Nanowires

Yong-Ho Kim[2], Dae-Young Um[1], Jeong-Kyun Oh[1], Sung-Un Kim[1], Vignesh Veeramuthu[1], Jae-Hong Ju[1], Cheul-Ro Lee[1], Yong-Ho Ra[*2]

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High indium-composition InGaN quantum layers pose significant challenges in III-nitride-based semiconductor architectures due to their high defect concentrations and inefficient strain-induced polarization fields. In this study, we introduce a novel approach utilizing non-polar InAlN/InGaN/InAlN/GaN multi-layers to effectively incorporate high quantities of indium into the InGaN quantum particle (QP) structure via MOCVD system. Our innovative method not only enhances crystalline quality through non-polar quantum dots but also enables high indium compositions in the InGaN QP structures on GaN nanowires. Additionally, we address strain induced by lattice mismatch between InGaN and GaN by introducing an InAlN intermediate layer. Adding the InAlN intermediate layer offers various advantages. Firstly, it enables facile strain engineering within InGaN-based structures by adjusting the strain state of InAlN through diverse indium compositions. Secondly, surface conditions can be controlled by modulating the adatoms of In and Al. Moreover, the epitaxy of InAlN at low temperatures enables the suppression of indium diffusion and facilitates high-concentration growth. Our approach demonstrated a 2.5 times higher peak photoluminescence intensity for InGaN QPs with the InAlN intermediate layer compared to conventional InGaN MQWs. Detailed TEM analysis validated the well-formedness of InGaN QPs and the InAlN intermediate layers on the GaN nanowires. The proposed new epitaxial growth offers a novel solution to address the efficiency of red wavelength light-emitting devices.

Keywords : InGaN QPs, MOCVD, GaN, 1D nanostructure, Red Light emitting micro-LED

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Abstract No. : **PO-S11-0746**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Converting Polymer trash to treasure: Transforming Silicone rubber for scavenging biomechanical and blue energy

Vigneshwaran Mohan[1], Parthiban Pazhamalai[1], Vishal Natraj[1], Sang-Jae Kim[*1]

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Droplet based triboelectric nanogenerators (TENG) convert mechanical energy from falling droplets into electricity based on the coupling effect of triboelectrification and electrostatic induction. Herein, a stretchable hydrophobic TENG was fabricated using a waterproof shoe cover made of silicone rubber (SR), and its energy harvesting properties were evaluated. The SR-TENG was tested with different liquids, such as DI water, rainwater, and seawater, collected from the environment, and the output voltage was evaluated. The results demonstrated that the fabricated SR-TENG exhibited superior performance with seawater dropped at an inclined angle of 60°, which is higher compared to other counterparts. With such outstanding performance and environmental adaptability, the SR-TENG has potential applications in water-based energy harvesting for wearable and portable IOT applications.

Keywords : Triboelectric nanogenerator; Droplet energy harvesting; Human movement monitor; Hydrophobicity; Silicone rubber

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Abstract No. : **OR-S14-0745**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

$Ti_3C_2T_x/SnS_2$ nano-heterostructures synthesized in situ to improve photocatalytic H_2 production through water splitting

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Here, we show how to synthesize $Ti_3C_2T_x/SnS_2$ nano-heterostructures in-situ while adjusting the Ti:Sn ratios. These nanostructures are then employed as photocatalysts to produce hydrogen by water splitting. The creation of nano-heterostructures was verified by XRD analysis, which reveals the presence of diffraction peaks in the generated nanostructures that correspond to $Ti_3C_2T_x$ and SnS_2. XPS, FE-SEM, and FETEM analyses confirm that $Ti_3C_2T_x/SnS_2$ nano-heterostructures are forming. Two-dimensional hexagonal SnS_2 nanosheets and stacked MXene structures are shown by FE-SEM. HR-TEM and SAED analysis were used to confirm the nano-heterostructures of $Ti_3C_2T_x/SnS_2$ and the presence of SnS_2 in addition to $Ti_3C_2T_x$ nanosheets. The generated nano-heterostructures absorption profile is observable and has a band gap between 2.17 and 2.34 eV. With the exception of virgin $Ti_3C_2T_x$ all prepared compositions exhibit band edge emission in the 535-550 nm range, according to the photoluminescence spectra. The breakdown of the methylene blue dye and the creation of H_2 by water splitting were used to gauge the photocatalytic performance of the produced nano-heterostructures. With an exceptional apparent quantum yield (2.2%) and effective MB dye degradation, the TS-5wt% produced composition showed the highest H_2 evolution, measuring around 1178μmol/0.1g, significantly greater than the other compositions. The investigation shows that the TS-5wt% performs better because photogenerated charge carriers have a longer decay time.

Keywords : MXene, Semiconductor, Photocatalysis, Water splitting

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Abstract No. : **PO-S01-0744**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Construction of $FeSe_2$/Carbon Nanocomposite Derived from Fe-Carboxymethylcellulose Biomass as a High-Performance Anode for Li-ion Storage

Shufeng Bo[1], Saad Hafeez Mirza[1], Jung Woo Lee[*1]

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The utilization of biomass for the production of valuable energy materials holds profound importance; however, it remains hindered by significant challenges. Herein, $FeSe_2$/carbon nanocomposites, serving as a sustainable and efficient anode, were successfully constructed by encapsulating $FeSe_2$ nanoparticles within carboxymethylcellulose (CMC)-derived porous carbon, forming uniformly dispersed nanostructures. Benefiting from the synergistic interplay of $FeSe_2$ nanoparticles and porous carbon, the prepared $FeSe_2$/carbon nanocomposite demonstrated a relatively high specific capacity and comparatively long cycling stability with high-capacity retention in half cells. The $FeSe_2$ contributed to augmented active sites and enhanced Li-ion storage capacity, complemented by the porous carbon skeleton, which provided excellent electrical conductivity, superior reaction kinetics, and the capacity to accommodate volume changes during lithiation/delithiation processes. This research offers a sustainable and environmentally friendly approach for the development of high-performance lithium-ion batteries with promising application prospects.

Keywords : FeSe2, Fe-Carboxymethylcellulose, Nanocomposite, Li-ion battery

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Abstract No. : **PO-S01-0743**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Regenerated Graphite-Silicon Composite as efficient anode material for Lithium-ion Batteries

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The exponential surge in electric vehicle demand necessitates the development of high-energy-density lithium-ion batteries. Silicon-based materials have emerged as promising anode materials due to their high theoretical capacity and lower working potential than conventional graphitic anodes. However, the significant volume expansion (>300%) of silicon during lithium dealloying poses a major challenge, potentially leading to fracture, pulverization, electrical isolation, and structural instability. Conversely, the co-utilization of silicon and graphite composites provides a viable solution. Incorporating silicon into the graphite matrix can mitigate volume changes, as the major reactive sites for solid electrolyte interphase (SEI) formation are provided by graphite particles. Thus, this co-utilization overcomes the drawbacks of both anode materials. In this study, the graphite matrix was sourced from spent graphite to address environmental hazards and leverage resource value. The uniform blending of silicon and graphite was achieved by homogeneously dispersing silicon onto the surface of the graphite matrix using a facile ball milling method. Physicochemical and electrochemical analyses were conducted to evaluate the synthesized material's performance. The Si/Gr composite demonstrated stable cycle life with 80% capacity retention after cycling. Consequently, our work not only advances the utilization of recycled graphite but also mitigates volume changes in silicon materials, resulting in a high-energy-density, low-cost anode material suitable for commercialization.

Keywords : Spent battery, Recycling, Silicon anode, volume expansion

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Abstract No. : **OR-S14-0742**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Enhanced Photocatalytic Hydrogen Generation Using Coupled Semiconductor Nanostructures

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Heterogeneous photocatalysis using Nanostructured semiconductors have been actively studied for various environmental and energy related applications. In 1972, Fujishima and Honda for the first time reported the generation of H_2 from water using TiO_2 as a photo-anode in presence of ultra-violet light [1]. Since then, enormous amount of efforts were taken to generate the H_2 via photocatalytic water splitting. The photocatalytic activity of the catalyst mainly depends upon the band gap and band positions of the materials. Till today various semiconductor oxides as well sulfides have been exploited viz. TiO_2, ZnO, SnO_2, WO_3, Fe_2O_3, CdS, ZnS, SnS_2 and so on, as photocatalyst for energy as well as environment related applications [2]. In order to enhance the activity of catalyst various modifications have been tried, like doping of cations and anions in the existing catalyst, loading of noble metals to minimize the generated electron hole recombination's etc. Furthermore, the change in synthesis methods showed change in the photocatalytic activity as function of surface area and crystallinity.

Recently, coupled semiconductor systems of oxide/oxide as well as sulphide/oxide, g-C_3N_4/metal oxide and Mxene /Oxide/Sulfide type also reported to have enhanced photoactivity [3]. This enhanced photoactivity is due to two important reasons. First, in the coupled semiconductor systems contains different energy levels, wide band-gap semiconductors can utilize visible light by coupling narrow band-gap semiconductors. Second, charge injection from one semiconductor into another can lead to efficient and longer charge separation by reducing the electron–hole pair recombination's. In the present work we have prepared many coupled catalytic systems and effectively utilized for photocatalytic H_2 generation.

Keywords : Water splitting, Photocatalysis, Hydrogen generation, coupled semiconductors

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Abstract No. : **PO-S11-0741**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Piezoelectric Mediated Self-Charging Electrochemical Supercapacitor using Binder-Free MnO_2 Nanosheets

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Integrated energy systems are growing rapidly in the modern era due to their intriguing characteristics of combining energy storage and harvesting into a single device for real-world IOT applications. In this work, we fabricated an integrated system comprising energy harvesting and storage into a single device and explored its self-charging capability. Electrochemically grown MnO_2 on carbon cloth is used as the flexible electrode, and an ionogelled electrospun PVDF nanofibrous mat as a piezoelectric separator for the piezoelectric-driven self-charging supercapacitor (PSCS). The fabricated MnO_2/CC PSCS shows enhanced self-charging properties compared to those of the other reported PSCS in the literature. Overall, the findings suggest that the binder-free electrode will be significant as an energy storage electrode compared to conventional electrodes due to the direct growth, which could result in a higher charging voltage compared to the current state of the art in elf-charging supercapacitors.

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Keywords : Self-charging supercapacitor; Binder-free electrodes; Electrospinning; piezoelectrochemical phenomenon.

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Abstract No. : **PO-S14-0740**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Nickel Ferrite Nanostructures: Bi-Functional electrocatalyst for Overall Water Splitting

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Electrochemical water splitting is an active area of research for the production of green hydrogen fuel. In this work, we demonstrated the bifunctional properties of nickel ferrite (NFO) nanostructures prepared via the solid-state method. The physico-chemical characterization such as X-ray diffraction, Fourier-transform infrared spectroscopy, laser Raman spectroscopy, field-emission scanning electron microscopic analyses confirms the formation of cubic spinel phase NFO nanostructures. The electrochemical characterization such as linear sweep voltammetry, chrono-potentiometric and multi-current analysis were performed for the NFO electrode to evaluate the hydrogen and oxygen evolution reaction. A lab scale water electrolyser has been fabricated with the NFO electrode and evaluated the device property for the efficient hydrogen and oxygen production. Overall, the results suggest that the development of the bi-functional electrocatalyst for the electrochemical water splitting will pay the way for low cost electrocatalyst for next generation hydrogen fuel generation.

Keywords : Nickel Ferrite; hydrogen evolution reaction; oxygen evolution reaction; electrochemical water splitting.

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Abstract No. : **PO-S03-0739**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Development of hybrid optical coating with multifunction of UV-VIS absorption, NIR transmission, mechanical durability and easy cleanability for automotive LiDAR window (policarbonate window)

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LiDAR (Light Detection and Ranging) is thought to be one of the necessary sensors for automatic driving systems and advanced driver assistance systems. Recently, the LiDAR of the automotive vehicle is installed in the grille or near the headlights. These installed positions are very weak for a variety of pollutions. One of the measures to keep the LiDAR window surface clean is the use of anti-fingerprint coating. In this study, the hybrid optical coating for automotive LiDAR window (PC window) which have the multifunction of UV-VIS absorption, NIR transmission, mechanical durability and easy cleanability was developed. The surface hardness of the whole front coating and performance of anti-fingerprint coating were measured. The several reliability tests were performed. The coated window passed all tests.

Acknowledgement
This research was supported by the development program of regional flagship industries of MSS(Ministry of SMEs and Startups)/TIPA(Korea Technology and information Promotion Agency for SMEs) (S3088701), the Materials and Components Technology Development Program of MOTIE/KEIT, 20010150 (Oxide-based visible-MW infrared transmitted optical glass material for dual-band optics) and the Industrial Infrastructure Program for Smart Specialization of MOTIE/KIAT, P0017725 (Project of Industry supporting optical materials for camera lenses).

Keywords : automotive LiDAR window, UV-VIS absorption, anti-fingerprint coating, NIR transmission, mechanical hardness, easy cleanability, contact angle of water

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Abstract No. : **PO-S09-0738**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Characterization of TiO2 Channel-Based Redox-Thin Film Transistor Using AlOx/Al2O3 Dual Layer as Gate Oxide

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Next-generation resistive switching memories, like NAND Flash memory, are gaining prominence. These memories exhibit a simple metal-insulator-metal structure and excellent operational characteristics. However, long-term stability and reliability remain challenging aspects. To address these issues, we report three-terminal ReTFTs with precise control over the redox reactions in the metal oxide channel by modulating the electric field via gate voltage. Our ultimate goal is to develop low-power and non-volatile neuromorphic devices with multi-level logic operations.

In this study, we employed TiO_2 as the channel material for ReTFTs. We induced resistance changes through redox reactions in TiO_x by ion control. Initially, we deposited Ti thin films using RF magnetron sputtering. Subsequently, we performed rapid thermal processing at 250°C in an oxygen atmosphere. Notably, we formed the oxide layer horizontally by covering the sample with a Si substrate. The channel thickness was characterized using atomic force microscopy, while X-ray photoelectron spectroscopy and X-ray diffraction analyses revealed the chemical composition and structure. The results confirmed the presence of various Ti compositions in an amorphous state due to non-uniform oxygen injection, allowing for ion movement. For the electrodes, we deposited Cr/Au using E-beam evaporator, and the gate dielectric consisted of Al_2O_3 deposited via RF sputtering. Additionally, we introduced an AlO_x buffer layer to enhance redox reactions in the channel. To verify TFT operation based on redox reactions, we applied electrical pulses up to +30V to the gate. Consequently, we achieved an on/off ratio of 10^3 and independent retention performance, demonstrating the non-volatile memory characteristics.

Our research highlights the feasibility of implementing high-speed, low-power devices using three-terminal ReTFTs based on redox channels. Furthermore, combining multi-terminal ReTFTs enables logic-in-processing operations such as AND, OR, and NOT. This finding opens a new venue for non-Si nonvolatile neuromorphic TFTs and logic devices chips.

Keywords : Three-Terminal ReTFTs, Resistive Switching Memories, Neuromorphic Devices

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Abstract No. : **IN-S05-0737**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Invited**

Synergistic Enhancement of Reversible Capacity and Cycling Stability in MoS_2/FeS_2 Heterostructure Anodes for Lithium/Sodium-Ion Batteries

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In the quest to improve lithium/sodium-ion batteries, the study introduces a hydrothermally synthesized MoS_2/FeS_2 composite. This approach capitalizes on the strengths of both MoS_2 and FeS_2 materials. MoS_2, known for its layered structure, is adept at hosting lithium and sodium ions but struggles with long-term structural integrity during battery use. Conversely, FeS_2 boasts a high theoretical specific capacity and better conductivity but suffers from stability issues upon repeated cycling due to substantial volume changes. In this study, we aimed to mitigate these issues by forming a composite. The MoS_2/FeS_2 composite material was designed to deliver a large surface area for ion exchange while also preserving electrical conductivity. This novel structure enhances ion diffusion rates and adds robustness to the anode during the charge and discharge cycles. The study suggests that the composite's ability to conduct electricity was improved by FeS_2, and its structural stability was enhanced by MoS_2. Optimizing synthesis conditions yielded the MoS_2/FeS_2 composite which exhibited a high reversible capacity, significantly outperforming the separate materials. The composite maintained a high capacity of 1356 mAh g^{-1} after 100 cycles at a lower current density (0.2C), and it showed resilience at higher loads with a capacity of 714 mAh g^{-1} at 1C. The MoS_2/FeS_2 composite combines a significant capacity with robust cycling stability, making it a promising anode candidate for next-generation battery technologies.

Keywords : 2D Heterostructure

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Abstract No. : **PO-S11-0736**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Advancements in Soft Robotics: Highly Responsive Strain Sensor for Wearable Motion Monitoring in Healthcare

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The progress in soft robotics has spurred increasing interest across diverse domains utilizing wearable electronics in the field of flexible and stretchable strain sensors. These sensors are designed to detect and monitor human body motion, prompting the need for highly durable and responsive soft sensors. Herein, a mixture of carbon black integrated into a silicone rubber matrix was deposited onto a stretchable substrate using a 3D printer. Notably, through precise manipulation of the Poisson's ratio, an auxetic-structured sensor was manufactured to establish a linear correlation between the applied stress and the resultant resistance variation during strain occurrences. This strain sensor exhibits remarkable attributes, encompassing elevated elasticity, exceptional sensitivity (as indicated by a gauge factor of 43.95 at 3% strain), and outstanding stability (as evidenced by nearly unvarying resistance alterations at 100% strain and across 1000 cycles). Moreover, by introducing micro-cracks into the conductive path, a notable outcome emerged: rapid resistance fluctuations at specific strain thresholds. This micro-cracked sensor was attached onto the human body – specifically the wrist and elbow regions – and subsequent bending of these areas up to angles of 45 and 110 degrees, respectively. It was observed that the sensor's resistance underwent a swift transformation when subjected to strains surpassing distinct thresholds. Consequently, the strain sensor holds substantial promise for effectively monitoring diverse human movements, offering potential applications within the realm of healthcare.

Keywords : Resistive strain sensors, solution mixing, DIW, auxetic structures

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Abstract No. : **PO-S03-0735**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Amplifying Photodetection of Hybrid Graphene/GaN Nanorods with AgAu Nanoplasmonic Integration

Shuo Han[1], Shuo Han[1], Jeong-Kyun Oh[1], Dae-Young Um[1], Sung-Un Kim[1], Bagavath Chandran[1], Sang-Wook Lee[1], Jin-Seo Park[1], Cheul-Ro Lee[1], Yong-Ho Ra[*1]

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The potential of graphene-based UV photodetectors to improve GaN UV photodetectors' performance has been thoroughly investigated. Graphene-based UV photodetectors are renowned for their high carrier mobility and broad spectral absorption. But graphene's intrinsic drawbacks-like its limited carrier lifetimes and low optical absorption rates-present significant challenges. In order to address these problems, we have developed a hybrid structure that integrates AgAu nanoparticles with graphene/GaN nanorods (NRs), which not only gets over graphene's drawbacks but also significantly improves photodetection capabilities. AgAu nanoparticles' localized surface plasmon resonance (LSPR) effect is responsible for the photodetector's improved performance. Through the collective oscillation of surface electrons on the metal nanoparticles, stimulated by input photons, this phenomenon plays a vital role in increasing light absorption. AgAu nanoparticles' plasmonic enhancement combined with graphene's high mobility results in a photodetector that is more responsive and efficient. This hybrid structure appears to be an intriguing contender for the development of faster and more sensitive ultraviolet photodetectors.

Keywords : GaN, Nanowire, Graphene Oxide, UV photodetector, AgAu nanoparticles

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Abstract No. : **PO-S10-0734**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Photocapacitive Quantum Dot based Flexible Biointerface for Stimulation of Neurons

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The light assisted modulation of neural activity is an emerging and promising field that holds significant potential for exploring neural circuits and advancing neural therapeutics. The photocapaciti ve c olloidal quantum dots stand out among the wide variety of accessible nanomaterials due to their particular optoelectronic characteristics, including sensitive tuning of electron and hole energy levels through the quantum confinement effect, precise con trol of carrier localization via band alignment, and the ability to engineer their surface using shell growth , ligand engineering and photo sensitiveness make them
excellent candidates for neural interfaces. Although colloidal quantum dots have already found applications in solar energy harvesting and lighting, their true potential in optoelectronic neural interfaces has remained largely untapped until the recent rise of bioelectronic medicine. The convergence of these fields has spurred attention toward s harnessing the exceptional nanoscale properties of colloidal quantum dots for neuromodulation. In this study , we delve into the fundamentals of quantum dot based optoelectronic biointerfaces. We explore the mechanisms of neuromodulation, starting from th e quantum dot level, extending to electrode electrolyte interactions, and ultimately reaching the stimulation of neurons along their physiological pathways. By shedding light on the unique advantages of colloidal quantum dots, we will highlight their capability to revolutionize nanodevices for optoelectronic stimulation of neural tissue. Our study concludes by proposing innovative strategies and discussing potential perspectives to fully exploit the extraordinary potential of colloidal quantum dots in advancing the field of optoelectronic neural therapeutics.

Keywords : Photosensitive, Neural stimulation

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Abstract No. : **PO-S02-0733**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Multi-Color Emitting InGaN Nanorod Structures via One-Step Epitaxial Growth

Min-Seok Lee[1], Sung-Un Kim[1], Dae-Young Um[1], Jeong-Kyun Oh[1], Bagavath Chandran[1], Se-Bee Shin[1], Cheul-Ro Lee[1], Yong-Ho Ra[*1]

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III-Nitride semiconductors are emerging workhorse in the field of next-generation displays for their potential to cover the entire visible light spectrum. The main issue is lattice mismatch resulting from increased indium concentration in the InGaN quantum wells(QWs). Low-dimensional (1D) nanostructures such as nanorods, nanodisks, nano-pyramids and nanowires can have to alleviate this to overcome challenges associated with heightened internal electric fields and diminished crystal quality in InGaN QWs due to high concentrations of indium. To control the dimensions of LEDs, the selective area growth (SAG) method was employed, allowing for the fabrication of LED structures with a nanopyramid-on-nanorod configuration distinct from conventional structures which were fabricated via metal organic chemical vapor deposition (MOCVD). Growth of InGaN QWs on these islands helps alleviate challenges such as the quantum confined Stark effect (QCSE) encountered during growth on the c-plane. This is due to the fact that QWs grow on the r-plane owing to the presence of islands. To assess the structural and optical characteristics of these nanostructure LEDs, field emission scanning electron microscopy (FE-SEM) was utilized to confirm the successful growth of the intended structure and to examine surface characteristics. Secondly, X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) were adopted to analyze the crystallinity and crystal structure of the grown nanorods. And micro-photoluminescence (PL) was employed to accurately ascertain the wavelengths of emitted light, confirming a variety of wavelengths ranging from 467nm, 496nm, 511nm, 525nm which corresponding blue and green emission. The promise of simultaneous multi-color growth is confirmed from micro-PL measurements indicates that LED structures emitting both blue and green wavelengths were successfully cultivated on the fabricated samples in a single step.

Keywords : Light Emission Diode, MOCVD, InGaN, Nanostructure, multi-color, Micro-LED

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Abstract No. : **OR-S12-0732**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Hydrophobic silica-polyurethane coating on carbon fiber reinforced epoxy composite for aerospace application of anti-icing and deicing

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The development of superhydrophobic surfaces has led to remarkable water-repellent properties. Water exhibits intriguing behaviors on such surfaces, forming nearly spherical droplets, defying gravity, and easily rolling off, carrying away contaminants. Superhydrophobic silica materials have garnered significant interest due to their applications, from self-cleaning surfaces to oil-water separation, mimicking natural phenomena. It has been studied the possibility of anti-icing and deicing due to small surface energy to reduce strong adhesion of water droplet to the surface reducing the formation of icing and making easy to remove ice formed on the surface. Overview of recent research about superhydrophobic coating in the application of anti-icing and deicing in aerospace application and it will be discussed how the variables of silica, surface modification, and coating process affects on the surface wettability and ice formation time through freeze test

Keywords : superhydrophobic, silica, polyurethane, C-FRP, anti-icing

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Abstract No. : **PO-S09-0731**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Fabrication of PEALD-based Ga_2O_3 TFT and Evaluation of Characteristics as a Power Device using Si substrate and Sn doping

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The demand for power semiconductors is increasing as the electric vehicle markets rapidly increase. Currently, as the market expands from Si to SiC and GaN, the material that has emerged as a next-generation material is Ga2O3. It has a wider UWBG of ~4.9eV compared to SiC and GaN, a high breakdown voltage of 8MV/cm, and low on-resistance characteristics. Most power devices use epi-wafers or Si substrates with a buffer layer deposited on them to induce epitaxial growth. However, in this study, we grew crystalline Ga2O3 on a commonly used Si-based substrate and proved that it can be operated at high voltage. This has great advantages in terms of process speed and manufacturing difficulty, and can be competitive in substrate price, which is the biggest problem in entering the power semiconductor market.

To use Ga2O3 as a channel layer, it was deposited on a SiO2 substrate using PEALD. Afterwards, RTP was performed in an oxygen atmosphere at 700°C. Through XRD analysis, it was confirmed that (002) and (512) crystal planes were created at 31° and 64° peaks, respectively. To overcome the low electrical conductivity of Ga2O3, the widely known doping method was used. Among them, Sn was selected to provide an N-type effect and implemented as T-ALD using SnO2. As a result of the probe measurement, it was confirmed that the current level of μA at 100V increased and that an operating voltage of 200V could be achieved without breakdown. In addition, $\sim 10^5$A On/Off ratio, SS below 200mV/dec, and ~10cm2/V*s mobility were obtained.

The results of this study suggest that Ga2O3 TFT based on a general-purpose Si substrate can be applied as a power device technology by integrating the conventional Si circuits. Lastly, we hope that this will lead to strengthening local production in the power semiconductor market.

Keywords : Ga2O3, Power semiconductors, TFT, PEALD, Crystalline, Sn doping

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Abstract No. : **PO-S05-0730**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Crystalline Two-dimensional semimetal via nitrogen substitution of chalcogen in transition metal dichalcogenides

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Two dimensional Transition Metal Nitrides (TMNs) have recently emerged as a next-generation materials in the fields of electronics and energy storage. This surge in attention is driven by the discovery of novel electronic, mechanical, and chemical properties of TMNs synthesized into atomic-layer-thickness. In particular, 2D TMNs with a nitrogen-rich composition have high stability and fascinating electromagnetic properties (e.g., semimetallicity, superconductivity, ferromagnetism), thus expecting as a material in quantum device application era. However, due to nitrogen's high bond enthalpy and low reactivity, it has not been possible to synthesize nitrogen-rich TMNs using the general synthetic method, and they can only be achieved in bulk under GPa pressure conditions. These methods have clear limitations due to the cost of facilities and low device applicability, prompting active research into new methods for synthesizing 2D TMNs.

In this study, 2D crystalline semimetal W_5N_6 were synthesized as a single-phase in a vacuum environment by substituting chalcogen with nitrogen in WS_2. Moreover, during the nitridation, the phase and reaction rate were systematically controlled by temperature and partial pressure of NH_3, and optimal conditions for synthesizing crystallized semimetallic W_5N_6 were investigated. Unlike previous studies on atomic substitution of TMDC, this study is significant in that the mechanism of conversion was experimentally demonstrated. Additionally, it is expected that two-dimensional semimetal films of wafer-scale can be synthesized through atomic substitution using wafer-scale synthesized WS_2 templates. Furthermore, in order to be applied to electronic devices, the W_5N_6 thin film must be patterned to the desired structure, but tungsten nitride has a limitation of chemical etching because of extremely stable properties. In this study, a patterned 2D semimetallic W_5N_6 film was achieved through UV-oxidation and post-nitridation, enabling its application in various electronic devices.

Keywords : Transition metal nitride, Semimetal, Substitution, Single phase, Crystalline

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Abstract No. : **OR-S11-0729**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

Self-charging ionotronic power source for next-generation stand-alone IoT System

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A dependable power source is necessary for the developing IoT and microelectronics industries to overcome the difficult task of routinely replacing and recharging traditional energy storage devices. Here, we present an ionotronic power source (IPS) that can harvest electrical output from the ionic gradient created by the diffusion of atmospheric moisture along the carbon particle-melamine foam interface. The mechanical strength of the IPS coated with eutectic hydrogel allows it to be bent and pliable without compromising its ability to harvest energy. The resilient foam-based IPS powers the micro-supercapacitors (MSCs) effectively which successfully acts as a power source for IoTs and microelectronics. This work acts as a stepping stone toward next-generation self-powered electronics.

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[2] Garemark, Jonas, et al. Advanced Functional Materials 33.4 (2023): 2208933.

Keywords : : Ionotronic power source, IoT, Eutectic gel, MSC, self-powered

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Abstract No. : **IN-S09-0728**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Invited**

Atomic Layer Deposition of Molybdenum-based Electrode Films for Cell Capacitor Applications

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As the miniaturization of memory cell capacitors advances, there's a growing need for novel electrode materials possessing low resistivity, high work function, and exceptional mechanical properties. Molybdenum (Mo)-based conducting films, such as MoNx and MoO2, are gaining attention as next-generation electrodes to replace conventional TiN films due to their excellent properties, including elevated work function (>5 eV) and high mechanical strength. In this presentation, we will report on the atomic layer deposition (ALD) of various Mo-based films, including MoNx and MoO2, for next-generation cell capacitor applications. Firstly, conductive MoNx films were grown by ALD, and MIM capacitors were constructed using a MoNx layer in combination with HfZrOx (HZO) films. Despite the excellent electrical properties of the PEALD Mo2N films, severe interfacial reactions between MoNx and HZO occurred. A bilayer electrode structure comprising ALD TiN and Mo2N was introduced to effectively regulate the interfacial reaction, aiming to enhance both the interface property and electrical performance of the capacitors. Secondly, a new strategy to grow monoclinic MoO2 films by ALD was investigated. It was found that the metastable MoO2 phase was stabilized by SnOx doping in MoOx thanks to the template effect between SnO2 and MoO2. ALD TiO2 films grown on Sn-doped MoO2 electrodes demonstrated remarkably high dielectric constants of 100–136, indicating that rutile structure TiO2 was grown. These findings indicate that ALD Sn-doped MoO2 films are promising electrodes for use in TiO2 based MIM capacitor.

Keywords : ALD, Capacitor, Molybdenum nitride, molybdenum oxide

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Abstract No. : **PO-S03-0727**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Research on the application of wearable electronic devices using carbon fabric

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This study introduces a novel approach utilizing carbon fabric for flexible heaters and gas sensors applicable in wearable devices. Conventional materials for such applications often suffer from a lack of flexibility and stability, along with challenges in mass production, necessitating methods to enhance production cost-effectiveness. Leveraging carbon fabric with inherent superior conductivity and devoid of additives from its manufacturing state, the research presents high-efficiency flexible heaters and sensors. Performance evaluation of the heaters involved analyzing heating temperature and power concerning applied voltage, supplemented by thermal imaging of carbon fabric temperature distribution. The highly flexible fabric heaters, based on a uniformly interconnected carbon fiber network, efficiently and rapidly heat with low input power. Additionally, a new carbon fabric gas sensor, comprising pure carbon fibers without additives, is proposed. The carbon fabric sensors exhibits sensitivity to NO_2 at room temperature (24.4% @ 5ppm) and demonstrates outstanding mechanical reliability against over 1,000 repetitions of extreme bending with a 3mm radius. This research sets the stage for a wearable gas sensing platform that is flexible and operates at room temperature.

Keywords : Carbon fabric, Flexible heater, Gas sensor, Wearable electronics

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Abstract No. : **PO-S14-0726**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Thermoelectrically powered high energy density asymmetric supercapacitor for driving overall water splitting: A novel dual-modulated builder for self-powered hydrogen production

Noor Ul Haq Liyakath Ali[1], Arunprasath Sathyaseelan[1], Vignesh Krishnan[1], Parthiban Pazhamalai[1], Sang-Jae Kim[*1]

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Amidst the growing demand for renewable and sustainable green hydrogen fuel, the development of electrocatalytic water-splitting devices driven by renewable energy sources has surged. However, the reliability of self-driven water-splitting remains a challenge, primarily due to the lack of efficient electrocatalysts, inefficient connection between the functional modules, and unpredictable power delivery. In this work, we have synthesized the binder-free grown copper molybdate ($Cu_3Mo_2O_9$) nanocones on conductive nickel foam as a multifunctional electrode via a one-step hydrothermal approach for electrocatalytic water-splitting driven by thermoelectrically powered asymmetric supercapacitor. To avoid the insulating binder for electrode preparation, rich active sites, and effective charge transfer, the $Cu_3Mo_2O_9$ nanocones deliver a high specific electrode capacity and superior rate performance of the supercapacitor. A beaker-type two-electrode electrolyzer assembled with $Cu_3Mo_2O_9$ nanocones on both cathode and anode requires a low cell voltage of 1.58 V to achieve a current density of 10 mA cm^{-2} in alkaline electrolyte, which encounters the state-of-art of the bifunctional electrocatalyst. To conclude, an integrated assembly containing a two-electrode electrolyzer driven by an asymmetric supercapacitor charged by a thermoelectric module delivers a high production yield, long durability, and uninterrupted power delivery.

Keywords : Copper molybdate nanocones; Asymmetric supercapacitor; Water-splitting; Uninterrupted power delivery; Self-powered hydrogen production.

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Abstract No. : **OR-S09-0725**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Oral**

Highly Efficient Photonic Crystal InGaN Tunnel-Junction Nanorod Structure

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In the advance of immersive display applications, GaN-based nanostructured micro-LEDs have emerged as the most promising pixel platform, owing to wide energy bandgap, a range from ultra-violet to infrared, such as augmented reality (AR), virtual reality (VR), and mixed reality (MR). However, challenges such as efficiency degradation with miniaturization, color mixing among adjacent pixels, broad emission spectra, and the absence of suitable ohmic materials for contacting high-resistivity *p*-GaN layers pose significant hurdles. To address these obstacles proactively, we have designed a novel photonic crystal nanorod structure. By eliminating the need for p-metal contacts, our design offers a potential pathway to exploit lasing emission, as supported by rigorous photonic simulations. Furthermore, our 3D-FDTD simulations confirm the nanorod formation ability to facilitate vertical emission. Employing plasma-assisted molecular epitaxy (PA-MBE) techniques, we have achieved precise growth of highly uniform GaN nanorod structures, enhanced with an InGaN tunnel-junction layer, on patterned sapphire substrates. Through meticulous fabrication processes, we have successfully demonstrated p-contact-free laser diodes (LDs) measuring 5 x 5 μm². Notably, these LDs exhibit remarkable operational efficiency, featuring an impressively low threshold voltage of ~2.5 V. They emit lasing emissions at a wavelength of ~502 nm, characterized by a narrow full-width half-maximum (FWHM) of ~1 nm, achieved at a current density of approximately 1.5 kA/cm². This groundbreaking endeavor signifies a new era in micro-LED technology, poised to revolutionize immersive visual experiences.

Keywords : Laser diode, Tunnel junction, InGaN, Nanorod, Photonic crystal

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Abstract No. : **PO-S06-0724**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Artificial Nucleation and Growth Mechanism of Pre-Electrodeposited Ni Nanoparticles for High Uniformity of Copper Nano-objects using AAO Template

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The exploration of electrodeposition technique using nanoporous templates has drawn a lot of attention owing to its application for diverse composition control of metallic nanostructure growth. Anodic aluminum oxide (AAO) has been widely used as a nanoporous template for electrodeposition onto various nanoobjects and innovative nanodevices. On the other hand, non-uniform nanoobject formation and random nucleation in each pore have presented challenges for this technique during the nanomaterial filling process in the porous template. Here, we study experimentally the regulated electrodeposition of Cu nanoobjects through the application of artificial nucleation guided electrodeposition in AAO templates. Ni nanoparticles deposited at the bottom of AAO nanopores have been effectively used as nuclei. By inhibiting the random overgrowth of Cu nanoparticles, the Ni nanoscale nuclei allow for the formation of uniform Cu electrodeposition inside the AAO template. Finally, Cu nanoobjects with a precisely controllable geometry and a well-dispersed surface on the substrate could be obtained. The potential of electrochemically synthesizing nanoobjects for a variety of uses in a broad range of applications will be significantly expanded by this innovative electrodeposition technique.

Keywords : Electrodeposition, AAO, Cu Nanoobject, Artificial nucleation

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Abstract No. : **PO-S13-0723**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Control of Bulk Defects in $MAPbBr_3$ Single Crystals via Non-stoichiometric Reactions for Improving the X-ray Limit of Detection

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$MAPbBr_3$ single crystals (SCs) have received sustained interest as X-ray detecting materials. However, their application in low dose X-ray detection is challenged by their dark current levels and low dose X-ray detectability compared to commercial X-ray detectors. Since the e^-/h^+ generation rate in X-ray detection materials is very low, it is known that the detection characteristics of X-ray detectors are very closely related to the internal defects, which are known to act as scattering centers.

In this study, we present the impact of the bulk defects control in $MAPbBr_3$ SCs through the MABr non-stoichiometric reactions on X-ray detecting properties. The excess of MABr enhanced the crystallinity of the $MAPbBr_3$ SCs and reduced bulk defects, thereby decreasing the concentration of scattering centers. This was confirmed by the increase in photon recycling emission peaks in the PL analysis and the improvement of the charge-carrier lifetime of the TRPL. These improvements result in an increase in the carrier mobility-lifetime product of 3.43×10^{-3} cm^2V^{-1} and a high X-ray sensitivity of 2.58×10^4 $\mu CGy_{air}^{-1}cm^{-2}$. Consequently, we achieved a minimum detectable X-ray dose rate of 2.22 $nGys^{-1}$, which is the lowest level for $MAPbBr_3$-based X-ray detectors.

Keywords : perovskite, single crystal, X-ray detector

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Abstract No. : **PO-S05-0722**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Interfacial Gelation Mechanism for Multidimensional Assembly of $Ti_3C_2T_x$ MXene Films

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The emergence of two-dimensional laminated materials, particularly transitional metal carbide (MXene), has catalyzed significant progress in energy storage, and electromagnetic interference (EMI) shielding applications. However, a critical challenge in the field of two-dimensional MXene lies in fabricating macro-scale functional architectures with diverse structural dimensions. Unlike graphene and metal dichalcogenides, MXene's weak van der Waals force poses limitations on its assembly without an adhesive binder.

We report an interfacial gelation mechanism for the electrochemical self-assembly of pure $Ti_3C_2T_x$ MXene on metal surfaces. This method includes spontaneous reduction reactions and subsequent loss of functional groups to facilitate the formation of multidimensional MXene architectures. Consequently, this approach enables the facile fabrication of three-dimensional open-porous nanostructue, while significantly enhancing electrical properties through the spontaneous removal of oxygen functional groups. Furthermore, this method offers versatility in producing various MXene-based films by shaping the metal substrate. Notably, supercapacitors based on multidimensional assembly MXene exhibit superior performance showing enhanced rate capabilities and capacitance.

Keywords : MXene, Gelation,

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Abstract No. : **PO-S10-0721**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

3D Plasmonic Sensor for Highly Sensitive and Machine Learning-assisted Detection of Multiple Hazardous Molecules

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For the development of a hazardous detection system suitable for on-site use, it is crucial to have both high sensitivity and the ability to swiftly and simultaneously identify several compounds. Herein, we have developed a paper-based 3D spiky needle-clustered gold-on-silver (Ag@Au) plasmonic nanoarchitecture (3D-SNCP), fabricated through a comprehensive solution process. The 3D-SNCP features a spiky, needle-clustered structure, which exhibits strong electromagnetic field enhancement via multiple hot spots, enabling the multiplex detection of hazardous molecules such as bipyridine pesticides, including paraquat (PQ), diquat (DQ), and difenzoquat (DIF). Furthermore, each pesticide and its mixtures were spiked into a ground apple matrix and then measured for multi-component analysis after training the Raman spectra of pure PQ, DQ, and DIF using multinomial logistic regression (MLR). Along with a blank sample, we successfully classified eight different combinations of mixture samples in the actual matrix, exhibiting high analytical ultra-sensitivity and demonstrating an accuracy above 98% in all cases. The developed 3D-SNCP sensor, combined with the MLR method, is expected to be utilized for the analysis of various hazardous substances and applied for untargeted screening of molecules in environmental sensing, healthcare, and medical diagnostics.

Keywords : Plasmonic sensor, surface-enhanced Raman scattering, machine learning

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Abstract No. : **PO-S09-0720**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

High-performance Indium Oxide by Atomic Layer Deposition on Compatible Toward BEOL

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As Moore's Law faces scaling limitations in integrated circuit (IC) devices, the development of three-dimensional and stacked structures for DRAM has gained momentum since the 2010s. The Multi-Stacked 3D (M3D) method offers an alternative to Through-Silicon Via (TSV) techniques, reducing Via area and improving economic efficiency. In response to the need for next-generation BEOL transistors, research focuses on overcoming challenges such as manufacturing at temperatures below 450°C and achieving low off-current. IGZO is a prominent candidate, albeit with compositional control issues.

This study presents an In2O3-based transistor with an Al2O3/In2O3 structure, offering low off-current and high mobility. The device features a bottom gate structure, with Ti/Au (5/20 nm) deposited using an electron-beam evaporator. The gate oxide comprises 20 nm of Al2O3 deposited at 200°C via thermal atomic layer deposition (ALD), achieving a growth per cycle (GPC) of 1.25Å/cycle. Wet etching is applied. The In2O3 channel, deposited at 5 nm, is processed in the range of 150 to 250°C using thermal ALD, with a GPC of 0.35Å/cycle. Wet etching is again employed. Source/drain (S/D) electrodes (5/20 nm of Ti/Au) are deposited using the same evaporator. Through this, a transistor with a bottom gate structure with a minimum line width of 5 μm was manufactured.

Characterization via GIXRD and TEM confirms the amorphous state of In2O3, while ARXPS reveals the reduction of In2O3 to a metallic state by Al2O3. Electrical characteristics are assessed via Kelvin Probe measurement, demonstrating insulation with a leakage of 10^{-12} A. Transfer and Output characteristics reveal a mobility of ~30 cm^2/Vs, subthreshold swing (ss) <100 mV/dec, and an On/Off ratio of $\sim 10^{11}$.

Manufacturing an In2O3 transistor through low-temperature ALD (<250°C) yields superior mobility compared to IGZO transistors and exceptionally low off-current characteristics, suggesting the potential for a next-generation BEOL transistor.

Keywords : 2DEG, Low Temperature TFT, High Mobility, Low Leakage Current

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Abstract No. : **PO-S01-0719**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Deep eutectic electrolyte incorporated solid polymer electrolytes for low temperature operation of solid-state lithium ion batteries

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Solid polymer electrolytes stand as the most promising technology among various solid-state electrolytes for the commercialization of lithium-ion batteries. However, their performance deteriorates at room temperature, and they are chemically unstable for wide temperature applications, requiring various improvement strategies. In this study, we introduce a novel approach by incorporating acetamide-based deep eutectic electrolytes into a polyethylene glycol (PEG) based semi-interpenetrated polymer electrolyte. Fluoroacetamide, with its high polarity and low melting point, serves as a solvent capable of enhancing the low-temperature performance of polymer solid electrolytes. The resulting electrolyte exhibits significantly improved ionic conductivity, reaching 3.1 mS cm^{-1} at room temperature and 0.1 mS cm^{-1} even at −20 °C. When applied in a $LiFePO_4$/Li solid-state battery configuration, stable cycling performance is achieved at room temperature, with capacity retention exceeding 99.9% after 100 cycles.

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Keywords : Lithium-ion batteries, Solid-state batteries, Solid polymer electrolytes, Deep eutectic electrolyte

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Abstract No. : **IN-S06-0718**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Aluminum Matrix Composites Manufactured using Nitridation-Induced Self-Forming Process

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Conventional manufacturing processes for aluminum matrix composites (AMCs) involve complex procedures that require unique equipment and skills at each stage. This increases the process costs and limits the scope of potential applications. In this study, a simple and facile route for AMC manufacturing is developed. In this process, a mixture of Al powder and the ceramic reinforcement is simply heated under nitrogen atmosphere to produce the composite. During heating under nitrogen atmosphere, the surface modification of both Al and the reinforcement is induced by nitridation. When the oxide layer covering Al powder surface is transformed to nitrides, temperature in the local region increases rapidly, resulting in a partial melt of Al powder. The molten Al infiltrates into the empty space among Al powder and reinforcement, thereby enabling consolidation of powders without external forces. It is possible to fabricate AMCs with various types, sizes, volume fractions, and morphologies of the reinforcement. Furthermore, the manufacturing temperature can be lowered below the melting point of Al (or the solidus temperature for alloys) because of the exothermic nature of the nitridation, which prevents formation of un-wanted reactants. The simplicity of this process, which is incomparable to that of the conventional processes, will not only provide sufficient price competitiveness for the final products but also contribute to the expansion of the application scope of AMCs.

Keywords : Aluminum matrix composites (AMCs), Low temperature processing

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Abstract No. : **PO-S01-0717**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

A Partially Disordered, Composite Rock Salt NCM Cathode for Lithium Ion Batteries

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Spinel cathodes are composed of cost-effective manganese and have a three-dimensional lithium diffusion pathway, which provides fast lithium ion mobility during charge-discharge. They also offer high thermal stability compared to nickel- and cobalt-rich oxides. However, due to their low electrochemical capacity and energy density, they have a lower market share in the lithium battery industry compared to nickel-rich stacked cathodes. To address these limitations, recent research has focused on synthesizing composite cathodes for lithium-ion batteries via low-temperature annealing containing partially disordered and structurally integrated lithium spinel and layered compounds to create high-capacity cathodes. In this work, we synthesized LT-LiNi1/3Mn1/3Co1/3O2 (LT-NCM111), a composite cathode structure for lithium-ion batteries via flame spray pyrolysis (FSP) method and low-temperature annealing. It is composed predominantly of structurally-integrated and partially-disordered lithiated-spinel and layered components, both of which can be broadly described as partially-disordered rock salt constituents. Furthermore, this study describes the evolution of the structure during the production of spinel and layered compounds via low-temperature annealing. The electrochemical properties of LT-NCM111 cathode materials improve lithium-ion battery capacity and cycle stability, and the partial disorder in the structure provides higher energy density and charge/discharge capacity. Therefore, this research has used lithiated spinel-like components such as LT-NMC111 to tailor and stabilize the composition and structural design of layered cathodes, especially lithium- and manganese-rich systems, to lower the cost of today's lithium-ion batteries.

Keywords : Lithiated spinel structure, Flame spray pytolysis, LT-NCM 111, Cathode, Lithium ion battery

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Abstract No. : **PO-S11-0716**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Designing a core-shell 2D/2D nano-on-micro sheet configuration to optimize supercapacitor efficiency

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This study explores the use of core-shell electrode structures to improve supercapacitor performance. Specifically, the present work focuses on creating binder-free 2D/2D $FeCo_2O_4$@$Ni(OH)_2$ core-shell architectures on a Ni-foam substrate. These electrodes showed significantly higher specific capacitance compared to individual $FeCo_2O_4$ and $Ni(OH)_2$ electrodes, attributed to synergistic effects within the core-shell architecture. Additionally, a two-electrode asymmetric supercapacitor composed of $FeCo_2O_4$@$Ni(OH)_2$ and activated carbon demonstrated impressive energy density, power density, capacitance retention, and coulombic efficiency over numerous cycles. Overall, the study highlights the effectiveness of hierarchical nano-architecture core-shell designs in enhancing energy storage device performance, emphasizing the importance of material combinations and surface-interface interactions for superior electrochemical behavior.

Keywords : Core-shell, Electrodeposition, Supercapacitor, Asymmetric Device, Sheet structure

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Abstract No. : **PO-S13-0715**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Spatially Segregated Catalyst and Light-Absorption in Silicon Microwires for Enhanced Photoelectrochemical CO_2 Conversion

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Photoelectrochemical (PEC) cells, which convert CO_2 into high-value chemical compounds, are one of the promising candidates for eco-friendly energy production techniques. Crystalline silicon (c-Si) is suitable material for photocathode due to its relatively narrow bandgap of 1.12eV, non-toxicity, and high-stability compared to conventional oxide-based materials. Especially, the Si microwire has been extensively investigated as a photocathode due to its superior light absorption and ability to achieve high-current density. However, when only c-Si is used, the Si photocathode exhibits low Faradaic efficiency due to its high overpotential. To overcome the high overpotential of c-Si based photocathode, applying PEC catalysts is essential to increase the Faradaic efficiency. Conventional c-Si microwire-based photocathode is decorated by catalysts onto the entire surface of c-Si microwires. The catalyst causes light reflection and surface recombination between the Si-catalyst interface, leading to optical and electrical losses. Therefore, optimizing catalyst proportion and placement is crucial to minimize them.

In this abstract, we aimed to fabricate a Si photocathode with surface-passivated microwire arrays that segregate between the absorption region capable of absorbing light and the catalyst region coated with the catalyst. In the absorption region, we fabricated the tapered microwire arrays to minimize light reflection in terms of morphology and we confirmed that light absorption was maximized compared to other structures through optical simulation. The catalyst region was constituted by each single catalyst wire array, with the inclined tip of the wire coated by the catalyst. We controlled the shape of the tip at the catalyst wire for inclined catalyst coating and figured out that this shape effectively reduced the light reflection at the top of the catalyst wire.

By optimizing the geometry and density of Si microwires and catalysts, we would suggest a method for developing a high-efficiency Si photocathode that maximizes light absorption while minimizing electrical losses.

Keywords : Photoelectrochemical cell, Silicon, microwire, absorption region, catalyst region

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Abstract No. : **PO-S10-0714**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Paper-based 3D plasmonic nanomaterial sensor for the detection of microplastic

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Microplastics (MPs), defined as synthetic polymers with a particle size of <5 mm, have been a major global concern for several years. In particular, MP pollution exists as a harmful threat to both ecosystems and human health. Herein, we developed a three-dimensional plasmonic nanomaterial sensor (3D-NS) on a paper substrate for effective filtering and label-free sensing of MP pollutants via surface-enhance Raman scattering (SERS) detection. Finite-domain time-dependent (FDTD) simulation revealed that MP particles are filtered out on a 3D-NS sensor using a syringe and could subsequently be surrounded by a 3D-NS network for effective SERS signal generation. Then, the SERS mapping images obtained from a portable Raman spectrometer are transformed into digital signals via a machine learning (ML) technique to identify and quantify the MP distribution. The developed SERS-ML-based MP detection method is applied to mixed MPs and real matrix samples, demonstrating that the method provides improved accuracy. The technology developed herein can be applied for not only developing an onsite MP detection system but also various environmental sensing tools in the near future.

Keywords : Microplastics, Surface-enhanced Raman Scattering, Machine learning

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Abstract No. : **PO-S03-0713**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Wearable and Self-Powered Temperature Sensing Platform: Harnessing Synergy between Biodegradable Polymer PHB and Mxene

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As a vital sign reflecting health status, body temperature measurement technologies, continually advancing for medical diagnostics, skin hydration monitoring, and physiological research, provide invaluable insights into overall well-being. We report a self-powered temperature sensing platform using PHB/mxene nanocomposite film with high linearity, low hysteresis and a TCR value of -1.45 %/ ºC. A piezoelectric nanogenerator has been developed using pristine PHB with highly electroactive β-PHB generating and electric output of ~35 V and ~60 nA with a power density of 6.35 mW/m^2. Electrospinning technique was used to prepare PHB and PHB/Mxene nanomeshes. The combination of electrospinning and HFIP as a solvent creates a potent environment for the formation of the beta phase in PHB. A thorough investigation using XRD has been carried out to confirm the formation of the beta phase in biodegradable PHB polymer. This research lays the groundwork for precise body temperature monitoring, offering significant implications for diagnosing conditions through continuous temperature tracking, as well as managing diseases pertinent to temperature regulation within healthcare settings.

Keywords : Wearable, breathable, temperature sensor, biodegradable, polymer, mxene

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Abstract No. : **OR-S12-0712**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Sustainable photocatalytic production of hydrogen peroxide using carbon-based materials: its applications as solar fuel and as water treatment agent

Do-yeon Lee[1], Hyoung-il Kim*[1]

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As the urgency of the climate crisis grows, there is a rising need to advance renewable energy technologies in the environmental sector. In this context, hydrogen peroxide (H_2O_2) is gaining recognition as a multifunctional chemicals, useful both as an oxidant or agent in water treatment and as an energy carrier from solar sources. The purpose of these researches is to devise methods for the economical and simple production of H_2O_2 using carbon-based materials as photocatalysts, transforming water and oxygen into an environmentally friendly product as both solar fuel and a chemical agent for organic contaminant degradation. Initially, the research delves into the transformation process of H_2O_2 production, starting from material precursors to effective photocatalysts, with a focus on the critical role of surface properties, particularly oxygen-related functionalities, in sustainable H_2O_2 production via photocatalysis. The investigation then extends to the exploration of oxygen functionalities that act as self-proton donors in the oxygen reduction reaction (ORR), proposing a technique to conjugate co-catalysts via amide links to improve charge separation and selectivity of the ORR. Additionally, this research emphasizes the practical uses of H_2O_2 both in wastewater treatments for the degradation of organic contaminants and in fuel cells, utilizing phosphate-modified resorcinol-formaldehyde (RF) resins with high H_2O_2 productivity. Ultimately, these researches introduce novel strategies for surface functionalization and photocatalyst innovation, offering significant contributions to effective H_2O_2 production for use in energy and environmental applications in terms of economic feasibility and material optimization.

Keywords : Renewable energy, Photocatalyst, Carbon-based materials, Solar fuel, Hydrogen peroxide, water treatment

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Abstract No. : **OR-S12-0711**
Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Oral**

Photoreforming of Plastic Wastes for Hydrogen Peroxide Production Using Surface Functionalized Carbon Nitride

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The increasing use of plastics and synthetic polymers leads to a rise in plastic waste, posing a severe threat to the environment. Current plastic waste recycling methods often require substantial energy and release secondary pollutants. Photocatalytic plastic waste recycling, utilizing solar energy, has emerged but faces challenges such as long processing times and a focus solely on decomposition. To address these limitations, plastic waste upcycling technology using solar energy is being explored as a promising alternative. Hydrogen peroxide (H_2O_2), a versatile chemical, can be produced through the photocatalytic solar conversion process, offering an eco-friendly and sustainable solution. While most studies focus on using organic matters and water as electron donors for H_2O_2 production, the potential of plastics as electron donors remains unexplored. Carbon nitride (C_3N_4) shows promise as a photocatalyst for H_2O_2 production due to its suitable properties. In this study, polymeric carbon nitride modified with KCl and NH_4Cl (Alk-CN) achieved a high H_2O_2 production rate (5.04 mmol g^{-1} h^{-1}) in the presence of polyethylene terephthalate (PET) pretreated in a strong alkaline solution. It showed that Alk-CN can produce H_2O_2 amount 1.86 times more than C_3N_4. PET plays a crucial role in controlling the photocatalytic H_2O_2 production of C_3N_4-based catalysts. This approach extends to other polyester-based plastics like polybutylene terephthalate (PBT) and polylactic acid (PLA), showcasing significant potential in both H_2O_2 production and organic oxidation of waste plastics. Thus, photocatalytic upcycling of plastic waste for H_2O_2 production presents a significant and insightful research direction, addressing both H_2O_2 production and organic oxidation of waste plastics.

Keywords : Upcycling; Photorefomring; PET; Hydrogen Peroxide; Carbon Nitride; Plastic Waste

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Abstract No. : **IN-S13-0710**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Invited**

All about solution based kesterite solar cells for new record efficiency over 15%

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The synthesis of multinary semiconductors for solar energy conversion applications such as kesterite ($Cu_2ZnSn(S,Se)_4$, CZTSSe) is extremely challenging due to the complexity of this type of compounds. Having multiple elements in their structure, the formation of secondary phases, punctual or extended detrimental defects, and/or singular interfaces is commonly very problematic. In particular, quaternary kesterite-type compounds are not the exception, and all these detrimental issues explain why during almost 10 years the world record efficiency was unchanged. But the very recent development of molecular inks route with special precursors, allows the accurate control of single kesterite phase with high crystalline quality. In addition, the use of selective diluted alloying has shown a high potential for minimizing detrimental punctual defects formation, contributing to increase the conversion efficiency record of kesterite based solar cells up to 15% in a short time.

This presentation will be focused first in demonstrating how the molecular inks synthesis route was of key relevance for the control of high-quality single phase kesterite, through the modification of the synthesis mechanisms. The relevance of the composition of the ink, the precursor salts, and the interaction between the solvent and the cations in the solution is key for a reliable and reproducible high efficiency kesterite production baseline. Then, diluted alloying/doping strategies will be presented including Cu, Zn and Sn partial substitution with elements such as Ag, Li, Cd or Ge. The positive impact of these cation substitutions will be discussed in regards of their impact on the kesterite quality, as well as on the annihilation of detrimental punctual defects, allowing for new efficiency records at 15% level.

Finally, very recent, and innovative interface passivation strategies will be discussed, showing the pathway to increase the record efficiency beyond 20%.

Keywords : Kesterite, Cu2ZnSn(S,Se)4, Ag-alloying, Li-doping, Thin Film Solar Cells

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Abstract No. : **PO-S02-0709**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Devolopment of CaF_2 Single Crystals Fabrication Techniques for UV Lens in Semiconductor Inspection Systems

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Abstract

The number of devices on integrated circuit (IC) increases rapidly as predicted by Moore’s law. Optical modules for shorter wavelength, such as ultraviolet (UV), are needed for visual inspection of smaller semiconductor chips. Owing to the development of calcium fluoride (CaF_2) crystals, lithography and many other areas of technology have made remarkable achievements. Low solubility and wide transmittance in UV-Vis-IR range of CaF_2 make this material extremely useful for a variety of different applications, including micro-lithography, mirror substrates for UV laser systems, windows, lenses and prisms for UV and IR applications and especially for the inspection of semiconductor. Here, we investigated the growth of UV-grade CaF_2 by the Czochralski method. ZnF_2 additives and CF_4 gas were used as scavengers for removing oxygen-related contaminants derived from the reaction of water molecules with CaF_2. Czochralski-grown CaF_2 crystals have very good crystallinity and excellent optical properties such as high transmittance in the spectral range of UV laser. This study aims to grow the 200mm width CaF_2 single crystal ingot which could be applied for 8-inch wafer production. We believe that our demonstrated research contributes to the improvements in optical inspection systems of semiconductor process.

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Keywords : CaF2, Single crystals, UV Lens, Semiconduction Inspection

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Abstract No. : **PO-S11-0708**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Wheel-type direct current piezoelectric generator based on wheel-shaped Sm-doped PMN-PT

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In the progressive technological milieu of the 2020s, a salient pivot in the electronics industry gravitates toward the amplified importance of power generation and distribution. Traditional centralized energy paradigms suffer from inefficiencies during transmission, conversion, and storage. This has led to an increased focus on decentralized energy generation. Consequently, there's a burgeoning interest in autonomous power reservoirs designed to power devices right where electricity is used. This manuscript delves into the potential of a refined piezoelectric mechanism, unveiling a wheel-inspired generator adept at both substituting conventional wheels and producing electrical energy. Its proclivity for direct current generation underscores its superior energy efficacy. An on-field assessment, conducted with a prototype applied to a suitcase, indicated promising efficiency and potential market applicability, highlighting its potential in the emerging landscape of self-sustaining power systems.

Keywords : piezoelectric generator, PMN-PT, self-sustaining power systems, piezoelectric

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Abstract No. : **OR-S02-0707**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Optical convolution operations for efficient color image recognition

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Optical neural networks (ONNs) have recently been exploited to carry out optically fully connected matrix-vector multiplication (MVM) operation for energy-efficient and high-throughput image processing and inference tasks. However, these optical neural network architectures still primarily rely on monochromatic illumination transformed from digital images, making it challenging to effectively classify real-world images with diverse colors. This study introduces an optical neural network system integrated into conventional display technology, utilizing a red, green, and blue (RGB) pixel array. In a proof-of-concept demonstration, we conducted 22 epochs of iterative training using a rank-4 kernel for standard convolution to accurately classify color images of five fruit categories. The ONN achieved 100% classification accuracy on the training dataset and maintained robust performance on modified test datasets and added noise. Our analysis showed operational efficiency, achieving over 94% classification accuracy per MAC operation using an average of less than 17 aJ of optical energy, providing substantial throughput at approximately 2.36 teraMAC/s. Additionally, we demonstrated depth-wise convolution using a rank-3 kernel, separating the system into R, G, and B channels. This architecture enabled successful classification of complex patterns containing three MNIST handwritten digits encoded in RGB. Our strategy contributes significantly to optical computing and neuromorphic vision, emphasizing the potential of optical convolution operations utilizing channels with various wavelengths.

Keywords : optical neural networks (ONNs), optical convolution operations, color image recognition, energy efficient recognition

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Abstract No. : **PO-S02-0706**
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Abstract Preference : **Poster**

Development of $LiTaO_3$ Single Crystals and Wafer-Bonded Thin Films Fabrication Techniques for SAW Filters

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Abstract

Lithium tantalate (LiTaO3) crystal is widely used in infrared detection, acoustic surface wave devices and optical applications due to its outstanding piezoelectric, pyroelectric, and nonlinear optical properties. Over the past few decades, LiTaO3 single crystals and thin films have been studied intensively for their excellent acoustic and electro-optical properties. Today, the most of radio-frequency (RF) filters, based on surface acoustic waves (SAW), are fabricated on this single crystal. This material in the form of thin films is needed considerably for the development of the next-generation of high-frequency, wide-band RF filters adapted to the fifth or sixth generation of infrastructures/networks/communications. Here, we grew LiTaO3 single crystals by czochralski methods. Annealing, poling and chemical reduction were conducted for enhanced performances of our LiTaO3 crystals. Subsequently, we shaped it to the form of wafer-bonded thin films on silicon. Finally, SAW devices were fabricated using our wafer-bonded LiTaO3 thin films. Several analyses from the grown crystals to the fabricated devices were carried out. We expect that the results of our research could contribute to the development of fabrication technique of LiTaO3 single crystals and high-quality RF filters.

ACKNOWLEDGEMENT

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Keywords : LiTaO3, Single crystals, SAW Filter, Wafer-Bonding

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Abstract No. : **PO-S04-0705**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

Study of argon flow effects on structural and optical properties of thin films for runway lighting devices

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Diverse lighting systems are deployed across airfields and runways to guarantee the safe operation of aircraft. The characteristics of these systems including color, brightness, and beam angle are governed by international regulations to avert accidents. Consequently, to maintain stable performance, it is imperative to integrate a bandpass filter into the aviation lighting system. We designed multilayer thin films using SiO_2 and Nb_2O_5, using the Essential Macleod program for the layout. The composition and thickness of the layers were optimized to maximize transmittance. Multilayer thin films deposited on glass substrates by RF sputtering at different argon flow rate contrastively studied. Transmittance was measured at Ar flows of 30sccm, 50sccm, and 70sccm, showing that the highest transmittance was at 30sccm, while the lowest was at 70sccm. This suggests that an increase in Ar flow tends to increase the density of the thin films, thereby reducing their transmittance. Elemental composition was verified using EDXRF (Energy Dispersive X-ray Fluorescence) analysis, and the microstructure and layer uniformity were evaluated using SEM (Scanning Electron Microscopy). XRD (X-ray Diffraction) analysis was used to assess the crystal structure and phase of the thin films. This research demonstrates that the spectral usage range of the bandpass filter can be diverse in various fields.

This work was supported by the Technology Innovation Program (20018828, Development of optical filter for wavelength control and light source module for lighting device) and (P0017725, Project of Industry supporting on optical materials for camera lenses) funded By the Ministry of Trade, Industry & Energy (MOTIE, Korea).

Keywords : Thin films, Argon gas flow rate, Nb2O5 thin films

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Abstract No. : **PO-S11-0704**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Self-assembly of unidirectionally polarized piezoelectric peptide nanotubes using environmentally friendly solvents

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Diphenylalanine (FF) peptide nanotubes are considered to be particularly promising biomaterials for bio-implantable devices due to their unique characteristics, such as strong piezoelectricity, remarkable physical properties, and chemical stability. However, the 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP)-water co-solvent system, which is often used for FF nanotube synthesis, is toxic and expensive. These are limitations for the development of eco-friendly and practical biocompatible piezoelectric devices. In this study, we developed an eco-friend and cost-effective approach for aligning piezoelectric FF nanotubes using an ethanol–water solvent system. First, we fabricated horizontally aligned FF nanotubes via a meniscus-driven self-assembly process. The fabricated FF nanotubes using ethanol exhibited unidirectional polarization and strong piezoelectric properties comparable to HFIP solvent based FF nanotubes. In addition, the FF-based piezoelectric nanogenerator generates voltage, current, and power of up to 1.66 V, 19.4 nA, and 19.2 nW, respectively, with a force of 40 N. These FF-based piezoelectric nanogenerators will be applicable as a compatible energy source for future biomedical applications.

Keywords : Piezoelectric, Diphenylalanine, Nanogenerator, Biocompatible, Peptide

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Abstract No. : **PO-S04-0703**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

Investigation of Li doping sites and their function to alter electrical transport in Li-doped cobalt tungstate

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In this work, we report the preparation and characterizations of Li-doped $CoWO_4$ and detailed studies about the defect sites influencing electrical transport properties. The compositions based on $Co_{1-x}Li_xWO_4$ (where $x = 0$, 0.05, 0.10, and 0.15) were synthesized through the solid-state reaction route. The powder X-ray diffraction results, accompanied by Raman spectroscopy, show that Li defect sites change with increasing Li concentrations, resulting in distinct unit cell volume and CoO_6 octahedron vibrational mode. The X-ray photoemission spectra study revealed that the Li defect mainly exists when substitution is replaced by the Co-site, suppressing the O vacancy concentration at $x = 0.05$. However, interstitial Li starts to increase at $x = 0.10$, affecting spin-orbit coupling behavior in Co^{2+} and Co^{3+} states with enlarging lattice volume. By analyzing the frequency-dependent ac conductivity data in $Co_{1-x}Li_xWO_4$ with $x = 0.10$ at selected temperatures, the electrical conductivity in $CoWO_4$ as increasing Li introduction originates not only from hole carriers doping but also from the endorsed hopping efficiency for small polaronic conduction under an alleviated lattice.

Keywords : Ternary transition metal oxide, CoWO4, electrical transport, Li-defect states,

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Abstract No. : **PO-S09-0702**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

A Colorimetric multifunctional flexible device using IGZO channel for Structural-Durability-Health Monitoring Systems

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Our study emphasizes the critical importance of monitoring reinforced concrete conditions in building structures to ensure long-term durability. Through the integration of sensors embedded within the concrete and proper quantitative analysis within the Structural Health Monitoring System (SHMS), we address the detrimental effects of chloride attack and carbonation. These factors significantly diminish the lifespan and strength of buildings by inducing pitting corrosion and lowering concrete pH, respectively. To address these challenges, we present a novel multifunctional colorimetric sensing system designed for Durability Health Monitoring Systems (DHMS). This system employs an array of IGZO phototransistors and a color-variable membrane strategically positioned between the light source(wavelength of 450nm) and the phototransistor array. By responding to specific stimuli, this membrane facilitates the assessment of pH and chloride levels, modulating transmitted light intensity accordingly. The phototransistor array effectively translates gradual light changes into electrical signals, including photo-induced current, Vth shift, and response metrics (Ids/IpH 12 and Ids/ICl 0 wt%), as well as photocurrent variation (Iphoto/Iphoto at pH 12 and Iphoto/Iphoto at Cl 0 wt%). Our findings demonstrate that Ids and R (Ids/IpH 12) decrease with decreasing pH, while for pH levels of 10-12, Ids and R increase approximately 10-3. Similarly, for chloride detection, Ids and R (Ids/ICl 0 wt%) exhibit nearly a 50 times increase with a 0.05 wt% Cl concentration rise, reaching approximately 10-3 at a 0.30 wt% concentration. This multifunctional system offers promising potential as a smart diagnostic tool for structural durability assessment, characterized by its high stability, sensitivity, and multifunctionality.

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Keywords : phototransistor, color membrane, IGZO

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Abstract No. : **IN-S19-0701**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Invited**

SNR FOM Characterization of 2D Materials-Based Piezoelectric MEMS Microphone

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The increasing demand for compact, low-power, and high-sensitivity acoustic sensors has spurred a significant global interest in the development of MEMS microphone technology. To address this demand and advance technology in the field, our focus lies in developing high-performance and durable MEMS microphones utilizing 2D piezoelectric materials.

To effectively assess the figure of merit (FOM), specifically the signal-to-noise ratio (SNR), of MEMS microphones, it is imperative to measure and evaluate key parameters such as piezoelectric coefficients, dielectric constants, and dielectric loss. In this study, we present the preparation and evaluation methods employed for material characterization in SNR FOM measurement. Additionally, we discuss the outcomes of these evaluations, shedding light on the potential of 2D materials in enhancing MEMS microphone performance.

Keywords : MEMS, Microphone, Piezoelectric, Dielectric

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Abstract No. : **IN-S11-0700**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Invited**

Polarized Surface Effect in Ferroelectric Materials

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Flexoelectricity is an electromechanical coupling effect between polarization and strain gradient in dielectrics. This effect has intensively studied in ferroelectrics, but the generating mechanisms are not completely understood. The flexoelectric effect of ferroelectric ceramics was investigated to understand the mechanism of this effect. We found that there exist polarized surface layers on ferroelectric ceramics. The piezoelectric response from the surface layers is a main mechanism responsible for the large flexoelectric-like response of the ferroelectric ceramics, which is much larger than the theoretically calculated response. We show that this polarized surface layer effect also exists in other materials, such as ferroelectric polymers. Our study provides an important mechanism to understand the flexoelectric effect in ferroelectric materials.

Keywords : ferroelectric ceramics, flexoelectric effect, surface layer effect

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Abstract No. : **PO-S08-0699**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Study of TeO2 Based Optical Glass for the application of Mid-Wavelength Infrared Lens Application

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The mid-wavelength infrared (MWIR) spans a spectrum range of 3-5 μm and serves primarily for detecting radiation emitted by sources operating below 1,000 oC. Its applications include thermal imaging technology for capturing heat distribution images and various fields such as chemical sensing, environmental monitoring, and long-distance detection. Optical lenses for MWIR, crucial components in thermal imaging devices, can be fabricated using single crystals, such as Ge, Si, and sapphire, as well as various glass materials, including chalcogenide and fluoride. However, single crystal materials pose several challenges due to their high material costs, limitations in single refractive index, and difficulties in mass production. On the other hand, glasses offer advantages such as ease of synthesis, tunability of optical properties through composition control, and feasibility of mass production via processes like Glass Molding Press (GMP) compared to single crystals. Nonetheless, chalcogenide and fluoride systems, as infrared optical glass materials, exhibit high refractive indices and excellent transmittance, alongside significant drawbacks such as manufacturing complexity and susceptibility to moisture.

Therefore, this study presents the development of optical glass for MWIR with a high refractive index, based on TeO2-ZnO-La2O3 oxide glasses. Glass samples were synthesized using a conventional melt-quenching method. The suitability of the produced glass as a lens material was evaluated through thermal, mechanical, and optical property analyses. Finally, we discuss the results of developing a thermal camera employing the prepared glass.

This work was supported by the Technology Innovation Program [(20010150) Oxide based visible MW infrared transmitted optical glass material for dual band optics, and (P0017725) Project of Industry supporting on optical materials for camera lenses] funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea)

Keywords : TeO2, Glass, Lens, Refractive Index

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Abstract No. : **PO-S06-0698**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Thermal stability and microstructure evolution of Al–Zn–Mg–Cu–Si–Zr sintered alloy fabricated via HEBM and SPS

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In this research, the influence of Zr addition on the microstructural evolution and thermal stability of Al–Zn–Mg–Cu–Si alloy was investigated. This alloy, fabricated through high-energy ball milling (HEBM) and spark plasma sintering (SPS), is known for its high-strength capabilities in powder metallurgy (PM) processes. HEBM facilitated the dissolution and refinement of Zr particles, ensuring their even distribution within the Al–Zn–Mg–Cu–Si matrix. This process also contributed to grain refinement and allowed surface Al-oxides to penetrate deeper into the powder.

During sintering, these Zr particles transformed into structures with a Zr core and Si_2Zr shells, as well as platelet Si_2Zr formations, while Al-oxides converted into MgO particles. Phase transformations were then observed by transmission electron microscopy after heat treatment at 500°C for 1, 24, and 168 h to investigate the effect on the thermal stability and microhardness of the alloy.

Keywords : Al–Zn–Mg–Cu–Si–Zr alloy, Thermal stability, High-energy ball milling, Spark plasma sintering, Transmission electron microscopy

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Abstract No. : **PO-S11-0697**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Broadband Piezoelectric Energy Harvester for Frequency-varying Environments

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We present an innovative autonomous resonance-tuning (ART) energy harvester that employs adaptive clamping systems driven by intrinsic mechanical mechanisms to achieve resonance tuning, without requiring additional energy sources. The adaptive clamping system adjusts the natural frequency of the harvester's main beam (MB) by modulating the clamping position of the MB. The resonance vibration of the tuning beam (TB) generates the pulling force that drives the adaptive clamp. The ART mechanism operates by matching the natural frequencies of the TB and the clamped MB. We conducted detailed evaluations to optimize the adaptive clamp tolerance and TB design to maximize the pulling force. Thanks to the ART function, the energy harvester achieved an ultra-wide resonance bandwidth of over 30 Hz in the commonly accessible low-vibration frequency range (<100 Hz). To demonstrate the practical feasibility of the ART harvester, we evaluated its performance under frequency and acceleration-variant conditions and successfully powered a location-tracking sensor.

Keywords : Piezoelectric, Energy Harvesting, Broadband

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Abstract No. : **PO-S08-0696**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Study of Ge-Ga-Se chalcogenide glass for the application of long-wavelength infrared optical lens

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Infrared optical technology has primarily been utilized in military applications, such as night vision goggles and thermal sensing in guided weapons. However, its application range has been expanding to civilian industries, including body temperature diagnosis, firefighting rescue, security monitoring, and night vision for vehicles. For these purposes, the lens module of a thermal imaging camera plays a crucial role in determining the camera's performance. Chalcogenide glass (ChG) offers a promising solution for lens applications, as it can be mass-produced through the glass molding press (GMP) process, and its properties can be tailored through compositional engineering. Nonetheless, most commercialized ChG currently contains arsenic (As) and antimony (Sb), making it unsuitable for application as a lens in smart devices due to its potential harm to human health and the environment.

Therefore, this study aimed to develop an eco-friendly ChG composition based on Ge-Ga-Se (GGSe), free from As and Sb. To demonstrate the potential of the eco-friendly ChG for IR lens applications through GMP, their properties were investigated. Differential scanning calorimeter (DSC) analysis was conducted to determine the glass transition temperature (Tg) and thermal stability, essential for securing the possibility of GMP. The GGSe system exhibited an average transmittance of more than 70% in the 8~12μm range. Additionally, their refractive index and its wavelength dependence were monitored and compared to commercial products.

This work was supported by the Technology Innovation Program [(P001354091) Development of compact infrared lend using eco friendly chalcogenide glass, and (P0017725) Project of Industry supporting on optical materials for camera lenses] funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea)

Keywords : Chalcogenide, Glass, Lens, Refractive Index

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Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Poster**

Wireless, skin-interfaced electronic system for simultaneous physiological monitoring and chemotherapy

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Fully integrated wearable medical devices (WMDs) with a closed-loop system is crucial for monitoring chronic diseases which need continuous biosensing and timely drug delivery. Typically, WMDs are composed of multiple subsystems including multi-modal sensing systems, drug delivery module, drug reservoir and operating systems such as wireless communication and power supply. Typically, most of fully integrated devices that combine these components form a single layer configuration. Such layer configuration has limitations of hardware miniaturization, conformal skin contact due to rigid components, and stability of components that can be easily damaged by dynamic environment on the skin. Recent advancements in multilayer configuration (e.g. laser ablation, strain-isolating layer and folding) make it possible to address these limitations. However, WMDs with multilayer configuration are still narrowly used in the field of electrical biosensing. Here, we propose a wireless, skin-interfaced electronic system with folded structure for multimodal physiological monitoring and drug delivery, which can mechanically isolate the upper and lower layer with engineered hard-soft interlayer. The proposed device consists of folded structure with engineered hard-soft interlayer, which hard layer can protect the functional components such as microheater, laser diodes and IC chips under the strain and soft layer can obtain the stretchability and conformal contact with the skin interface. For achieving the closed-loop system, biosensing and drug delivery modules are developed electrically, optically and chemically. In terms of biosensing, electrophysiological signals including ECG, temperature and accelerometer are captured by folded electrodes and optical signal is captured by flexible PDMS waveguide aligned with commercial laser diode and photodetector. In terms of drug delivery module, micropump-driven drug delivery module is developed based on thermo-pneumatic peristaltic mechanism.

Keywords : wearable electronics, drug delivery, electrophysiological monitoring, multimodal

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Abstract Preference : **Oral**

R-PC-T multi-phase and piezoelectric properties of the (1-x)Pb(Zr, Ti)O_3-xPb$(Zn_{0.4}Ni_{0.6})_{1/3}Nb_{2/3}O_3$ ceramics

San Kwak[1], Geun-Soo Lee[1], Jung-Soo Kim[1], Sahn Nahm*[1]

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The structural and electrical properties of (1-x)Pb$(Zr_{1-z}Ti_z)O_3$-xPb$(Zn_{0.4}Ni_{0.6})_{1/3}Nb_{2/3}O_3$ [(1-x)P$(Z_{1-z}T_z)$-xPZNN] piezoceramics have been systematically investigated to identify compositions having the rhombohedral-pseudocubic-tetragonal (*R-PC-T*) multi-structure. According to Rietveld refinement, pseudocubic (*PC)* structure was observed in the (1-x)P$(Z_{1-z}T_z)$-xPZNN piezoceramics, which is very similar to the *Pm3m* cubic structure. However, the *PC* structure cannot be a cubic structure because the (1-x)P$(Z_{1-z}T_z)$-xPZNN piezoceramics with the *PC* structure show ferroelectric and piezoelectric properties. The *R-PC-T* multi-structure was observed in the (1-x)P$(Z_{1-z}T_z)$-xPZNN piezoceramics ($0.335 \leq x \leq 0.44$) with different z values and the compositions with the *R-PC-T* multi-structure have been suggested. Typically, the piezoceramics with the *R-PC-T* multi-structure exhibit remarkable piezoelectric properties with a high T_C. In particular, the 0.58P$(Z_{0.41}T_{0.59})$-0.42PZNN piezoceramic (x = 0.42 and z = 0.59) shows the large d_{33} of 825 pC/N, k_p of 0.7 and strain of 0.185 % at 3.0 kV/mm with a high T_C of 240 ^{o}C.

Keywords : Piezoceramic, Multi-structure, relaxor, pseudocubic

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Abstract Preference : **Oral**

$Na(Nb_{1-x}Sb_x)O_3$ templates for the [001]-texturing KNN-based piezoceramics and their application to piezoelectric energy harvesters

GEUN-SOO LEE[1], San Kwak[1], Sahn Nahm[*1]

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$Na(Nb_{1-x}Sb_x)O_3$ [$N(N_{1-x}S_x)$] templates were fabricated to texture the $0.96(Na_{0.5}K_{0.5})(Nb_{1-y}Sb_y)O_3$-$0.01BaZrO_3$-$0.03(Bi_{0.5}Ag_{0.5})ZrO_3$ [$KN(N_{1-y}S_y)$-BZ-BAZ] piezoceramics along the [001] direction. Thus far, $NaNbO_3$ (NN) templates have been utilized to texture KNN-modified piezoceramics; however, they produce many holes in the piezoceramics because of the dissolution of the NN templates during sintering. The piezoceramic textured using the $N(N_{0.9}S_{0.1})$ templates showed a large hardness (7.56 ± 0.26 GPa) and an elastic modulus (154 ± 5 GPa) similar to those of the untextured piezoceramic. However, the piezoceramic textured using the NN templates showed reduced hardness (5.94 ± 0.58 GPa) and elastic modulus (127 ± 14 GPa) because of the presence of the holes. The $KN(N_{0.95}S_{0.05})$-BZ-BAZ piezoceramics textured using the $N(N_{0.9}S_{0.1})$ templates provided large d_{33} (740 pC/N) and k_p (0.62) values. Cantilever-type piezoelectric energy harvesters (CPEHs) were produced using the $KN(N_{0.09}S_{0.01})$-BZ-BAZ piezoceramic textured with $N(N_{1-x}S_x)$ templates and the CPEH produced using the piezoceramic textured by $N(N_{0.9}S_{0.1})$ templates generated the largest power of 2.92 mW. Therefore, $N(N_{0.9}S_{0.1})$ is a promising template for the [001] texturing of KNN-based piezoceramics with good mechanical properties.

Keywords : Lead-free, Harvester, Texturing, Piezoelectric ceramics, Template

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Abstract No. : **PO-S03-0692**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Synthesis of $PdRhO_x$@N-CeO_2 core-shell nanoparticles to improve selectivity of H_2 gas sensor

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CeO_2 is a n-type metal oxide semiconductor (MOS) that gained attention as a gas detection material because of its high chemical stability and low price. Furthermore, CeO_2 can provide a more gas adsorption site by converting from Ce^{4+} to Ce^{3+} ion state. However, they have limitations for H_2 sensing due to high operating temperature and low selectivity.

Metal oxide heterostructures can enhance sensitivity even further through heterogeneous junction barriers. $PdRhO_x$ is a p-type MOS with excellent hydrogen absorption ability, which can increase selectivity towards H_2 gas. Due to the high operating temperatures, $PdRhO_x$ particles were agglomerated. This agglomeration can lead to changes in the bandgap, altering the characteristics of the material. As a result, long-term stability is compromised. To overcome this drawback, a core-shell structure was employed to prevent agglomeration.

In this study, $PdRhO_x$@N-CeO_2 core-shell nanoparticles (CSNPs) were synthesized by hydrothermal method and high-temperature calcination. Additionally, calcination was conducted at various temperatures due to the variation in the crystallinity of the CeO_2 shell and the $PdRhO_x$ core according to temperature, after that the crystalline structure and oxidation behavior were investigated through XRD and XPS. Gas sensing tests were performed at various gases and concentrations.

Keywords : PdRhOx, N-CeO2, core-shell structure, nanoparticles, hydrogen gas sensor

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Abstract No. : **OR-S05-0691**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Precious Metals Atomic Layer Deposited 2D MXene for Human–Machine Interface Sensing and Energy Applications

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Precious metals such as Ir, Ru, and Pt are the rarest noble metals with limited reserves requiring precise use. They are costly for real-time applications like human-machine interfacing healthcare monitoring and hydrogen energy applications. To address their scarcity and preciousness challenge as bulk precious materials, we introduce an emerging atomic-level control technique through self-limiting growth and precision, i.e., the atomic layer deposition (ALD) process of the rarest noble metals, for instance, Ru and Ir as single metal atoms or clusters. ALD could potentially overcome the cost issues, selective area deposition-utilization with optimal precision by downsizing the precious metals nanoparticle sizes to its single/dimer/trimer atoms or atomic clusters, hence the improved active surface area over highly hydrophilic, open accordion-like structure 2D MXene. Where MXene is 2D carbide/nitrides/carbonitrides, a broad class and variety of inorganic nanomaterials originated from their parent MAX phase through the chemical etching process. Precious metals (Ru, Ir) ALD-engineered 2D MXene enhanced the overall electronic and electrochemical properties and electron transport channels throughout its layered structure for healthcare sensing and hydrogen electrocatalysis applications. There is an exceptionally high sensitivity performance (approx. 400% times higher), and electrocatalytic activity (approx. 250% times higher) has been demonstrated for (Ru, Ir) ALD incorporated 2D MXene than those of pristine MXene, highlighting the significant influence of Ru, Ir precious metal single atom/clusters on MXene both geometrically and electronically. Hence, we can wisely use precious metals for targeted applications like sensing and clean energy by smartly controlling the Ru-ALD or Ir-ALD cycle numbers, exploring the true potential of the ALD technique.

Acknowledgments
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Keywords : Precious Metals; ALD; MXene; Human-Machine Interface; Clean Energy

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Abstract No. : **KN-S13-0690**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Keynote**

Controlling the Crystallization of Halide Perovskite Film for Solar Cell Applications

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Due to the outstanding properties and solution processability, organometal halide perovskite solar cells (PSCs) rapidly emerge as a high-efficiency and low-cost photovoltaic technology. One of key issues in the manufacturing of PSCs is the facile growth of the halide perovskite films, which is covered in this presentation.

The 1st part of the presentation will show how engineer the SnO_2/perovskite interface by introducing a thin PbS quantum dots (QDs) interlayer and explored the dual roles of PbS QDs in the passivation of SnO_2 ETL and the crystallization of the active PVK layer. A solution of PbS QDs was spin-coated on the SnO_2 film to passivate dangling Sn bonds on the top of SnO_2 and anchor the iodide on the bottom of active layers. The PbS modifier dramatically decreases the defects at the interlayer and suppresses the nonradiative recombination of the deivces. In addition, the PbS QDs underlayer assists the nucleation of perovskite film by stabilizing the intermediate phase between δ and α-$FAPbI_3$ phases. The PVK layer grown on the SnO_2-PbS ETL has a better morphology and crystallization.

The 2nd part of the presentation will address the combination of solvent engineering with the inkjet printing, which can be used for large-scale PSCs fabrication. This presentation reports the printing process of the perovskite precursor solution using a single nozzle printer and the crystallization process of the inkjet-printed perovskite films by solvent engineering. Concerning antisolvent bathing, we systematically studied the effect of the polarity difference between the solvent and the antisolvent on the crystallization and grain growth of the film. It is found that the difference in polarity of solvents and antisolvents proved to be a valuable indicator of if an intermediate phase would form, which in our case was essential for dense grain growth.

Keywords : perovskite solar cell, interface engineering, inkjet printing

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Abstract No. : **PO-S03-0689**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Performance prediction and sensitivity enhancement of piezoelectric microphone using acoustic metamaterials

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In this research, the performance of a piezoelectric microphone is predicted by a simulation model developed using COMSOL multi-physics. Parametric study is carried out investigating the influence of geometrical factors of the membrane, vent-holes, and back chamber on the sensitivity of the piezoelectric microphone. Additionally, we investigate microphone's sensitivity enhancement by adding a specially designed zigzag-shaped acoustic metamaterial structure above the membrane. The air cavity is surrounded by two materials with high acoustic characteristic impedance values(the membrane and the acoustic metamaterial), which induces Fabry-Perot resonance of acoustic waves, leading to higher sound pressure levels. We investigate the effects of diverse variables such as design parameters of the acoustic metamaterial, height of the air cavity (distance between the membrane and the metamaterial), etc., on microphone sensitivity.

Keywords : acoustic metamaterial, acoustic characteristic impedance, piezoelctric microphone

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Abstract No. : **PO-S09-0688**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Effects of carrier trapping on the AlGaN/GaN nanowire wrap-gate transistor's surface and core

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In an AlGaN/GaN nanowire wrap-gate transistor (WGT), we investigated the carrier trap mechanisms at the surface/core using capacitance-voltage (C–V), conductance–voltage (G–V), and noise measurements. The anticipated surface trap density decreases quickly with increasing frequency, with values ranging from 9.1×10^{13} $eV^{-1} \cdot cm^{-2}$ at 1 kHz to 1.2×10^{11} $eV^{-1} \cdot cm^{-2}$ at 1 MHz. Based on the 1/f-noise features, the power spectral density grows with gate bias and shows 1/f-noise behavior in the barrier accumulation area. The gadget displays 1/f-noise behavior at lower frequencies and $1/f^2$-noise behavior at higher frequencies, above 1 kHz. The cutoff frequency for the 1/f2-noise features also shifts to the subordinated frequency ($\sim 10^2$ Hz) side when the manufactured device operates in the deep-subthreshold region.

Keywords : AlGaN/GaN, nanowire, 1/f-noise

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Abstract No. : **PO-S10-0687**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Plasmonic Hydrogel Actuators for Octopus-Inspired Photo/Thermo-Responsive Smart Adhesive Patch

Jeeyoon Kim[1], Jeonghee Yeom[1], Yun Goo Ro[1], Geoseong Na[1], Woonggyu Jung[1], Hyunhyub Ko*[1]

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Living organisms in nature exhibit remarkable adhesive properties, such as mussel, gecko, tree frog, and octopus, inspiring the development of novel adhesive systems for various applications like skin attachable electronics, biomedical devices, and locomotion devices. Recently, octopus-inspired adhesives have gained attention owing to their ability to achieve high adhesion on various substrates. In this study, we propose a smart adhesive patch that mimics the octopus adhesion mechanism, offering tunable adhesion in response to temperature and near-infrared (NIR) light. The smart adhesive patch utilizes photothermally responsive gold nanostar (GNS) and thermo-responsive poly(N-isopropylacrylamide) (PNIPAM) hydrogel on a nanohole-patterned polydimethylsiloxane (PDMS) to modulate the adhesion properties under NIR light and elevated temperatures. The muscle-like, thermo-responsive PNIPAM hydrogel functions as a volumetric actuator to regulate the cavity pressure. The smart adhesive patch shows strong adhesion forces up to 134 kPa at 45 °C and large on-off adhesion ratio (~63) through temperature control. The integration of GNSs in the smart adhesive patch significantly improves the adhesion performance and decreases the response time, especially at high temperatures, due to the high thermal conductivity of gold. The photothermally excited GNS increase the temperature under NIR light irradiation, resulting in high adhesion force of 71 kPa. Finally, we successfully demonstrated the transfer of an ultrathin temperature sensor onto an organ using the smart adhesive patch under NIR light irradiation.

Keywords : smart hydrogel, plasmonic, actuator, adhesion

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Abstract No. : **PO-S03-0686**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Poster**

Low Energy Modulated Multi-layered Artificial Synapse Based on Hyperstable Double Network of Biopolymers

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Artificial synapses have attracted significant interest to mimic the synaptic characteristics of the biological neural system, which are crucial for the learning process in neuroprosthetics, brain-machine interface, and deep learning technology. By emulating the neurotransmitter-based biological signal transmission system, artificial synapses have achieved synaptic characteristics *via* ion migration according to various external stimuli. Meanwhile, despite of the necessity for developing biodegradable materials to address discarded electronic waste, their susceptibility to moisture and heat has retarded them to be utilized on electronic devices. Here, we develop a biopolymer-based hyperstable and low energy modulated multi-layered artificial synapse (M-AS) in stacked ion active layer (IAL)-ion binding layer (IBL)-ion active layer (IAL) structure, where IALs are crosslinked chitosan (CS) and guar gum (GG) double network with NaCl ion and IBL is a dielectric cellulose acetate (CA) to provide ion accumulating sites through the ion-dipole coupling (IDC). Since CS and GG polymers assigned their hydrogen bonding to crosslinking, crosslinked CS/GG is less susceptible for moisture to achieve hyperstability. Additionally, IDC at the interface of IAL-IBL facilitates ion accumulation to generate synaptic characteristics including paired-pulse facilitation and long-term plasticity, which can be improved by introducing CA with high dielectric properties. Consequently, extremely low threshold voltage (20 μV) is enough to operate M-AS with remarkably low energy consumption (0.85 fJ), which is lower than that of biological synapse.

Keywords : Artificial synapse, Biodegradable material, Hyperstability, Low energy consumption

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Abstract No. : **OR-S11-0685**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

Ferroelectrically Augmented Thermoelectric Potential for Efficient Heat Utilization System

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A thermoelectric generator (TEG) is a promising device for energy harvesting, which produces electric energy via the Seebeck effect. However, low energy conversion efficiency and stability still remain the main challenges of TEG. To address these limitations, the recent work demonstrated the optimized Bi_2Te_3 ink-based TEG with charged triboelectric materials to enhance the output voltages by contact electrification. Although the output power was increased, the retention time was still short to applicate. Herein, we propose TEG with a Cu/p-type BiSbTe/Au/Cr/SiO_2/Si in which poled ferroelectric materials are attached at the cold zone. When the poled ferroelectric materials are attached at the back of TEG, the remanent polarization increases charge mobility permanently, inducing charges created on the TEG. The output voltage of TEG coupled with *x* vol.% $BaTiO_3$-added Pb(Ni,Nb)O_3-PbZrO_3-PbTiO_3 ceramic (*x*=0, 1, 2, 4) is 8.3 mV when the temperature difference is 25 K, which is up to 2 times higher than the output voltage of conventional TEG, sustaining this enhancement for over 30 days. In addition, investigations into varying BT compositions reveal significant dependencies of output voltage on remanent polarization (P_r) values and electric polarization direction. To achieve application to thermoelectric cooler, large-scale TEG is fabricated, consisting of 16 legs, and the 10 mF-capacitor is fully charged within 30 seconds. Finally, thermoelectric cooling (TEC) system has been applied and the cooling rate is 1.8 times faster than the system without TEC. This approach provides broad applications of TEG and promises practical implementation by significantly enhancing output performance and retention time without requiring further material modification.

Keywords : thermoelectric generator, ferroelectric, heat utilization

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Abstract No. : **PO-S10-0684**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Label-free colorectal cancer detection using Gold nanoparticle and plasmonic SERS needle sensor

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In this paper, we introduce a SERS needle sensor for label-free detection of colorectal cancer applications. Polymerized dopamine (PD) was used as an adhesive layer on the needle surface and at the same time functioned as a reducing agent for nucleation of gold seed nanoparticles. Then, based on the surface-catalyzed reduction of gold ions by hydroxylamine, the Au nanostructures were further grown to form high-density gold nanocages (AuNCs) with a size of 200 nm. The layered components forming the AuNC structure on the needle surface could be well defined by transmission electron microscopy (TEM) analysis. Due to the abundant hotspot regions formed between the AuNC sites, the SERS needle sensor exhibited high uniformity and good molecular sensitivity with detection limits of 2×10^{-8} M for malachite green. For field application, the SERS needle sensor was equipped with an endoscopy system for colorectal cancer sensing using a mouse model. The Raman signals obtained from SERS needle sensor-assisted endoscopy were analyzed and classified using a machine learning method, successfully discriminating the colorectal cancer and normal mouse models. The developed SERS needle sensor is expected to be utilized for non-invasive and label-free on-site sampling and detection of tumor tissues.

Keywords : colorectal cancer; endoscope; dopamine; gold nanoparticle

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Abstract No. : **OR-S05-0683**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Bioelectric Sensor Utilizing Nanoporous MoS_2 FETs Mimics *Drosophila* Olfactory System for Highly Selective and Sensitive Ethanol Detection

Junoh Shim[1], Anamika Sen[1], Heekyeong Park[1], Arindam Bala[1], Sunkook Kim[*1]

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Our sense of smell, primal and powerful, deeply influences our emotions and instincts. This sensory mechanism plays a crucial role in detecting volatile organic compounds (VOCs) and interpreting the chemical landscape. Unlike humans, animals possess a superior olfactory system. Thus, artificial olfaction endeavors to mirror nature's excellence in VOC detection.

In this study, we introduce an innovative artificial olfactory sensor employing nanostructured bio-field-effect transistors (bio-FETs) based on transition metal dichalcogenides (TMDs) and the odor-binding protein LUSH from *Drosophila*. To create an efficient sensing platform, we fabricated hexagonal nanoporous structures of molybdenum disulfide (MoS_2) using block copolymer lithography and selective etching techniques. This architecture provides numerous active sites for integrating the LUSH protein, enhancing its binding affinity with ethanol (EtOH) for detection purposes.

The integration of biomolecules with EtOH influences the bio-FET, generating discernible electrical signals. By emulating the sniffing mechanism observed in *Drosophila*, these bio-FETs exhibit an impressive detection limit of $10^{-6}\%$ for EtOH, demonstrating high selectivity, sensitivity, and efficacy even in real-world conditions. This bioelectric sensor holds significant promise in advancing the field of artificial olfaction, particularly in VOC detection.

Keywords : artificial olfaction, OBP, field-effect transistor-based biosensor, block copolymer lithography, hexagonal nanoporous MoS2

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Abstract No. : **KN-S13-0682**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Keynote**

Harnessing Light Energy with Crystalline Silicon Nano- and Micro-Structures

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Recent advances in nanotechnology and our growing understanding of how light interacts with nano- and micro-structures have significantly improved our ability to capture and manipulate light. In this talk, I will discuss research results that have leveraged crystalline silicon micro-structures as a promising approach for developing next-generation energy-harvesting devices from solar energy. Specifically, micro-structuring crystalline silicon enables the creation of novel devices, such as flexible and transparent solar cells—applications not previously feasible with traditional, rigid, and opaque crystalline silicon. Moreover, crystalline silicon is considered a leading material for solar-to-chemical conversion applications. I will also present demonstrations of an artificial leaf for water splitting and a large-scale hydrogen generation system using crystalline silicon. Additionally, I will introduce a discussion on a nanowire-based photodetector with high external quantum efficiency.

Keywords : crystalline silicon, solar cells, flexible, transparent, photodetector

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Abstract No. : **OR-S05-0681**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Friction Material Optimized for DLC Coating with Transition Metals

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Diamond-Like Carbon (DLC) coatings exhibit low-friction properties primarily because of a tribofilm that forms through carbon transfer to the mating material, although the friction level can vary based on the material used. This study aimed to identify an optimal mating material for DLC. We evaluated four 3d-transition metals—titanium (Ti), iron (Fe), nickel (Ni), and copper (Cu)—choosing them for their chemical compatibility with carbon, including aspects like carbide formation and work of separation. Titanium was identified as having the lowest friction coefficient among the materials tested, followed by iron, nickel, and copper. Employing non-destructive Raman spectroscopy with confocal optics, we analyzed the tribofilm structures on the materials. The findings indicated that titanium effectively bonds with carbon to create a durable tribofilm, leading to reduced friction

Keywords : Diamond-Like Carbon; Transition metal; Low friction ; Tribofilm

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Abstract No. : **PO-S09-0680**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Applying Nanoporous Morphology Formation Techniques to Large-Area Thin Film Semiconductor Materials for Next-Generation Optoelectronics

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Amorphous metal oxide semiconductors exhibit characteristics such as a smooth interface, low roughness, and lack of grain boundaries, leading to a large current on/off ratio and high field-effect mobility. They demonstrate excellent transport and controlled carrier concentration. Additionally, they possess optically transparent properties and have already been commercialized in the field of flat panel display technology. The band gap of IGZO is 3-4 eV, which is considerably larger than that of typical semiconductor materials. Consequently, while they exhibit high reactivity in the UV region of the spectrum, their reactivity is limited in the visible to near-infrared range due to the formation of defect imparted subgap states within the IGZO band gap for electronic transition. In this study, we introduce nanoporous IGZO thin film that exhibits reactivity not only in the UV region but also in the visible to NIR range, using block copolymer lithography. This process enabled selective etching, resulting in the trapping of subgap states, thereby extending the detection of the bandgap to the visible range and even the NIR region. By investigating the photosensitivity and photoresponsivity of bottom-gate phototransistors using nanoporous IGZO material under 638nm (Pinc=512mWcm^{2-}) light illumination, we obtained values of 8.6x10^{4} for photosensitivity and approximately 120A/W for photoresponsivity. Based on these results, we fabricated a 7x5 active pixel image sensor array comprising 35 individual pixels and confirmed its excellent performance under RGB and NIR illumination. These research findings suggest potential applications in next-generation large-area optoelectronics as well as in fields such as olfactory gas sensory systems.

Keywords : Optoelectronics, Amorphous metal oxide semiconductor, Active pixel image sensor array

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Abstract No. : **PO-S06-0679**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of heat treatment on wear mechanism of TiC/FC250 composites.

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In this study, metal composites were prepared using TiC as the reinforcing material and FC250 as the matrix material through the Liquid Pressing Infiltration process. Heat treatment was conducted to enhance the mechanical properties, and the wear test was performed using the ball-on-disc method to assess the wear behavior of the composite. The test temperatures were room temperaturee(RT), 50ºC, and 100ºC, respectively. The hardness of FC250 was 153HV. It has been confirmed that there are flake-shaped graphite particles in the ferrite base structure in its as-cast state. After incorporating TiC into the FC250, the hardness increased approximately two-fold in all heat treatments. SEM-EPMA analysis confirmed the even distribution of TiC in the base material. During hte high-temperature process, the fragmented graphite was observed to become sphericalized and coarsened.No defects were found at the interface; the black dots observed were TiC particles and graphite from the base material, not pores. Among the heat treatment conditions, the quenching-tempering condition showed a wear width approximately 5times wider and a wear depth about 1.4 times deeper at all wear test temperatures. The microstructure of the base material was transformed into accicular martensite through heat treatment, which increased its hardness and enhanced wear resistance.

Keywords : FC250, TiC/FC250 composites, heat treatment, wear test

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Abstract No. : **PO-S18-0678**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Poster**

Flexible Neural Probe with mechanically transient insertion shuttle for Deep Brain Decoding in Non-Human Primates

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The demand for long-term monitoring has prompted the development of flexible neural probes designed to match the mechanical properties of brain tissue. This engineering approach aims to minimize the risk of tissue damage and inflammation, enabling long-term implantation and reliable signal recording. Despite the considerable advantages offered by flexible neural probes, their utilization is hindered by the inherent challenge posed by their flexibility, which impedes precise insertion into brain tissue. This limitation has largely restricted the application of such probes to small animals like rodent where depth of insertion required is minimal. Larger animals, such as non-human primates, present a greater challenge due to the need for deeper probe placement. NHPs are crucial component of this type of research, given their complex brain connectivity and neuroanatomy that closely resembles that of humans. In this study, we develop a bioresorbable, shuttle-assisted flexible neural probe specifically designed for the deep brain regions of NHPs. The study employed a 32-electrode PI neural probe, designed narrowly in two layers to reduce brain invasion. Building upon this foundation, the electrodes, initially patterned with gold, and then electroplating with platinum and iridium oxide, enhancing their conductivity. The shuttle, designed with a u-beam shape, provides temporary stiffness and high buckling force of 90 mN, enabling precise insertion. Upon insertion into the deep brain regions, the shuttle rapidly dissolves, exposing the electrodes to the brain tissue and facilitating signal recording. We recorded local field potentials (LFPs) in the NHP's lateral hypothalamic area (LHA) during phases with and without food for a month. These data were subsequently analyzed using a Convolutional Neural Network (CNN), enabling the classification of distinct eating behaviors with an accuracy of 90.3%. This approach demonstrates the probe's capability to facilitate brain circuit studies in deep brain region, showcasing its substantial promise for advancing brain research.

Keywords : Flexible neural probe, Deep Brain, Non-Human Primates, Neural Recording

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Abstract No. : **OR-S03-0677**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Oral**

Plasmon-activated H_2 gas sensor based on $Au_{nanorod}$@ZnO core-shell nanoparticles at room temperature

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Zinc oxide (ZnO) is regarded as one of the most promising materials for hydrogen gas sensor due to its high surface area, chemical stability, and low cost. However, while operating at room temperature, the surface of ZnO is unable to supply an adequate amount of activation energy, resulting in poor sensitivity and imperfect recovery in detecting hydrogen.

To overcome the above constraints, developing a light-assisted gas detection protocol is highly essential. Herein light induced-noble metal (e.g., Au) leaded ZnO is proposed, which is expected to promote the sensitivity and improve the detection ability of hydrogen gas sensor based on ZnO materials at room temperature. The introduction of Au nanorods (NRs) is considered as an effective method to enhance the visible light absorbance of ZnO materials, which can be attributed to the excitation of localized surface plasmon resonance (LSPR) effect along transverse and longitudinal directions.

In this study, the $Au_{nanorod}$@ZnO core-shell nanoparticles (CS-NPs) are prepared via hydrothermal method and their gas sensing characteristics working under visible light illumination with different wavelengths using LEDs having blue light (450 nm), green light (515 nm), and red light (650 nm) at room temperature are presented. The LSPR properties of Au NRs enhance the absorption in the visible range providing sufficient energy to promote the sensor response compared to pure ZnO and Au_{sphere}@ZnO sensors. According to our results, the presence of LSPR by Au NRs in $Au_{nanorod}$@ZnO sensor not only extends the functionality of ZnO NPs towards longer wavelengths (green and red light) but also increases the response at shorter wavelengths (blue light). Moreover, this sensor also exhibits high selectivity to hydrogen against other target gases. The better performance of the $Au_{nanorod}$@ZnO sensor is mainly attributed to the LSPR and electronic sensitization effects of Au NRs core.

Keywords : Visible-light activation, Au nanorod, core-shell, ZnO, hydrogen gas sensor

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Abstract No. : **PO-S05-0676**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

First-principles investigation of phonon transport properties of fluorographene

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As electronic devices become increasingly integrated and miniaturized in the semiconductor industry, there's a growing demand for high-performance thermal interface materials. These materials need to exhibit both high thermal conductivity and low electrical conductivity. Moreover, if they demonstrate strong anisotropy, they can efficiently control heat. Fluorographene, a derivative of graphene with fluorine atoms attached, possesses these desired characteristics and is being explored as a potential candidate for next-generation thermal interface materials. In our study, we delved into the heat transport properties of fluorographene compared to pristine graphene using density functional theory and density functional perturbation theory. We obtained the room-temperature in-plane lattice thermal conductivity of monolayer fluorographene: 112.2 W/mK and 145 W/mK by using the single mode relaxation time approximation (RTA) and the full linearized Boltzmann transport equation (LBTE) solutions, respectively. Notably, the LBTE value for fluorographene is significantly lower than that of graphene, which can mainly be attributed to the heavy substituent fluorine atoms. We meticulously examined each phonon mode to understand their individual contributions to heat transport properties. Furthermore, we analyzed the thermal conductivity of multilayer fluorographene, observing variations with the number of layers. Overall, our research sheds light on the potential of two-dimensional thermal interface materials and provides valuable insights for the development of next-generation solutions in this field.

Keywords : fluorographene, graphene, density functional theory, thermal conductivity, thermal interface material

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Abstract No. : **IN-S11-0675**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Invited**

Functional Electroactive materials for Heat managements and Nanoplastic filtration

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Tribomaterials are important not only for improving the output performance of energy harvesting devices but also for extending their applications. In general, the static surface charges are created by the contact electrification, in which the driving force is possibly related to the difference of the surface chemical potential. However, as limited by the surface potential difference, the charge density generally cannot reach an ultimate high level to approach, commonly ~ tens of uC/m2.

Here, we present facile strategies to maximize the charge density via sophisticated materials design as well as the potential applications such as Heat managements and nanoplastic filteration. A new dielectric, a C60-containing block polyimide (PI-b-C60)1, a new cationic material structure consisting of SiO2 and MoS2 coated on a Ni-mesh in sequence was presented.2 These materials are applied to enhancing the output voltage of a thermoelectric generator by introducing highly charged polyimide-based dielectrics.3 Finally, an efficient strategy to enhance the filtration of nanoplastic will be also presented.

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Keywords : Tribomaterials, Energy harvesting, Nanoplatic filteration

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Abstract No. : **OR-S16-0674**
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Abstract Preference : **Oral**

In-depth correlation analysis between tear glucose and blood glucose using a wireless smart contact lens

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With the development of a healthcare system, studies regarding the diagnosis of diabetes non-invasively by monitoring the glucose level in various body fluids such as tear, saliva and ISF are ongoing. Among them, tear is emerging as the one of the most promising body fluids for monitoring health conditions and many studies are underway to measure the tear glucose level through various biomedical platforms including contact lenses. For these platforms to be reliable for diagnosing diabetes, it is essential to clarify the correlation between blood glucose and tear glucose which remains controversial. To address this controversial issue, studies that present the relationship between blood glucose and tear glucose using smart contact lens were reported. However, previous smart contact lenses were operated only at specified time which is non-continuous and have failed to identify the exact correlation.

Herein, we present an in-depth investigation of the correlation between tear glucose and blood glucose using a wireless and soft smart contact lens for continuous monitoring of tear glucose. This smart contact lens is capable of quantitatively monitoring the tear glucose levels in basal tears excluding the effect of reflex tears which might weaken the relationship with blood glucose. Furthermore, this smart contact lens can provide an unprecedented level of continuous tear glucose data acquisition at sub-minute intervals. These advantages allow the precise estimation of lag time, enabling the establishment of the concept called ‘personalized lag time’. This demonstration considers individual differences and is successfully applied to both non-diabetic and diabetic humans, as well as in animal models, resulting in a high correlation.

Keywords : smart contact lens, tear glucose, wearable device

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Abstract Preference : **Poster**

Fully implantable neural recorder for studying naturalistic behaviours in primates

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A neural recorder is a central device for studying neurological mechanisms inherent in specific behavioural and cognitive states by monitoring brain neural signals. Real-time recording of large volumes of brain neural signals is particularly important for the diagnostic performance of future clinical electroceuticals. Among several animal models, non-human primates can provide pre-clinical insights through neural recorders due to their resemblance to humans in brain neuroanatomy and complex neural connectivity allowing exploration of advanced cognitive functions. However, the large brain volumes, extensive range of uncontrolled movements, and inherent wildness of primates pose substantial engineering challenges for the covert, long-term recording and analysis of deep brain neural signals amidst wild-like naturalistic behaviours. Here, we introduce a stealthy neural recorder for studying naturalistic behaviours in freely-moving primates. The neural recorder incorporates a miniaturised wireless embedded system, a flexible neural probe with a 3D nano-porous multielectrode array, a mechanically transient bioresorbable shuttle for deep brain insertion, and a repeater coil-based wireless power transfer system for body-scale operation range. we successfully recorded neural signals in the lateral hypothalamus area (LHA) and behavioural signals over one month in the freely moving monkey during eating behaviours. Then, the developed artificial intelligence model classified eating behaviour phases with extracted biomarkers from recorded neurobehavioural signals. By analysing neural and acceleration signals, we can dissect the various phases of eating behaviour, shedding light on the neural circuitry involved in these instinctive actions. Our stealthy neural recorder not only validates the functionality of our neural interface but also offers a blueprint for future research aimed at unravelling the complex interplay between neural activity and behaviour. The potential applications of this technology extend far beyond academic inquiry, offering promising insights for the development of novel diagnostics and therapeutic strategies in neurology and psychiatry.

Keywords : Neural Interface, Wireless, Wireless Power Transfer, Brain, Non-Human Primates

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Abstract Preference : **Poster**

Deep Neural Network (DNN)-Assisted Monitoring of Trastuzumab Efficacy in HER2-Overexpressing Breast Cancer via SERS Immunoassays of Tumor-Derived Urinary Exosomal Biomarkers

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Monitoring drug response is an important part of the current approach to companion diagnostics in metastatic breast cancer. Trastuzumab, a drug that targets the human epidermal growth factor receptor 2 (HER2), is an effective treatment for metastatic breast cancer. However, some patients develop resistance to this therapy, so monitoring its efficacy is essential. Here, we describe a deep neural network (DNN)-assisted monitoring of trastuzumab efficacy based on a surface-enhanced Raman spectroscopy (SERS) immunoassay against HER2-overexpressing mouse urinary exosomes. Individual Raman reporters bearing the desired SERS tag and exosome capture substrate were prepared for the SERS immunoassay; SERS tag signals were collected to prepare DNN training data. Using this DNN algorithm, various complicated mixtures of SERS tags were successfully quantified and classified. Exosomal antigen levels of five types of cell-derived exosomes were determined by SERS-DNN analysis and compared with those obtained by quantitative reverse transcription-polymerase chain reaction and Western blot analysis. Finally, drug efficacy was monitored by SERS-DNN analysis using urinary exosomes from trastuzumab-treated mice. The use of this monitoring system should allow proactive responses to any treatment-resistant problems.

Keywords : exosomal antigen, trastuzumab efficacy monitoring, surface enhanced Raman scattering, HER2-overexpressing breast cancer, deep neural network

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Abstract No. : **PO-S14-0671**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Stabilizing 2D-TiO$_2$ nanorod arrays in strong alkaline conditions via amorphous carbon layer shielding toward solar-driven water splitting

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Titanium dioxide (TiO$_2$) has emerged as an ideal photoanode for photoelectrochemical (PEC) water splitting; however, its redox activity is substantially hampered by the limited light absorption, slow charge dynamics, and sluggish oxygen evolution reaction (OER) kinetics. To overcome these issues, in this study, we present a unique strategy for the encapsulation of TiO$_2$ nanorods (NRs) with an amorphous carbon layer. Herein, the functional carbon layer is served for interface passivation and to facilitate charge transport from electrode to electrolyte. Moreover, the crystalline-amorphous (c-a) interface led to improved activity and inhibited the hole accumulation at TiO$_2$ NRs surface. The PEC water splitting experiments demonstrated the photocurrent density value of c-TiO$_2$ NRs is increased multi-fold as compared with bare TiO$_2$ NRs. Moreover, the applied-bias photon-to-current conversion efficiency (ABPE) value for c-TiO$_2$ NRs is drastically improved. The electrochemical impedance spectroscopy (EIS) analysis revealed that the charge transfer resistance of TiO$_2$ NRs is dropped after the deposition of the carbon layer. The long-term stability studies in strong basic media showed that c-TiO$_2$ NRs were highly stable over ~24h without any considerable structural deformation. These results showed that encapsulation of TiO$_2$ NRs with an amorphous carbon layer is an effective tactic to develop a durable PEC water splitting system.

Keywords : Titanium Dioxide, Nanorods, Photoanode, Carbon, Photoelectrochemical Water Splitting.

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Abstract No. : **OR-S14-0670**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Exploiting the full potential of bismuth vanadate photoanode via Z-scheme heterojunction, surficial oxygen vacancies, and interfacial co-catalyst loading for durable photoelectrochemical water splitting

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N-type bismuth vanadate ($BiVO_4$) is gaining considerable attention owing to its fascinating photoelectrochemical (PEC) features toward water splitting application. Nevertheless, the performance of $BiVO_4$-based systems is far from practical realization, and further improvement is urgently required. The major intrinsic hurdles of $BiVO_4$ include sluggish oxygen evolution reaction (OER) kinetics, limited light harvesting, charge recombination, and below-par stability in electrolytes under illumination. To address these limitations, we present multiple innovative strategies such as the construction of Z-scheme heterojunction with graphitic carbon nitride (g-C_3N_4), formation of surficial oxygen vacancies (O_{vac}), and loading of interfacial 2D-NiFe-layered double hydroxide (LDH) co-catalyst. The PEC water splitting analysis revealed that $BiVO_4$/g-C_3N_4 photoanode exhibited a photocurrent density maximum of 1.14 mA cm^{-2} at 1.23 V vs. RHE along with 10h of long-term stability. Moreover, the integration of oxygen vacancies and 2D-NiFe-LDH nanosheets onto $BiVO_4$ demonstrated the superior photocurrent value of 2.92 mA cm^{-2} at 1.23 V vs. RHE which was multifold higher than bare $BiVO_4$ photoanode. Further studies showed that the $BiVO_4$:O_{vac}/NiFe-LDH photoanode retained ~91% of its initial photocurrent over ~20h without any significant deterioration. Our studies shed light on the involved mechanism that boosted the PEC performance of $BiVO_4$ photoanode via a combination of various rational strategies. This work can provide the foundation for developing highly efficient and stable $BiVO_4$-based systems in the PEC water splitting landscape.

Keywords : Photoelectrochemical Water Splitting, Bismuth Vanadate, Heterojunction, Surface Engineering, Co-catalyst Loading.

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Abstract No. : **OR-S18-0669**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Oral**

An Integrated Monitoring System for Brain Organoids with Electrical Stimulation as a Bioreactor Technology

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Cerebral organoids have emerged as a powerful tool, offering profound insights into complex brain functions, developmental processes, and neurological diseases. However, conventional platforms lack the capability to precisely monitoring intra-organoids over extended periods and do not effectively address issues such as the formation of necrotic cores, which compromise the long-term integrity of organoids. Here, we present an integrated monitoring-stimulation system designed to comprehensively analyze the density distribution and electrophysiological signals within organoids. Thise system utilize electrical stimulation as a bioreactor technology to enhance organoid viability and quality. On this platform, we cultured organoids with electrical stimulation and simultaneously monitored their maturation and condition over the long-term with minimal invasiveness, thus validating the efficacy of our approach. By cultivating the organoids and specifically targeting the central region with electrical stimulation, we enhanced metabolism and neuroplasticity, which in turn promoted cell proliferation and maturation, and effectively reduced the formation of necrotic cores. This approach represents a significant advancement in utilization of organoids within brain research, demonstrating promising potential for broader scientific inquiry and therapeutic development.

Keywords : Cerebral organoid, Monitoring platform, Bioreactor

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Abstract No. : **IN-S17-0668**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Invited**

Microfluidic Approaches for Innovative Pharmaceutical Production & Development Process

Dongpyo Kim[*1]

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Continuous-flow chemical process in the confined microfluidic space at submillimeter scale is attractive owing to inherent advantages such as efficient heat transfer and rapid mixing, enabling greater control of reaction conditions in easy up-scaling, and the integrated operation for productions of drug delivery systems (DDS), as well as cosmetics and specialty chemicals.

At first part of the talk, general advantages of microfluidic reactor against bulk reactors is introduced for better understanding on the reason why the flow-chemistry leads to superior chemical performance. And, microdroplets (μ-droplet) and nanoparticles (NPs) have been attracted to address different DDS challenges in the aspects of bioavailability, drug solubility and targeted delivery. And the microfluidic approaches are used for effectively encapsulating various therapeutic agents (small molecular drug, genes, enzymes, chelators, functional NPs etc.) into uniform size of μ-droplet and NPs from polymer and lipids using on-demand type of micro-reactor or -mixer.

Moreover, development of new materials using current passive chemical methodologies faces limitations in terms of time and cost. Following by microfluidic approaches, we are moving toward developing “flow-based autonomous optimization system” that quickly derives the optimal parameters or new routes of DDS process, by using computer controlled microreactors, real-time analysis, AI (artificial intelligence)-based virtual experiment algorithm, such as Bayesian optimization, and predictive decision, reactions in feedback loop. In the future, robot controlled “self-driving lab” would be developed by a convergence/collaborative teamwork among interdisciplinary experts.

Keywords : microfluidic, drug delivery systems, rapid optimization, autonomous process,

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Abstract No. : **OR-S19-0667**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Acoustic optimization for MEMS microphone and sensitivity enhancement through acoustic metamaterial

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The development of a MEMS microphone requires optimization of the acoustic design, as smaller sizes exhibit high acoustic impedance in the low-frequency regime. In this study, we use a multi-physics simulation model to optimize the geometrical parameters of the membrane and the vent holes of the MEMS microphone, including their shape, size, and thickness. Additionally, we propose a unique shape for the back chamber that incorporates impedance-tailoring acoustic metamaterials, aiming to tailor peak sensitivity toward a desired frequency. We demonstrate that by carefully designing the membrane, vent holes, and back cavity, an enhancement of 10 dB or more can be achieved in the low-frequency regime.

Keywords : acoustic, optimization, MEMS, metamaterials

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Abstract No. : **PO-S02-0666**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Development of super narrow band gap all-inorganic perovskite by solution-processing

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The utilization of perovskite materials in solar cells has attracted significant attention due to their promising efficiency and cost-effectiveness. Nevertheless, challenges remain in controlling the bandgap of perovskites to below 1.2 eV, which is crucial for their photovoltaic applications targeting infrared regions. Recent advancements have seen the emergence of **novel perovskite materials capable of absorbing longer wavelength photons IR region (up to ~1800 nm)** are highly sought for their utilization as super narrow band gap sub-cells in tandem solar cells, single-junction perovskite solar cells, and diverse device applications. This research particularly emphasizes the potential of materials inspired by metal halide perovskites, namely halide double perovskites. However, the exploration of this materials is currently in its early stages of development.

This study proposes halide double perovskites as viable alternatives, by offering a comprehensive investigation of synthesis and characteristics especially for **$Cs_4CuSb_2Cl_{12}$ (CCSC) double perovskite**. CCSC nanocrystals were successfully synthesized through grinding and ball milling, and a thin layer (~10μm) was also fabricated using a sonicated suspension solution in IPA. Absorption measurements revealed that the band gap of CCSC nanocrystals is 0.92 eV, demonstrating **ability of absorbing wavelength beyond 1300 nm**. Also, the CCSC thin film exhibited an exceptionally low bandgap of approximately 1.05 eV. Additional measurements including X-ray diffraction (XRD), photoluminescence (PL) and scanning electron microscope (SEM) were performed to elucidate the properties of material. The detailed process and characterization were descripted, including strategies to address current challenges and future outlook for its applications. Consequently, this study provides crucial guidance on search new classes of perovskite materials and the advancement of next-generation technologies.

Keywords : super narrow band gap, all-inorganic, perovskite

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Abstract No. : **PO-S10-0665**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Early diagnosis and label-free detection of arthritis using 3D plasmonic paper-based SERS sensors

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This study presents the development of a paper-based surface-enhanced Raman scattering (SERS) sensor for the label-free detection and early diagnosis of rheumatoid arthritis(RA) and osteoarthritis(OA). A three-dimensional gold nanoarchitecture is fabricated on a paper substrate with high absorptive properties via a simple one-step direct gold reduction, resulting in the formation of dense urchin-like nanoparticles. The sensor exhibits remarkable uniformity and high SERS sensitivity towards malachite green, with a detection limit of 1 nM. The developed sensor is then utilized for the diagnosis of RA and OA by the analysis of patient synovial fluid samples via label-free SERS sensing. A support vector machine-based machine learning method was used to successfully classify the Raman spectral features of RA and OA samples, with high sensitivity and specificity. Furthermore, Raman profiling of metabolites previously reported to be released in synovial fluid is conducted, with the objective of identifying potential biomarker candidates for the sensing and diagnosis of arthritis. It is anticipated that the developed sensor will be applicable for the screening and diagnosis of various conditions utilizing not only synovial but also other human biofluids.

Keywords : SERS, Label-free detection, Machine learning, Metabolites

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Abstract No. : **PO-S14-0664**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

High-Performance Copper-Based Cathode for Solar Panel-Integrated Carbon Dioxide Reduction Systems

Chaewon Seong[1], Jiwon Heo[1], Pratik Mane[1], Vishal Burungale[1], Hyojung Bae[2], Jun-Seok Ha[*1]

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Converting CO_2 to value-added chemicals and fuels has been considered an effective approach to mitigate environmental challenges. In this regard, copper (Cu) plays a crucial role as an intermediate in CO_2 conversion, facilitating the formation of diverse products due to its strong adsorption properties. Notably, it stands out as an ideal material capable of yielding C2+ compounds, which are challenging to obtain through electrochemical processes. Hence, copper holds great potential as an electrode material in carbon dioxide reduction. However, enhancing performance and stability remains imperative, given issues such as suboptimal Faraday efficiency (FE) and product selectivity. To address these issues, herein, we developed a highly efficient metal-organic framework (MOF) catalyst combined with Cu metal. MOFs provide a porous structure that can stabilize Cu and create the catalytic active sites for the CO_2 conversion process. In addition, MOF offers suitable support to Cu and inhibits aggregation and deactivation during redox reactions. The Integrated solar PV system was employed to carry out CO_2 reduction reactions via a fabricated catalyst. This approach utilizes the fascinating features of both materials and provides a unique pathway for mitigating carbon emissions and harnessing solar energy for environmental benefit.

Keywords : Electrochemical(EC), CO2 reduction(CO2RR), Copper-based catalysts, Metal organic frameworks (MOFs)

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Abstract No. : **PO-S03-0662**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Stretchable Ionic Composites for Strain-Insensitive Dual-Mode Pressure and Proximity Sensors

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A stretchable pressure sensor independent of disturbances is crucial for wearable applications. In this study, we introduce a stretchable and strain-insensitive pressure sensor, achieved by establishing a conductive pathway through an ionic bridge between conductive fillers. With a micro-patterned insulating layer, our pressure sensor exhibits high strain insensitivity under tensile strain (~ 50 %) and bending curvature (~ 1.3 cm^{-1}). Moreover, it functions as a capacitive-type proximity sensor capable of identifying approaching objects with high sensitivity (capacitance change ($\Delta C/C_0$) of -0.88). As a proof-of-concept, our dual-mode pressure sensor with a multichannel array enables real-time monitoring of contact/noncontact pressure distribution regardless of mechanical interference and surface roughness. Our approach to achieving high sensitivity and selectivity for desired contact/noncontact stimuli independent of mechanical interferences offers a novel platform for practical sensor applications.

Keywords : Strain-insensitive, Stretchable, Contact/Non-contact sensor, Electrical bridge, Electronic-ionic conductive composite

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Abstract No. : **OR-S05-0661**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Structural Phase Transition of Triangular MoS_2 Nanocrystals using small gas molecules: DFT study

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Molybdenum disulfide (MoS_2) has attracted much attention as a material to replace the noble-metal-based hydrogen evolution reaction catalyst. Polymorphism is an important factor in improving the catalytic performance of transition-metal dichalcogenides (TMDs) including MoS_2. Several methods have been proposed to synthesize the 1T/1T′ phase with high catalytic efficiency, and a gas−solid reaction has recently been proposed as one of the alternative methods. However, the atomic-scale reaction mechanism between gas molecules and MoS_2 has not been clarified. Here, we report a detailed atomic-scale mechanism of structural phase transition of MoS_2 nanocrystals under reaction with CO gas molecules using density functional theory calculations. We confirm that the evaporation of S atoms at the edge is much faster than the evaporation at the basal plane of MoS_2 nanocrystals. It is found that the S evaporation at the edge induces the structural change from 2H to 1T/1T′ in the basal plane of nanocrystals. The structural change is also attributed to the chain reaction due to the sequential migration of S atoms to the octahedral sites, which is energetically favorable. The present results provide a guideline for the gas−solid reaction-based phase control of TMDs including MoS_2 to synthesize a high-performance catalyst.

Keywords : MoS2, DFT, TMD, Phase transition, Nanocrystal

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Abstract No. : **OR-S14-0660**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Tailoring Schottky Barriers and Active Sites in Bi-metallic Cluster Mesoporous Carbon Nitride Heterostructures nanocomposite for Hydrogen Evolution with In-situ insights

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The advancement of photocatalysis relies on the development of novel hetero-structured materials with unique architectures. In this study, we successfully synthesized a hetero-structured g-C_3N_4 (GCN) material with a distinctive surface modification. To further enhance its photocatalytic performance, we optimized the Ag-Ni concentration to maximize the active sites for hydrogen evolution reactions. By using systematic physicochemical characterizations and density functional theory (DFT) calculations, we elucidated the pivotal role of graphitic carbon nitride (g-C_3N_4) in facilitating the formation of an efficient charge transfer channel and promoting the effective generation and separation of photo-generated carriers. From the DFT calculations, we also demonstrated that the Ag-Ni nanoparticles provide more efficient active sites than Ni nanoparticles for water splitting and hydrogen evolution and In-situ TEM exploration. Furthermore, the hetero microstructure consisting of thin g-C_3N_4 nano scrolls has a crucial role in shortening the migration distance of the carriers, effectively suppressing carrier recombination. Consequently, these extraordinary characteristics resulted in a superior solar light-driven photocatalytic H_2 evolution rate of 2507 μmol h^{-1} g^{-1}, surpassing the rate achieved by bulk g-C_3N_4 by a remarkable 18.6-folds. Moreover, the apparent quantum efficiency of this hetero-structured material reached an exceptional value of 1.6% under a 1.5 G air mass filter.

Keywords : Nano scrolls, Surface-active site, Solar, Photocatalyst, and quantum efficiency

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Abstract No. : **IN-S09-0659**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Invited**

A study on the structural and electrical properties of ferroelectric $Hf_{0.5}Zr_{0.5}O_2$ thin films fabricated under vacuum condition

Younghwan Lee[2], Alex Hsain[1], Jacob Jones[*1]

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HfO_2-based metal-ferroelectric-metal (MFM) capacitors have attracted increased interest from the ferroelectrics community and the semiconductor industry due to their ability to exhibit ferroelectricity at nanometer length scales. In order to expedite the practical use of HfO_2-based MFM capacitors including ferroelectric field effect transistor, several performance metrics need to be considered in aspects of reliability: uniformity, scalability, endurance, program write/erase speed, retention, etc. The performance of ferroelectric HfO_2-based MFM capacitors generally depends on various factors such as surface energy (e.g., through grain size or thickness), defects (e.g., through dopants, oxygen vacancies, or impurities), electrodes, interface quality, and preferred crystallographic orientation (also known as crystallographic texture, or simply texture) of grains and/or domains. Importantly, it should be noted that an interfacial layer (IL) is inevitably created when dissimilar materials are adjacent and the IL between ferroelectric/electrode in MFM capacitors often deteriorates the measured electrical properties. To improve reliability performance of the HfO2-based MFM capacitors, thus, the IL should be avoided in the capacitor stack.

In this study, we fabricated MFM capacitors of TiN/$Hf_{0.5}Zr_{0.5}O_2$ (HZO)/TiN via Atomic Layer Deposition (ALD) without breaking vacuum to avoid IL formation, named as Sequential, No-Atmosphere Processing (SNAP). Specific design of the unconventional SNAP recipe and its effect on structural and electrical properties of the HZO-MFM capacitors is systematically studied here. Hence, we demonstrate the ability to control crystallographic texture of the HZO by using different texture of TiN during the SNAP deposition. Our results will provide new insight on the importance of the vacuum processing as well as the effect of texture

Keywords : Ferroelectric, HfO2

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Abstract No. : **IN-S13-0658**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Efficient and Stable Perovskite Solar Cells through Rationally Designed Hole Transporting System

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Since 2009, the power conversion efficiencies (PCE) of perovskite solar cells (PSCs) have increased from 3.8% to 26.1% over the last decade. Most highly efficient PSCs employ an n-type layer of mesoporous titanium dioxide or tin oxide in an n-i-p device configuration, where organic/polymer conductors are commonly used to transport holes into a metal. Numerous efforts have thus far been devoted to achieving a defect-free perovskite film with high-quality morphologies for achieving reduced loss-in-potential results and increased efficiency levels. These comprehensive advances in interface engineering, composition engineering, and charge-transporting layer engineering for perovskite solar cells allow us to attain a PCE greater than 25%. In this talk, I will present our contribution to enhancing photovoltaic performance for PSCs. Furthermore, much efforts have been made to ensure both high efficiency and long-term stability, in research to commercialize PSCs. The doped hole transporting layers (HTLs) with lithium-based hygroscopic dopant are not stable under high thermal stress, which is a primary cause of device degradation. Thus, I will discuss rationally designed HTL system for efficient and stable PSCs and also present our recent work to introduce new dual-functional ionic liquid (IL) dopants into HTL. Finally, I will briefly introduce our efforts to develop scalable PSCs for practical applications.

Keywords : perovskite solar cells, efficiency, stability, hole transporting layer

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Abstract No. : **PO-S10-0657**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Harnessing Light for Responsive Drug Release: Development of a Photo-Responsive Hydrogel based on GFP.

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Environmental adaptive hydrogels, which can rapidly and controllably alter their physicochemical properties and phase states in response to various stimuli, have been widely studied as model systems for drug delivery and controlled release. Among these, photo-responsive hydrogels are particularly attracting a lot of attention for their potential application in drug delivery. Here, we introduce a photo-responsive hydrogel with tunable photophysical and mechanical properties. The hydrogel was synthesized using maleimide-functionalized hyaluronic acid (HA-Mal), crosslinked by a photo-dissociable dimeric GFP called pdDronpa. pdDronpa can be reversibly switched off/on and undergoes dissociation/association under the illumination of cyan/violet light, respectively. As a result, physical state of the pdDronpa-HA hydrogel was able to be reversibly changed between sol and gel by cyan/violet illuminations. SEM images and rheological measurements provided further evidence of the hydrogel's responsive behavior, demonstrating the disintegration and reformation of its entangled network upon two different wavelengths. Additionally, the photo-controlled release of drugs from hydrogels was investigated using DNA fragments, a model nucleic acid drug, and insulin, a small peptide drug. These results demonstrated that the release of encapsulated molecules could be precisely regulated by changing the pdDronpa concentration and illumination parameters.

Keywords : Photo-responsive hydrogel, pdDronpa, Drug delivery

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Abstract No. : **PO-S13-0656**
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Abstract Preference : **Poster**

BIPV Design and Performance Evaluation Using 5kW Shingled Solar System

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The increase in global warming due to climate change is rapidly leading to research to zero-energy buildings worldwide. The key to representing zero-energy buildings can be seen as the Building Integrated Photo-Voltaics (BIPV) system. Traditional BIPVs not only show low energy efficiency but also damage the aesthetic appeal of buildings because they use terrestrial solar panels as they are. Therefore, there is a critical need for the development of modules that combine aesthetic considerations with high-performance technology. In this study, we developed BIPV modules using patterned and colored glass, as compared to conventional BIPV modules. Simultaneously, we developed Singled Photovoltaic Module fabrication technology to produce high-power solar modules. Building upon these technological advancements, we constructed a 5kW-class integrated high-power Singled photovoltaic module demonstration system, measuring 2240mm by 12900mm, suitable for application on building facades and roofs. Furthermore, to ensure the reliability of our research, we implemented a real-time monitoring system within the Validation system, incorporating vertical, horizontal, and slope illuminance meters, as well as module temperature gauges. This setup enables continuous monitoring of meteorological data and power generation, facilitating a thorough analysis. By comparing predicted energy generation from pre-simulation with actual energy production, we anticipate an improvement in the accuracy of energy generation predictions.

Keywords : Color PV, Pattern PV, Building-integrated photovoltaic, monitoring system, solar power generation

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Abstract Preference : **Poster**

적외선 레이저 조사에 의한 Shinlged Heterojuntion 태양전지의 최적화된 분할 조건

EunBi Lee[2], Sungmin Youn[1], Eunae Jo[1], Ki Seok Jeon[1], Minseob Kim[1], Jin Ho Shin[1], Yu Jin Kim[1], Chaehwan Jeong[1], Min-Joon Park*[1]

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현재 태양광 산업의 혁신 추세 중 하나는 실리콘 웨이퍼 크기의 증가입니다. 웨이퍼 크기가 증가함에 따라 모듈의 직렬 저항이 증가하므로 태양전지를 절단-접착하는 분리 방법에 대한 연구가 필요합니다. 그 중에서도 적외선(IR) 레이저 스크라이빙 기술이 광범위하게 연구되어 왔다. 그러나 이종접합 태양전지(HJT)의 투명 전도성 산화물(TCO)층에서 레이저에 의한 열 손상에 대한 최적화 연구는 아직 부족한 실정이다. 따라서 본 연구에서는 IR 레이저 스크라이빙 속도, 주파수, 출력, 스크라이빙 횟수 등의 조건을 체계적으로 변화시켜 각 조건에서 분리된 셀의 성능에 미치는 영향을 조사했습니다. 또한 다양한 스크라이빙 깊이에 따른 TCO 레이어의 열 손상 효과에 대한 비교 분석을 수행했습니다.

Keywords : Cell separation process, Infrared raser, Heterojuntion solar cells, Transparent conductive oxide

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Abstract No. : **PO-S05-0654**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

Spiral-driven vertical conductivity in nanocrystalline graphene

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Although graphene, with its useful electrical and chemical properties, is considered a promising material for future electronic applications, there are some issues that should be resolved for the practical applications of graphene. Chemical vapor deposition (CVD) is the most widely employed method to grow high-quality graphene at large scale, however, the growth rate of graphene is quite low on the noncatalytic substrates, resulting in small grain size. In addition, the multilayer graphene has good thermal and electrical conductivities in the in-plane direction; however, these superior properties do not appear along the out-of-plane (vertical) direction. Therefore, these drawbacks have hampered the practical application of graphene in silicon-based electronic devices. In this study, we circumvented these problems by preparing high-quality spiral-structured nc-G films directly on noncatalytic substrates using inductively coupled plasma CVD (ICP-CVD). Combining C-AFM, STM, and TEM, the atomic and electronic structures as well as the electrical properties of nc-G were investigated. Remarkably, we found that the nc-G structures grew in a spiral shape, showing an excellent vertical conductivity, which is not possible with typical multilayer graphene films. The Klein-edges electrically connected the individual nc-G structures, resulting in homogeneous electrical conductance of the graphene film. Moreover, the nc-G structures exhibited an epitaxial relationship with the substrate, despite the fast growth rate of ICP-CVD method.

Keywords : graphene, electronic structure, scanning tunneling microscopy, conductive atomic force microscopy

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Abstract No. : **PO-S14-0653**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Sea-Water Splitting Enhanced: Corrosion-Resistant Graphene Oxide/GaN Core-Shell Nanowire Electrode

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The study focuses on photoelectrochemical water splitting, a carbon-neutral method of producing hydrogen that is also environmentally benign. Seawater's abundance makes it a desirable electrolyte for large-scale hydrogen production, but one major obstacle is that ions like chloride in the water can cause photoelectrode corrosion. In order to overcome this, a unique core-shell structure was developed using GO/GaN core-shell nanowires coated with graphene oxide (GO) nano membrane as the photoelectrode material. The efficiency loss in hydrogen production caused by corrosion from seawater is averted by this innovative design. Unique bonding processes and charge transport systems on various GaN planes were demonstrated by the GO/GaN core-shell structure. Photoelectrochemical water splitting using GO/GaN core-shell electrodes shown more than a tenfold increase in current density when compared to conventional Si substrates and pure GaN nanowire architectures. Stability tests conducted over 48 hours of seawater exposure demonstrated sustained photocurrents for both Hydrogen Evolution Reaction (HER) and Oxygen Evolution Reaction (OER) without degradation. Furthermore, notable enhancements in photocurrent were observed at temperatures as high as 70°C. The H_2 production efficiency was roughly 2.3 mmol cm^{-2} per 10 hours, while the measured current density was about -12.45 mA cm^{-2}. The utilization of Graphene Oxide nano membrane and GaN nanowires in GO/GaN core-shell nanowire photoelectrodes presents a promising pathway for commercializing large-scale water splitting using seawater.

Keywords : GaN, Nanowire, Graphene Oxide, Photoelectrochemical water splitting, Hydrogen generation

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Abstract No. : **PO-S06-0652**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Microstructural Influences on Low-Temperature Impact Toughness of Polar Offshore Structural Steel Weldments

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In response to recent developments in polar resource extraction, there has been a noticeable surge in the demand for offshore plants designed to operate in extreme low-temperature environments reaching as low as -60°C. Structural steels intended for such offshore installations in polar regions must exhibit exceptional low-temperature impact toughness to withstand the forces exerted by drift ice, while also requiring low carbon equivalents to optimize weldability. Moreover, as the scale of these facilities increases for efficient operation, thicker steel sections are required. Despite the excellent physical properties of the steel, challenges arise during the welding process, resulting in the formation of a heat-affected zone (HAZ) where mechanical properties may deteriorate. Notably, the HAZ poses difficulties in controlling microstructure and is susceptible to cracking.
This study meticulously investigates the low-temperature fracture behavior of an 80 mm thick low carbon steel plate welded using the submerged arc welding (SAW) technique. Through advanced Electron Backscatter Diffraction (EBSD) analysis, quantitative assessments of grain size and complex constituent phases were conducted to elucidate the relationship between impact absorption energy and ductility-brittle transition temperature (DBTT). It was observed that the microstructure varied significantly depending on the extent of heat input, thereby influencing fracture properties in low-temperature environments. Among the various microstructures observed in the HAZ, acicular ferrite (AF) exhibited the highest resistance to low-temperature impact owing to its finely interlocked formation and high-angle grain boundaries. This study contributes valuable insights into enhancing the performance and reliability of structural steels in polar offshore applications.

Keywords : thick plate steel; low-carbon steel; submerged-arc welding; welding microstructure; impact test

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Abstract No. : **PO-S14-0651**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Enhanced Electrode Activity in Alkaline Water Electrolysis via Post-Treatment of Stainless Steel Electrode

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Water electrolysis stands as a rapidly expanding environmental technology, serving as a basis in the creation of next-generation energy sources by electrolytically segregating water into hydrogen (H_2) and oxygen (O_2). Within the branch of alkaline water electrolysis, considerable research efforts have been directed towards seeking electrocatalysts capable of replacing noble metals used previously. The efficacy of these electrode materials is inherently tied to critical parameters such as the overpotential necessary to achieve the desired current density and endurance during continuous operation. To enhance electrode properties and optimize their utilization as either anodes or cathodes, various surface control methodologies including anodization, electrodeposition, hydrothermal synthesis, deposition, and heat treatment have been explored.

Robustness and efficiency emerge as pivotal characteristics for attaining highly active electrocatalysts within water electrolysis systems. Particularly, in the case of metal oxide catalysts, issues such as low electrical conductivity and catalytic activity present significant bottlenecks under Oxygen Evolution Reaction (OER) conditions, leading to a decline in electrode performance. In this study, we apply metal oxides formed through hydrothermal synthesis and introduce an approach for electrode activation through post-processing. Hydrothermal synthesis was conducted utilizing stainless steel 304 (SS304) as the substrate material, followed by subsequent processing steps. Material properties were meticulously scrutinized before and after the water electrolysis procedure using scanning electron microscopy (SEM), X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS). Electrochemical properties were assessed in a 1 M KOH electrolyte employing techniques such as linear sweep voltammetry (LSV), Tafel gradient analysis, electrochemical impedance spectroscopy (EIS), and long-time potentiometry utilizing specialized equipment. Additionally, the prepared specimens underwent comparison before and after the long-term stability test. Based on a comprehensive experimental analysis, this study provides invaluable insights poised to facilitate the design of significantly enhanced electrodes, thereby advancing water electrolysis technology.

Keywords : Stainless Steel, Hydrothermal Synthesis, Water electrolysis, Oxygen evolution reaction, Surface Treatment

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Abstract No. : **OR-S09-0650**
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Abstract Preference : **Oral**

Exploring PVDF-Modified SnO_2 Based Perovskite Solar Cells: Interface Engineering for Enhanced Photovoltaic Performance

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Despite the significant progress made in enhancing the performance of perovskite solar cells, challenges persist in optimizing the crystallinity of the perovskite active layer and its interfaces with electron transport layers (ETLs), which are crucial for further advancements. Ion migration is identified as a key factor contributing to the suboptimal crystallinity of perovskite solar cells, thereby limiting their overall efficiency. In this study, we investigated the impact of incorporating a cross-linking material, poly(vinylidene fluoride) (PVDF), into the perovskite layer. Additionally, we developed a novel layer structure for the SnO_2-based ETL, aiming to enhance the interface and promote the formation of high-quality perovskite films. Our investigations revealed a strong correlation between the charge transfer dynamics in different SnO2 layer configurations. Furthermore, we evaluated the performance of perovskite solar cells synthesized under ambient air conditions. The inclusion of PVDF was found to facilitate the nucleation and growth of perovskite crystals, leading to improvements in the open-circuit voltage (VOC), short-circuit current density (JSC), and fill factor (FF) within the solar cells. Our results demonstrate that the photovoltaic performance of perovskite films coordinated with PVDF, fabricated under ambient conditions on 1A2C ETLs, achieved the highest power conversion efficiency (PCE) at 18.6%. This improvement was accompanied by VOC, JSC, and FF values of 1.06 V, 18.53 mA/cm^2, and 72.50%, respectively. The observed enhancements can be attributed to two primary factors: (i) increased crystallinity of the perovskite layer due to reduced bulk PbI_2 presence, and (ii) decreased carrier recombination, as evidenced by a 4-fold quenching of photoluminescence emissions (PL). These findings highlight the potential of PVDF incorporation into the perovskite layer for producing high-quality perovskite films by modifying the surface of the ETL layer structure, ultimately leading to improved device performance.

Keywords : Perovskite, SnO2, Room-temperature, PVDF, Hysterisis

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Abstract No. : **PO-S05-0649**
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Abstract Preference : **Poster**

Low residue transfer of two-dimensional materials using nitrocellulose film.

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Nowadays, the usage of 2D materials is continually growing due to their special properties. However, since their thickness is on the nanometer scale, they are highly vulnerable, making them difficult to handle. This work focuses on transferring 2D materials such as MoTe2 and MoS2 to other locations without residue and damage. To achieve this goal, we utilized a nitrocellulose stamp for transferring the 2D materials.

The stamp is composed of a thin nitrocellulose film placed on PDMS, which is adhered to a glass slide. When the stamp is placed on the 2D material and heat is applied, the material and nitrocellulose film adhere together, facilitating the transfer of the desired 2D materials. Following the adhesion of the nitrocellulose film and 2D material, the edge of the film is trimmed. The excitation step enables the transfer process at low temperatures. Subsequently, the stamp with the attached material is affixed to the desired location and then detached, leaving only the nitrocellulose film with the 2D material in place. The nitrocellulose film is then removed using a solvent.

Keywords : Two-dimensional materials, low residue transfer method

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Abstract No. : **PO-S14-0648**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Doping mediated electronic modulation of Ni3S2 for economically viable electrochemical hydrogen production and methanol electroreformation

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Hydrogen is the future of the carbon-free energy economy. An electrochemical water electrolyzer is found to be the leading technology to meet the current and future hydrogen demand. The anode catalyst plays a prime role in the overall efficiency of the water electrolyzer. The sluggish oxygen evolution reaction (OER) at the anode catalyst is the bottleneck obstacle for the commercial water electrolyzer. The rational design of highly efficient and cost-efficient catalysts is the prime interest. Noble metal-based RuO_2/IrO_2 is the benchmark OER catalyst. Herein, group VI elemental (Cr, Mo, and W) doped nickel sulfides (Ni_3S_2) is synthesized by two-step hydrothermal methods in the search for high efficient noble metal-free anode electrocatalyst. The doping-mediated synergistic interfaces along with the in-situ formed surfaces species enhanced the performance of pure Ni_3S_2, Cr-doped Ni_3S_2 catalyst outperformed the other catalyst with an overpotential of 248 mV to attain a current density of 10 mA/cm^2 with a Tafel slope of 95.5 mV/dec. To further reduce the overall overpotential of the conventional water electrolyzer, herein, a methanol-mediated water electrolysis system which performed at a low overpotential of 1.36 V with 46.4 mV dec^{-1} Tafel slope is explored. The overall device performed with an overpotential of 1.48 V attain 10 mA cm^{-2} current density displaying superior performance surpassing commercial $Pt/C_{(-)}||RuO_{2(+)}$. The device of for methanol mediated hybrid water electrolyzer was explored which performed attained 1.38 V @ 10 mA cm^{-2} while additionally electro-reforming methanol to formate.

Keywords : hydrogen, OER, methanol, noble metal-free catalyst

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Abstract No. : **PO-S14-0646**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Improving Oxygen generation efficiency with ZIF-67 and IrO2 synthetic catalyst electrode

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In the typical electrolysis of water for the oxygen evolution reaction (OER), the production of electrons and the formation of O-O bonds occur through successive steps of electron transfer. The OER exhibits significantly slower kinetics and require substantial overpotential compared to the hydrogen evolution reaction (HER). As a result, it significantly influences the overall performance of water electrolysis Researchers have recently studied noble metal-based catalysts like Ir, Ru, Pt, etc transition-metal-based catalysts like Co, Ni, Fe, etc, and metal-organic framework (MOF) based catalysts as potential electro-catalysts for OER.

In this study, synthesized a composite catalyst by integrating IrO2 nanoparticles with a Co-based zeolite imidazolate framework (ZIF-67) to utilize synergistic in ZIF-67 catalysis. Furthermore, ZIF-67/IrO2 was connected to the Ni foam (NF), known for its outstanding OER activity. We employed two distinct methodologies to produce electrodes. The initial method involves the utilization of stirring and hydrothermal techniques to synthesize IrO2 nanoparticles, ZIF-67 precursor materials, and Ni foam, forming IrO2@ZIF-67_NF. The second method uses pre-synthesized ZIF-67 powder and IrO2 nanoparticle solution to create a slurry. This slurry is then used to adhere the ZIF-67_IrO2_NF onto the Ni foam. As a result of specific surface area analysis (SSA), the specific surface area of IrO2@ZIF-67_NF was found to be 8.6 times larger than that of ZIF-67_IrO2_NF. Nevertheless, the overvoltage of IrO2@ZIF-67_NF and ZIF-67_IrO2_NF was found to be 388mV and 320mV, respectively, at a current density of 50mA/cm^2. The SEM-EDS and XPS analysis verified that ZIF-67_IrO2_NF exhibited a higher average number of IrO2 nanoparticles adhered to the Ni foam than IrO2@ZIF-67_NF. Therefore, hydrothermal synthesis achieved stable and effective attachment of IrO2@ZIF-67 onto Ni foam. However, it is estimated that the slurry procedure of ZIF-67_IrO2 improved the catalytic active surface area through strong selectivity and dispersion of IrO2 nanoparticles.

Keywords : Electrolysis, oxygen evolution reaction (OER), Co-based zeolitic imidazolate(ZIF-67), IrO2 nanoparticle, Hydrothermal, Slurry

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Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Fabrication of GaN Nanorods Using Metal-Assisted Photochemical Etching TechniqueFabrication of GaN Nanorods Using Metal-Assisted Photochemical Etching Technique

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Extended reality (XR) technology provides a real/virtual/mixed experiences that converge our life to the electronic/computing information through displays. In order to enhance the immersiveness and boundlessness of XR, it is essential to fabricate ultra-high resolution displays. GaN nanorod is one of ultimately minute light-emitting components for an exquisitely miniaturized lighting pixel. Conventional bottom-up method using metal-organic chemical vapor deposition (MOCVD) hardly yields nanorod arrays with homogeneous diameter and length. Thus, top-down etching is one of the straightforward way to obtain homogeneous nanorod arrays, but dry etching to form nanorod has a side effect, such as side-wall damage, difficulty in vertical etching, etc. Metal-assisted photo-chemical etching (MAPCE) has enabled highly anisotropic etching under low-temperature/atmospheric pressure conditions and cost-effective fabrication of large-area nanorods, thus is regarded as an ideal technique for nanorod formation.

In this study, we investigated the feasibility of MAPCE for nanorod etching. First, substrates of undoped GaN (u-GaN) and n-doped GaN (n-GaN) were prepared using MOCVD epitaxy growth. Then, the uniform nanopatterns were formed via nanoimprint lithography, and various metal masks (Ni/Au, Cr/Au) were deposited using an electron-beam evaporator. Etchants were prepared by adjusting the composition and concentration of etching solutions (KOH, HF) and oxidants ($AgNO_3$, $K_2S_2O_8$). The etching was processed with UV irradiation under various power conditions for etching condition optimization. By optimizing the metal mask type, etchant preparation conditions, and etching time, we successfully fabricated nanorods with heights greater than 1 μm on both u-GaN and n-GaN substrates. These results imply the potential of MAPCE for nano-pixelated display fabrication.

Keywords : XR, MOCVD, MAPCE, Nanorod, GaN

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Abstract No. : **PO-S12-0644**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Synergistic Hybrid Carbon Supports for Superior Durability in Oxygen Reduction Catalysts of PEM Fuel Cells

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In the realm of proton exchange membrane fuel cells (PEMFCs), the development of catalysts that can endure the stringent demands of oxygen reduction reactions (ORR) while maintaining high activity and durability is of paramount importance. This study reports on the synergistic effect of small reduced graphene oxides (srGO) and carbon nanotubes (CNTs) as hybrid carbon supports for ORR catalysts, which exhibit significantly improved performance and longevity. Platinum nanoparticles were deposited onto both srGO and CNT substrates using the polyol process. These two types of catalysts were then mechanically mixed in various ratios to create hybrid catalysts (HC). The optimal HC55 catalyst, featuring a 1:1 ratio of Pt/srGO to Pt/CNT, showcased remarkable ORR performance, surpassing standard benchmarks in both activity and durability over 1000 accelerated durability test (ADT) cycles. Notably, the electrochemical surface area (ECSA) of the Pt/HC55 experienced only an 11.9% reduction post-ADT, considerably less than the 21.2% and 57.6% reductions observed for Pt/srGO and Pt/C, respectively. This notable retention of ECSA can be attributed to the distinctive combination offered by HC: the expansive surface area provided by srGO and the exceptional electrical conductivity of CNT. A thorough evaluation of structural and electrochemical attributes indicates that the HC design yields a symbiotic effect, enhancing both the efficiency and the endurance of the catalyst. The outcomes from this research promote a new class of hybrid carbon supports as a viable path forward for advancing the durability and performance of catalysts in PEMFC applications.

Keywords : Proton exchange membrane fuel cells, Oxygen reduction reaction, Hybrid carbon support, Reduced graphene oxide, Carbon nanotubes, Durability

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Abstract No. : **PO-S01-0643**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Optimizing Hydrothermal Synthesis Parameters for Enhanced Electrochemical Performance of LiFePO4 Cathode Materials

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$LiFePO_4$ has emerged as a prominent candidate for cathode materials in lithium-ion batteries. Among various synthesis methods, hydrothermal synthesis has been employed to obtain phase-pure $LiFePO_4$ materials efficiently. In this study, we investigated the optimal temperature for minimizing iron disorder formation during the hydrothermal synthesis process. Temperatures of 170 °C (A), 175 °C (B), and 180 °C (C) were evaluated to assess their effectiveness in reducing iron disorder in lithium. Additionally, we explored the use of a water-soluble reducing agent, such as ascorbic acid, to minimize iron oxidation. Furthermore, the electrical conductivity of the synthesized $LiFePO_4$ was enhanced by introducing carbon deposition from glucose or acetylene black into the hydrothermal reactor. Subsequently, coin cells were assembled using the prepared A, B, and C samples to evaluate their electrochemical performance. Our findings shed light on optimizing the synthesis parameters and improving the electrochemical properties of $LiFePO_4$, contributing to the advancement of lithium-ion battery technology.

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Keywords : Lithium iron phosphate, Hydrothermal process, Cathode materials, Lithium-ion batteries

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Abstract No. : **PO-S12-0642**
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Abstract Preference : **Poster**

Enhanced PFAS Water Remediation with Titanium Carbide MXene-PEDOT:PSS Electrosorbent

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The pervasive contamination of water sources by perfluoroalkyl substances (PFAS), due to their extensive industrial utilization and extreme durability, has escalated into a pressing environmental and public health issue. Regulatory measures have been initiated against long-chain PFAS; nonetheless, the hazardous implications of short-chain variants are increasingly being recognized. In response, adsorption emerges as a compelling method for the purification of PFAS-laden water, with electrosorption presenting a promising enhancement to conventional adsorption techniques by enabling targeted PFAS removal and on-demand regeneration via applied voltage modulation. This investigation reports on the development of a novel titanium carbide (Ti3C2Tx) MXene-PEDOT:PSS composite that functions as a highly efficient electrosorbent for PFAS decontamination. Through acid etching, the surface area and porosity of the adsorbent are significantly increased, translating to an approximate 400% boost in volumetric capacitance for a selection of PFAS species in comparison to its non-etched analog. The electrosorption capacity of our composite for prominent PFAS pollutants—perfluorohexanoic acid (PFHxA), perfluorooctanoic acid (PFOA), and perfluorononanoic acid (PFNA)—was found to be remarkably high at 45.6 mg/g, 51.1 mg/g, and 54.9 mg/g, respectively, when subjected to an initial concentration of 750 ppb and an electrosorption voltage of +1.0 V. Additionally, through cyclic adsorption-desorption trials, the material has proven its potential for recycling and sustained application. The outcomes of this study point towards a transformative approach to advance the treatment of PFAS contaminants, offering a scalable and environmentally sustainable solution to a global challenge.

Keywords : PFAS, water remediation, electrosorption, MXene, PEDOT:PSS, titanium carbide, environmental sustainability

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Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Enhancing PEMFC Efficiency in Low-Humidity with Poly(sulfobetaine methacrylate)-Infused Anode Catalyst Layer

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The quest for efficient operation of proton exchange membrane fuel cells (PEMFCs) at low humidity levels is pivotal for reducing or potentially eliminating the need for external humidification systems. This study introduces a cutting-edge anode catalyst layer integrated with a novel zwitterionic polymer, poly(sulfobetaine methacrylate) (pSBMA), to sustain high water retention and facilitate proton conduction. The pSBMA is expertly synthesized through precipitation polymerization and blended with a standard Pt/C catalyst. The resultant PEMFC anode catalyst layer unveils impressive enhancements in cell performance and durability under challenging low-humidity environments. The cell incorporating an optimal concentration of pSBMA in the membrane achieves an ionic conductivity of 8.8 mS cm−1 at an ultra-low 19% relative humidity (RH). Furthermore, the cell performance at the same humidity level reaches a remarkable current density of 0.59 A cm−2 at a voltage of 0.6 V. Critically, the PEMFC maintains high-performance stability, evidencing a negligible decrease to 98% of its original output after 75 hours of rigorous durability testing. The outcome of this pioneering research delivers substantial insight into the feasibility of PEMFC systems operating under low RH conditions without foregoing efficiency and stability, thus providing valuable guidance for future fuel-cell technology designs.

Keywords : Proton exchange membrane fuel cell; sulfobetaine; zwitterionic polymer; low humidity; self-humidification

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Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Gradient Multi-Layer Catalysts for Proton Exchange Membrane Fuel Cells

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Achieving highly efficient catalyst layers (CLs) is crucial for maximizing the performance of proton exchange membrane fuel cells (PEMFCs). These layers must facilitate both a highly active electrochemical surface and efficient mass transfer. Traditional CLs face the challenge of balancing cost with performance due to the expensive platinum (Pt) and Nafion components. In this study, we explore a novel approach to this problem by designing gradient multi-layered CLs. This design strategically varies the loading of Pt-C catalyst and Nafion ionomer across multiple layers to optimize functionality: higher ionomer levels are positioned proximal to the membrane to enhance proton transfer, whereas increased Pt-C loading towards the gas diffusion layer improves electrochemical reactivity. Our findings indicate that disproportionate loading across layers can detrimentally impact performance due to the creation of non-uniform Pt active surfaces. Through a comparative evaluation of one-layer, three-layer, and five-layer CL architectures, we demonstrate that additional layers can mitigate loading disparities, resulting in a higher electrochemical surface area (ECSA) and superior fuel cell performance. This multi-layered gradient approach presents a promising pathway for the development of cost-effective and high-performing PEMFCs.

Keywords : gradient catalyst, membrane electrode assembly, proton exchange membrane fuel cell

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Abstract No. : **PO-S12-0639**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Enhanced Low-Temperature SCR Efficiency with Nitrate-Modified Vanadium Catalysts

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Vanadium-based catalysts are a cornerstone for selective catalytic reduction (SCR) processes due to their excellent catalytic performance over a broad temperature spectrum. Despite their widespread usage, these catalysts suffer from reduced efficiency at low temperatures in the presence of SOx, with decreased catalytic activity stemming from surface formation of ammonium sulfate. Addressing this challenge, our study introduces the integration of ammonium nitrate into the conventional V2O5-WO3/TiO2 catalyst framework, thereby endowing the catalyst with nitrate functionalization. This modification not only enriches the surface with NO3- groups but also enhances the chemisorbed oxygen presence, collectively boosting the density of active Brønsted and Lewis acid sites. The altered surface chemistry of the nitrate-incorporated V2O5-WO3/TiO2 catalyst manifests in outstanding NOx conversion rates and improved N2 selectivity at the crucial low-temperature window around 300 °C. The pivotal role of NO3- in concert with chemisorbed oxygen is revealed to accelerate the SCR reactions. Our findings suggest a promising avenue for refining a range of SCR catalysts aimed at superior low-temperature applications, potentially setting a new standard for emissions control technologies.

Keywords : Nitration, SCR, Vanadium, Catalyst, Nitrogen, Oxide

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Abstract No. : **OR-S03-0638**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Oral**

Structural and thermal effect of Au@NiO core-shell nanoparticles for hydrogen sulfide gas sensor

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Hydrogen sulfide (H_2S) is a highly toxic gas that can readily occur in industrial environments. As it can lead to various chronic illnesses in humans despite exposure to low concentrations, the prompt detection of leakage is crucial. Therefore, the research on metal oxide semiconductor (MOS) gas sensors for H_2S gas is being conducted diversely. Among them, NiO, which is a p-type semiconductor, has attracted remarkable attention as a sensing material due to low resistance, low cost, and easy fabrication. However, it has limitations as a gas sensor because of its low selectivity to H_2S gas.

The addition of noble metal as a catalyst has been proposed to enhance the gas sensing performance, which reduces the activation energy of the adsorption reaction, and promotes the adsorption of gas molecules. Especially, Au has a high affinity for sulfur-containing compounds, making it highly effective in detecting H_2S gas. Additionally, the metal@metal-oxide core-shell nanostructure (CSNPs) represents a promising material structure for gas detection, as it ensures the stability of noble metal nanoparticles (NPs) without aggregation even at high operating temperatures of the MOS gas sensor.

In this study, Au@NiO CSNPs were synthesized via a two-step hydrothermal method and were subsequently annealed at various temperatures (350-550°C) to investigate the material's characteristics and surface properties according to calcination temperature. Gas sensing performances of the fabricated samples were tested toward H_2S gas at various test temperatures (100~300°C) and concentrations (1~50 ppm). Furthermore, the sensing properties were contrasted with those of Au-loaded NiO nanocomposites and pure NiO to confirm the structural effect and catalytic effects of Au NPs.

Keywords : Au, NiO, metal oxide, core-shell, nanoparticle, H2S gas sensor

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Abstract No. : **IN-S01-0637**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

Nanocomposite Engineering of Heterogeneous Mn-Based Cation-Disordered Cathodes for High-Performance and Low-Cost Lithium-Ion Batteries

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High-capacity cathodes for Li-ion batteries without Co and Ni are critical for lower $/kWh. Mn-rich cathode compounds are cost-effective alternatives. Partially cation-disordered cathodes are promising due to their high energy densities and fast rate capability. However, they have a poor cycle life, requiring an understanding of the structure-property relationship. This study shows these cathodes have a multi-phase heterogeneous nature and presents a nanocomposite engineering strategy to modify the phase heterogeneity and enhance cycling stability.[1] Additionally, we demonstrated that these engineered cathodes can achieve high energy densities at the electrode level with over 95% weight-active material. These findings expand cation-disordered cathode materials and offer insights into developing low-cost Li-ion cathodes.[2]

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[2] E. Lee†, D.-H. Lee†, S. Bessette, S.-W. Park, N. Brodusch, G. Lazaris, H. Kim, R. Malik, R. Gauvin, D.-H. Seo*, J. Lee*, Nearly all-active-material cathodes free of nickel and cobalt for Li-ion batteries, Energy Environ. Sci., online published (2024)

Keywords : Li-ion batteries; DFT, Cathode

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Abstract No. : **PO-S04-0636**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

MoS_2 Based Backplane for Driving Micro-LED Using 2T1C Structure

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The synthesis of large-scale transition metal dichalcogenides and their heterogeneous integration with compound semiconductors provides opportunities to implement various useful devices. For example, MoS_2 can be effectively utilized in forming the backplane of micro-led. Micro-led are promising materials for future displays due to their excellent properties such as high brightness, color contrast, low power consumption, fast response time, and great mechanical properties. Therefore, micro-led can be useful in producing transparent and flexible displays for wearable or vehicle device. The most widely method for forming active matrix micro-led display involves transferring micro-leds onto a backplane substrate where the circuitry is formed. However, to create a flexible micro-led display, a backplane substrate with good flexibility is required. The thin 2D material MoS_2 which have excellent electrical property can be transferred or deposited at low temperature onto thin and flexible polymer substrates without causing damage to target substrate. Its excellent flexibility allows it to withstand higher strains compared to other channel materials. Thus, MoS_2 is highly suitable as a channel material of transistor on flexible backplane for driving micro-led display. Here, we form 2T-1C structure micro-led driving circuit on ultra-thin polymer using MoS_2 transistors by directly depositing a MoS_2 layer at low temperature. The MoS_2 layer, which will serve as the channel, is directly deposited onto the polymer substrate at low temperature, thus enabling the formation of a uniform MoS_2 layer without damage. This strategy represents a method to fabricate high-quality flexible future displays that can be used to diverse area.

Keywords : MoS2, micro-led, future display, transition metal dichalcogenides

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Abstract No. : **OR-S05-0635**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Oral**

Residue-free van der Waals fabrication method of two-dimensional materials

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Two-dimensional (2D) materials have attracted considerable attention due to their unique properties and potential for various applications. However, residues from the fabrication process, such as polymethyl methacrylate (PMMA) and polypropylene carbonate (PPC), can significantly impede the intrinsic performance of 2D materials. Here, we proposed a novel fabrication method using van der Waals interactions. Molybdenum disulfide (MoS_2) back-gated field effect transistors (FETs) are employed to measure the electrical mobility (up to 60 $cm^2V^{-1}s^{-1}$) and on/off ratio ($\sim10^7$). High-resolution transmission electron microscopy (HR-TEM), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), and Raman spectroscopy measurements are also performed to characterize the absence of contaminations and mechanical damage on the samples. Various manipulation techniques with MoS_2, such as pick-up and release, exfoliation, stacking, wipe-out, flipping, and stretching, are performed. Furthermore, we also successfully fabricated a multilayer graphene (MLG)/hexagonal boron nitride (h-BN)/MoS_2 heterostructures. Our approach enables high-quality 2D materials device fabrication and application.

Keywords : Two-dimensional materials, Residue-free fabrication, ,Manipulation method, Van der Waals heterostructures

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Abstract No. : **PO-S04-0634**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Active micro-LED display with transferred Silicon nanomembrane TFT

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The most widely used method in producing micro-LED displays is to remove the micro-LED chips from the substrate on which the LEDs were grown, transfer them onto the display's driving circuit, and connect them electrically. This method requires highly sophisticated technique, a lot of time, and high process costs because fine LED chips must be transferred to the exact location of the circuit without error. In addition, defects occur in the micro-LED during the transfer process, causing performance degradation, and it is difficult to apply the method to high-resolution displays, which has been an obstacle to commercializing micro-LED displays. Here, we propose a method of producing an active drive display based on a monolithic integrated structure by transferring single crystal thin film silicon onto the mother substrate on which LEDs were grown. Single-crystal thin-film silicon is separated from a Silicon on Insulator (SOI) wafer using a PDMS stamp and transferred onto a GaN wafer coated with an epoxy material. The silicon transistor formed at the top is electrically connected to the GaN wafer at the bottom through a via-hole to operate the micro-LED. With this method, it is possible to produce an active drive display directly on a substrate on which LEDs are grown without a micro-LED transfer process, thereby eliminating various problems that occur in the LED chip transfer process. Additionally, because the transistor's channel material uses single-crystal silicon with very high charge mobility, it is possible to produce an active drive display with very fast response speed and low power consumption. This strategy represents a method to overcome the challenges associated with micro-LEDs and integrated single-crystal silicon and compound semiconductors effectively.

Keywords : Silicon nanomembrane TFT, micro-LED

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Abstract No. : **PO-S11-0633**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Magneto-Mechano-Triboelectric Nanogenerator for Stray Magnetic Field Energy Harvesting

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With the rapid increase in the usage of electronic devices, electromagnetic pollution has become a growing concern, potentially leading to health issues and interference with the performance of other electronic devices. To address this problem, inserting a magnetic shielding layer can effectively shield magnetic fields, but it incurs energy loss. In this study, we propose replacing the magnetic shielding layer with a Magneto-mechano-triboelectric nanogenerator to harvest wasted magnetic fields. We will be able to drive various IoT devices using this wasted magnetic field energy. The operating principle of the Magneto-mechano-triboelectric nanogenerator involves generating mechanical changes through the magnetostriction effect induced by magnetic fields. Subsequently, mechanical changes produce vibrations due to length variations, leading to the generation of triboelectric energy. Conventional Magneto-mechano-triboelectric nanogenerators have complex and bulky structures, and producing thin layers is challenging due to the metallic nature of magnetostriction materials. In this research, we fabricated a flexible and thin film by blending P(VDF-TrFE) with magnetic powder. We applied this film to electronic devices for energy harvesting.

Keywords : Magneto-mechano-triboelectric nanogenerator, flexible, energy harvesting, magnetic fields

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Abstract No. : **PO-S02-0632**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

High indium content InGaN/GaN Multi Quantum Wells(MQWs) red LED

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Light-emitting diodes (LEDs) have drawn great attention as an ideal lighting source for indoor illumination and emissive pixel applications in displays, due to their superior physical properties such as high quantum efficiency, high carrier mobility, ultra-long lifetime, etc. Currently, high-efficiency red and blue LEDs are traditionally produced by phosphide and nitride compound semiconductor materials, respectively. However, phosphide-based red LED has some critical points including size-dependent efficiency drop. In contrast, InGaN-based red LEDs have stable efficiency, regardless the LED chip size, thus are regarded a potential candidate for micro-LED display application. However, InGaN-based red LEDs also have some challenging issues (e.g. indium re-evaporation, strain effect, compositional pulling, defects, etc) during active layer growth. Many research (related to high efficiency-high indium content red LED) have developed to solve above issues through thick InGaN buffer layer, superlattice, AlN quantum barrier for strain relaxation. In this study, we demonstrate an efficient method to growing indium-rich InGaN/GaN multiple quantum wells (MQWs) structure using metal organic chemical vapor desposition (MOCVD). We grew the additional low-temperature-grown GaN quantum capping layer (LT-GaN QC) on the InGaN QWs resulting in red emission with high indium content. QC layer can effectively prevent re-evaporation of indium atoms from the quantum wells as a protection layer. To specify the roles of QC layer, we varied the growth time of QC from 0 to 80 sec and investigated optical property of active layer from EL spectra. The wavelength showed redshift as QC growth time increased. As a result, electroluminescence (EL) spectra of the LED shows 642 nm red emission with turn on voltage 2.2 V. We discuss the strategy for growing indium-rich red InGaN LEDs and the application of InGaN-based for commercial industry.

Keywords : High indium content, InGaN based red-LED, MOCVD, LT GaN QC, redshift

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Abstract No. : **OR-S02-0631**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Controlled 2D Growth Approach via Atomic Layer Deposition and In-Situ Capping Process for Flexible P-type SnO Thin-Film Transistors

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Tin monoxide (SnO) has been studied widely over the past several decades due to its promising theoretical p-type performance. However, challenges in fabrication processes due to the low thermal and air stability of SnO, have hindered its performance in thin-film transistors (TFTs). In this study, we aimed to address these challenges by employing an in-situ atomic layer deposition to stacking process of Al2O3 capping layer to protect vulnerable SnO thin films from exposure to air and contamination, and by controlling the precursor feeding process to enhance the 2D structure of (001)-aligned tetragonal SnO. These processes resulted in a highly c-axis aligned crystal structure of SnO, confirmed by grazing incidence wide angle X-ray scattering (GIWAXS) and various analysis tools. Upon optimizing lateral grain growth of SnO, we observed exceptional electrical performance, including a remarkably low subthreshold swing (0.12 V/decade), high on/off ratio (7.38x10^6), and moderate field effect mobility (1.86 cm^2/Vs) in bottom gate bottom contact TFT with 7 nm of SnO channel layer. Additionally, we not only exhibited record stability in positive/negative bias stress tests by rigid substrate based SnO TFT, but also exhibited highly stable flexible substrate, polyimide, based SnO TFT with a low threshold voltage shift (-0.06 V) after a 10,000-cycle bending test with a 5 mm bending radius, a feat never reported before.

Keywords : Oxide Semiconductor, Atomic Layer Deposition, Thin Film Transistors

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Abstract No. : **IN-S04-0630**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

Wearable Ophthalmic Devices for Disease Monitoring and Health Management

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The eye contains a complex network of physiological information and biomarkers for monitoring disease and managing health, and ocular devices can be used to effectively perform point-of-care diagnosis and disease management. This talk explains the target biomarkers and various diseases, including ophthalmic diseases, metabolic diseases, and neurological diseases, based on the physiological and anatomical background of the eye. This talk also introduces the recent technologies utilized in eye-wearable medical devices and the latest trends in wearable ophthalmic devices for the purpose of disease management. After introducing ocular devices such as the retinal prosthesis, we further discuss the current challenges and potential possibilities.

Keywords : Ophthalmic Devices; Wearable Electronics

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Abstract No. : **IN-S18-0629**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Invited**

Formation of Neural Interfaces Using High-resolution 3D Printing of Liquid Metals

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Rapid advances in neurotechnology enable bidirectional communication between the nervous system and engineered devices. The precise recording and stimulation of typical target neurons by neural interfaces with adequate materials and structures can provide revolutionized medical applications, including the diagnosis and treatment of neurological disorders. Thereby, a proper understanding of the electronic device and its interfacing biological surroundings is necessary.

The utilization of gallium-based liquid metals as functional materials in bioelectronics has been extensively explored over the past decade as a key to stimulation of biological systems and recording of biological signals. The motivation behind this class of electronics is driven by the opportunities to exploit mechanical properties similar to biological tissues. These bioelectronic devices are required to maintain functionality under deformation and, especially for implantable applications, should interface with biological tissues in a minimally invasive manner. LMs are attractive for such applications due to their ability to deform while retaining their electrical conductivity. Furthermore, unlike most liquids that form droplets to minimize surface energy, the ultrathin solid-state oxide layer on the outer surface of LMs enables them to be shaped to specific 3D patterns. Unlike mercury, Ga-based LMs are considered biocompatible due to their low toxicity and vapor pressure, highlighting their potential as advantageous materials for bioelectronics.

This talk presents the fundamental aspects of these materials, with a focus on their effectiveness in stimulating and recording specific biological tissues, as well as their diverse applications as soft and stretchable electrodes in bioelectronics. Additionally, this talk investigates additional strategies aimed at driving future advancements in this field. The basic concepts of neural signaling, neural recording, and stimulation to help understand neural interfaces are introduced. Then, the considerations of the materials and a variety of materials that satisfy the requirements are summarized. Furthermore, the key challenges for next-generation neural interfaces are considered.

Keywords : neural interfaces; liquid metals; 3D printing

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Abstract No. : **OR-S18-0628**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Oral**

Electrophysiological analysis of retinal organoid development using three-dimensional microelectrodes of liquid metals

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Despite of the substantial potential of human-derived retinal organoids, the degeneration of retinal ganglion cells (RGCs) during maturation limits their utility in assessing the functionality of later-born retinal cell subtypes. Additionally, conventional analyses primarily rely on fluorescent emissions, which limits the detection of actual cell functionality while risking damage to the three-dimensional (3D) cytoarchitecture of organoids. Here, we present an electrophysiological analysis to monitor RGC development in early to mid-stage retinal organoids, and compare distinct features with fully-mature mouse retina. Our approach utilizes high-resolution 3D printing of liquid-metal microelectrodes, enabling precise targeting of specific inner retinal layers within organoids. The adaptable distribution and softness of these microelectrodes facilitate the spatiotemporal recording of inner retinal signals. Our study not only demonstrates the functional properties of RGCs in retinal organoid development but also provides insights into their synaptic connectivity, reminiscent of fetal native retinas. Further comparison with fully-mature mouse retina in vivo verifies the organoid features, highlighting the potential of early-stage retinal organoids in biomedical research.

Keywords : Liquid metals, 3D printing, Organoids

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Abstract No. : **PO-S14-0627**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Mo-Doped NiFeS Hybrid Electrocatalyst: Enhanced Activity Across Multiple Reactions for Energy Applications

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The advancement of highly efficient electrocatalysts holds significant importance for the practical use of various important electrocatalytic processes. This study presents the synthesis and electrocatalytic characteristics of a versatile hybrid electrocatalyst composed of Mo-doped nickel iron sulphide. When compared to unaltered nickel iron hydroxide and nickel iron sulphide electrocatalysts, Mo-doped NiFeS, produced through a straightforward hydrothermal method, displays notably enhanced activity across multiple reactions, including hydrogen evolution (HER), oxygen evolution (OER), and glucose oxidation (GOR). Specifically, the electrode achieves a current density of 10 mA cm^{-2} in the hydrogen evolution reaction at a low overpotential of 113 mV. Furthermore, Mo-doped NiFeS demonstrates exceptional electrocatalytic efficacy with potential of 1.45 V for the OER and 1.35 V for GOR, maintaining stability over 50 h in an alkaline environment at a current density of 50 mA cm^{-2}. This study introduces a simple approach for fabricating superior, effective catalysts devoid of noble metals through doping techniques, offering promising prospects for energy-related applications.

Keywords : OER, HER, glucose oxidation, Mo-doping, hybrid composite

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Abstract No. : **IN-S11-0626**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Invited**

Piezoelectric Thin Films for a Micro-Power Source

Isaku Kanno[*1]

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Recently, piezoelectric electromechanical systems (MEMS) using piezoelectric thin films have been actively investigated as next-generation functional microdevices [1]. Vibration energy harvesting is one of the promising applications in piezoelectric MEMS because piezoelectric thin films are able to generate relatively large electric power even with simple micro- or millimeter-scale unimorph cantilevers. For practical application of piezoelectric energy harvesters, piezoelectric thin films are required to have not only large piezoelectric properties but also sufficient long-term stability, high fracture toughness, and flexibility. Our group has developed piezoelectric PZT thin films deposited on metal foils to satisfy the above requirements [2]. Among various metal foils, stainless steel is the most suitable because thin stainless steel foils can be easily obtained at low cost. In this study, we deposited PZT thin films on stainless steel foils with a thickness of less than 50 μm by rf-magnetron sputtering method and used them for intentional bending power generation. We fabricated finger-flexion PZT thin-film power generators and succeeded in lighting an LED by the generating electric power [3]. In addition, card-bending-type PZT thin film power generators were fabricated and successfully generated a large electric power of 177 μW [4].

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[3] R. Harada, et al. , Sens. Actuators A, 322 (2021) 112617
[4] D. Teramoto, et al., Sensors and Materials, to be published

Keywords : piezoelectric, thin film, PZT, energy harvesting

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Abstract No. : **PO-S13-0625**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Enhanced performance of Sn-Pb perovskite solar cells through $Sn(SCN)_2$ passivation

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In recent times, narrow-bandgap (NBG) perovskite solar cells (PSCs) have been developed due to their potential for the bottom cell of all-perovskite tandem cells and their suitable bandgap range, according to the Shockley-Queisser limit. To reduce lead toxicity and lower the band gap, utilizing tin and lead has become popular for the B-site of the perovskite. However, non-radiative recombination of the Sn-Pb PSCs is considered a severe problem that can decrease the performance and hinder the development of PSCs. Various passivation strategies have been introduced to reduce defect density and enhance stability. In this research, we apply tin (II) thiocyanate [$Sn(SCN)_2$] to passivate Sn-Pb PSCs. It was confirmed that the reduction of crystal defects and improved charge transport of the PSCs can be achieved by $Sn(SCN)_2$ passivation. Additionally, enhancement of the open-circuit voltage and short-circuit current were observed. This research demonstrates that applying $Sn(SCN)_2$ to the Sn-Pb PSCs can enhance the device's performance.

Keywords : Perovskite solar cell, Narrow-bandgap, Sn-Pb, Sn(SCN)2

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Abstract No. : **PO-S13-0624**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Accelerating Metal Nanoparticle Exsolution for Plasmonics by Exploiting Tolerance Factor of Perovskite Stannate

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Perovskite oxide (ABO_3) with catalytically active metal nanoparticles (NPs) has the potential as a promising energy application with the plasmonic metallic particles with oxide matrix. In particular, *in-situ* exsolution is emerging method that metal NPs are segregated from an oxide matrix to a surface under a reducing atmosphere for enhancing the interfacial adhesion between metal NPs and the perovskite support with high electrical conductivity. In this presentation, we demonstrate a novel method to control a density of Ni metal NPs on surface of A-site deficient perovskite stannate matrix ($A_{0.9}Sn_{0.9}Ni_{0.1}O_{3-\delta}$, A = Ca, Sr, Ba) by manipulating distortion of SnO_6 octahedron by diffusion kinetics of Ni metal during exsolution process. Remarkably, the density of Ni NPs increases from 47 particles um^{-2} ($Ba_{0.9}Sn_{0.9}Ni_{0.1}O_{3-\delta}$) to 304 particles um^{-2} ($Ca_{0.9}Sn_{0.9}Ni_{0.1}O_{3-\delta}$) by decreasing the Goldschmidt tolerance factor of perovskite stannate epitaxial films. Quantitative analysis using ambient pressure X-ray photoemission spectroscopy (APXPS) during *in-situ* exsolution process experimentally confirmed that Ni diffusion is enhanced with decreasing the tolerance factor of perovskite stannates. Experimental characterization combined with theoretical calculation shows that Goldschmidt tolerance factor of perovskite stannate promote the Ni diffusion kinetics from the oxide matrix to surface by manipulating the A-O bonding strength. Motivated by the high density of Ni NPs on perovskite stannate support, *in-situ* CO oxidation was also performed using APXPS to identify the effect of the catalytic activity of perovskite stannate support with exsolved Ni NPs. This new strategy on the manipulation of tolerance factor for promoting exsolved metal diffusion kinetics can be exploited to enhance the density of populated metal nanoparticles for emerging plasmonic applications.

Keywords : Metallic Nanoparticles, Perovskite, Stannate, Plasmonics, Exsolution

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Abstract No. : **PO-S06-0623**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of niobium addition on the temperature of abnormal grain coarsening

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SCr420H steel, produced by the carburizing heat treatment process, is a material used in automotive components. The occurrence of abnormal grain growth during the carburizing heat treatment process causes major disturbances in the mechanical properties of the parts. If the process time can be reduced by increasing the carburizing heat treatment temperature, costs can be reduced and carbon emissions can be reduced, thus contributing to carbon neutrality. For this purpose, it is necessary to design a process that suppresses grain growth even at high temperatures. Nb was added to secure the grain refinement effect. To simulate the carburizing heat treatment process, the steel was reheated in the region of 940~1080°C after a secondary solution heat treatment. MatCalc software was used to examine the behavior of the precipitates. The carbonitrides that could be observed at high temperatures were AlN, (Nb,Ti)(C,N). Scanning electron microscopy was used to observe the microstructure of the secondary solution treatment specimens. The microstructure showed bainite and ferrite organization. Transmission electron microscopy was used to identify the type, shape, and size of the carbonitrides. This show that the fraction of AlN was high at 1050℃, the temperature of the secondary solution treatment, and the fraction of (Nb,Ti)(C,N) was high at 1200℃. Optical microscopy was used to observe the grain size by reheating at each secondary solution treatment temperature. The temperature of abnormal grain coarsening increased as the secondary solution treatment temperature increased. This showed that the influence of (Nb,Ti)(C,N) increased with the increase of heat treatment temperature. As a result, it was confirmed that the grain growth control can be achieved by secondary solution treatment at 1200°C followed by reheating at 1040°C in the case of Nb addition.

Keywords : Abnormal grain coarsening, Niobium, Carbonitride, Precipitation, Grain coarsening temperature.

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Abstract No. : **PO-S12-0622**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Quantitative analysis and implications of Journals and patents with advanced countries on ESS technology

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Addressing the climate change, sustainable development, and energy and environment issues are the crucial agenda for the countries globally. U.S, E.U and Japan have implemented energy and environemt policy for realizing the carbon neutrality. Korea, a resource-poor country with a manufacturing-centered energy-consuming industrial structure, also has to cope with strategic energy technology R&D and energy policy with limited resources. Korea also needs to active energy transition efforts with a mid- to long-term perspective. Like other new and renewable energy technologies, the role of ESS is increasing. In this research, we carried out quantitative analysis based on journals and patents with advanced countries on ESS technology and derived implications through comparative analysis with developed countries, including U.S, E.U, Japan and China. The results of this study will be used as fundaemental decision-making data for analyzing industrial ecological analysis and technology level assessment in case of ESS technology sector.

Keywords : ESS, Quantitative analysis, Journal and patent analysis, Industrial ecological analysis, Technology level analysis.

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Abstract No. : **PO-S02-0621**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Development of ternary compound $AgBiS_2$ semiconductor material and solar cell applications using co-sputtering

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$AgBiS_2$ has recently attracted significant attention as a promising light-absorbing material for thin-film solar cells due to its high light absorption coefficient, abundant and non-toxic elemental composition, and tunable bandgap. $AgBiS_2$ exists in a cation-ordered form in the bulk state. However, when the thin film is fabricated by the solution process, which is mainly studied, local atomic inhomogeneity leads to the separation of Ag or Bi overcrowding regions, which reduces the light absorption coefficient. Therefore, additional post-processing is required to create a homogeneous cation disorder.

In this study, we utilized the co-sputtering method to fabricate metal-chalcogen light-absorbing layers based on AgBiS2, analyzed the properties of the fabricated thin films, and investigated the feasibility of developing high-efficiency solar cells based on them. The co-sputtering technique can control the composition ratio of each element by controlling the sputtering power for each target, and it is possible to achieve uniform element distribution in the thin film through simultaneous deposition. In addition, as it is a vacuum process, contamination from the external environment can be minimized, making it possible to produce thin films with high purity.

According to the different post-processing conditions of the co-sputtered thin films, the structure of the thin film phase was analyzed by XRD measurements, and the ratio of each component was analyzed according to the sputtering process conditions to find the optimal conditions by XRF measurements. As a result, the thin films deposited at a power ratio of 80:75 W on Ag_2S: Bi_2S_3 targets, with a post-annealing process of 200 °C for 1 hr and a sulfurization process of 20 min at the same temperature, we were able to confirm the composition ratio of Ag:Bi:S = 1:1:2.

Keywords : AgBiS2; Solar cells; Co-sputtering; chalcogenide materials

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Abstract No. : **PO-S14-0620**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Optimization of CO_2 Reduction Performance via Sulfidation Time and gCN Integration in CuS Synthesized from Cu_2O

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This study investigates the synthesis of copper sulfide (CuS) through a two-step process involving the thermal treatment of copper foil (Cu) under an argon (Ar) flow using chemical vapor deposition (CVD), followed by the controlled oxidation to copper oxide (Cu_2O). Subsequent sulfidation of Cu_2O was conducted using hydrothermal synthesis to transition to CuS. The focus of this research was to optimize the sulfidation duration, examining increments of one, two, and three hours, to determine the most effective time frame for enhancing the catalytic performance of CuS in carbon dioxide (CO_2) reduction. Further enhancement was explored by incorporating graphitic carbon nitride (gCN) into the optimized CuS structure. The experimental results reveal that extended sulfidation times significantly influence the catalytic activity, with an optimal time identified for peak CO_2 reduction efficiency. The introduction of gCN was also found to enhance the catalytic activity synergistically, showcasing a novel approach to improving CO_2 reduction. These findings contribute to the development of more efficient catalysts for environmental remediation and sustainable energy applications.

Keywords : CO2 reduction, CuS, gCN, Electrochemistry

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Abstract No. : **IN-S13-0619**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Bifacial Cu(In,Ga)Se_2 solar cells for enhanced efficiency, modularization, and durability

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The Cu(InGa)Se_2 (CIGS) solar cell exhibits strong potential in future energy markets such as building, mobility and public facilities due to its high efficiency, good stability, and outstanding applicability. By replacing the opaque Mo back electrode with a transparent conducting oxide (TCO) film in a bifacial cell structure, it is possible to increase the photovoltaic power output from rear light incidence, improve processability of laser scribing for modulation, and enhance mechanical stability in a flexible application due to high interface adhesion at TCO/CIGS. However, the interface presents challenges in forming ohmic contacts and has a high recombination rate at the interface, which degrades the photovoltaic efficiency. In this study, we applied ITO thin films as the back electrode and explored ohmic contact formation and interface passivation capabilities. We presented several ways to form an ohmic ITO/CIGS interface and compared their passivation abilities, achieving over 20% cell efficiency for front light incidence and at the same time the rear incident photocurrent comparable to 20 mA/cm^2. During the P3 laser scribing required for fabricating monolithic-integrated module, laser heating can damage the CIGS/CdS interface, inevitably reducing photovoltaic efficiency. By directing the laser from substrate, heating of the CIGS/CdS interface by the laser can be avoided, thus securing excellent P3 scribing performance. The electrical degradation mechanisms associated with different P3 scribing processes were compared. Additionally, CIGS solar cells can be implemented as flexible modules on polyimide films. Replacing the conventional Mo back electrode with ITO significantly improved mechanical stability. Especially in repeated bending tests, while the efficiency stability of cells were no different between Mo and ITO back electrode, the modules demonstrated vastly superior stability with ITO. We successfully demonstrated transparent solar module and flexible module by employing the bifacial CIGS cell structure and the laser processing techniques, achieving either excellent transparency or flexibility, together with enhanced modulation and durability due to improved interface adhesion of TCO/CIGS.

Keywords : bifacial CIGS solar cell, monolithi-integrated module, transparency, flexibility, laser scribing

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Abstract No. : **KN-S07-0618**
Symposia : **Computational Materials Science**

Abstract Preference : **Keynote**

Nanophononics Interlayer Design of Heterostructure Thermal Boundary Resistance

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The needs for high power electronic devices are expanding for diverse applications including power conversion, smart grid, renewable energy generation and storage systems. The power capacity of devices is correlated to the bandgap of the semiconductors, and the current GaN power devices are expected to evolve to more powerful devices with ultra-wide bandgap semiconductors (e.g., b-Ga2O3, diamond, AlN, c-BN) in the future. As the power capacity of a device increases, the waste heat generated by the operation must be removed efficiently and maintain the device temperature sufficiently low to avoid accelerated degradation and premature failure of the devices. However, even the performance of current GaN power device is limited by the waste heat removal at the device level (8 W/mm compared to the electronic limit of 80 W/mm). Specifically, the thermal resistance along the heat transport pathway from the GaN device hot spots to an adjacent heat spreader (e.g., diamond) is dominated by the thermal boundary resistance (TBR) of the heterostructure interfaces. To enable the potential performance of GaN power devices, it is critically important to optimize the GaN/diamond TBR well below the previously reported values which are larger than the classically limit of ~3 m^2K/GW from the diffuse mismatch model (DMM) study of phonon transport at the heterostructure interfaces. In this talk, we will discuss the role of nanoscale interlayers at the heterostructure interfaces and demonstrate that the interlayer phonon engineering can enable novel phonon transport mechanisms at nanoscale leading to TBR values lower that the classical DMM limit. We expect to apply to nanophononics design of interlayers to lower the TBR in high-power devices.

This work was supported by DARPA Sponsored Special Projects (DSSP) in 2021 and 2022 and is currently supported by DARPA Technologies for Heat Removal in Electronics at the Device Scale (HTREADS) program.

Keywords : Thermal boundary resistance, power electronic devices, interlayer design, nanophononics

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Abstract No. : **PO-S11-0617**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Enhancing Piezoelectric Characteristics with Ferroelectric Copolymer Nanofibers at Morphotropic Phase Boundaries

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PVDF materials, which are ferroelectric and piezoelectric polymers are biocompatible, excellent processibility and mechanical flexibility, but relatively low piezoelectric properties compared to piezoelectric ceramics. Recent research results have been derived that relaxor ferroelectric appears by the composition of the TrFE units in P(VDF-TrFE). The concept for the morphotropic phase boundary (MPB), which was defined only in ferroelectric ceramics, was confirmed in PVDF-TrFE piezoelectric copolymer. In this work, we investigated the energy harvesting device fabricated from P(VDF-TrFE) copolymer nanofibers through electrospinning that have an MPB configuration and simultaneously exhibit relaxor properties. Piezoelectric and dielectric properties of P(VDF-TrFE) depend on the molar fraction of TrFE, CTrFE=50mol% with relaxor ferroelectric characteristics and CTrFE=30mol% with normal ferroelectric characteristics are compared. Piezoelectric energy harvesting performance of 50/50 P(VDF-TrFE) nanofibers clearly improved due to the MPB and relaxor ferroelectric properties. Even the unpoled 50/50 P(VDF-TrFE)-based device has shown higher output performance than the poled 70/30 P(VDF-TrFE)-based device. This study physically demonstrated a method to dramatically improve the performance of ferroelectric polymer-based piezoelectric devices by using the MPB properties of PVDF-TrFE depending on the copolymer composition.

Keywords : Morphotropic phase boundary (MPB), Electrospinning, Nanofiber energy harvesters, P(VDF-TrFE), Relaxor ferroelectrics

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Abstract No. : **PO-S11-0616**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Multilayered Self-Powered Hybrid system for Sensors applications

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In recent years, hybrid nanogenerators (HNGs) have emerged as a promising technology due to their ability to combine multiple energy sources for improved output. Notably, the hybridization of piezoelectric and triboelectric nanogenerators addresses limitations present in each individual technology. Additionally, piezoelectric morphotropic phase boundary (MPB) based ferroelectric systems have garnered increased interest for their multifunctional properties. This study explores a hybrid nanogenerator (HNG) design that combines multilayered piezoelectric and triboelectric mechanisms for enhanced output. The piezoelectric layer utilizes a morphotropic phase boundary (MPB) based ferroelectric system derived from Barium Titanate (BTO). Specifically, the research focuses on BCST (xBaCT-yBST) due to its improved piezoelectric and ferroelectric properties [1]. Polydimethylsiloxane (PDMS), a well-known triboelectric layer material, is used as a filler material within the BCST to form the composite piezoelectric layer. The study investigates a multilayered structure comprising this BCST-PDMS composite and a triboelectric layer to achieve performance improvement through hybridization. Physiochemical characterization of BCST, PDMS, and the resulting hybrid films is also conducted. Ferroelectric measurements were carried out for the BCST ceramic and found to be 10.03 μC/cm^2. The electrical output performance for the piezoelectric (39 V), triboelectric (114 V) and hybrid devices (145 V) was performed at a load resistance of 300 MΩ. The hybrid self-powered sensor was further used for various communicator systems and IOT.

Keywords : Multilayer, Piezoelectric, Triboelectric and Hybrid Nanogenerators.

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Abstract No. : **PO-S14-0615**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Post-treatment Induced Anisotropic Growth of MOF-derived Surface Modified Heterogeneous Catalyst for Efficient Oxygen Evolution Reaction

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In this study, we present a pioneering method for synthesizing Co-MOF directly immobilized onto a Ni foam substrate via hydrothermal synthesis. In contrast to traditional methods employing powder-based synthesis with binders, our direct attachment technique offers an innovative and efficient approach to creating sturdy Co-MOF@NF hybrid catalysts. Subsequently, we utilized a chemical reduction method employing sodium borohydride to introduce oxygen vacancies into the Co-MOF structure. The resulting material, sodium borohydride-treated Co-MOF@NF (Red. 1h Co-MOF@NF), demonstrated a remarkable improvement in oxygen evolution reaction (OER) activity compared to the pristine Co-MOF@NF sample. Notably, Red. 1h Co-MOF@NF exhibited a substantially reduced overpotential of 235 mV to achieve a current density of 10 mA cm^{-2}, in contrast to the 300 mV overpotential required by the pristine Co-MOF@NF under identical conditions. Furthermore, the Red. 1h Co-MOF@NF catalyst displayed outstanding stability, maintaining a current density of 50 mA cm^{-2} for over 48 hours, underscoring its promising potential for practical applications. The synergistic effects of direct hydrothermal attachment, oxygen vacancy engineering, and improved OER performance make this study a significant contribution to advancing efficient and stable electrocatalysts for energy conversion applications.

Keywords : Co-MOF, Hydrothermal, Oxygen Evolution Reaction, Oxygen vacancy, Red. 1h Co-MOF@NF

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Abstract No. : **OR-S18-0614**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Oral**

Multi-spot detectable 3D liquid metal-based electrode array for high-spatial resolution neural recording of brain organoids

Enji Kim[1], Inhea Jeong[1], Eunseon Jeong[1], Junghoon Kim[1], Seung-Woo Cho[1], Jang-Ung Park*[1]

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Brain organoids have emerged as a miniaturized substitute for the human brain as they recapitulate the functionality of three-dimensional (3D) neural network circuits. Existing devices to detect intra-organoid signals require either the section of organoids or the insertion of rigid electrodes, which curtails the 3D cellular organization of the organoids. Also, a restricted number of electrodes in fixed positions has disturbed the precise analysis in the 3D spatial scope of the organoids.

Herein, we present a multi-spot detectable 3D liquid metal-based microelectrode array (MEA) by high-resolution 3D printing of biocompatible metals for high-spatial resolution electrophysiological analysis of brain organoids. Recording neural signals from the organoid with this printed device is non-destructive and non-invasive owing to the soft mechanical properties of the liquid metals. Furthermore, facile deformability of the liquid metals facilitates the shift of the electrode tips by manipulating the magnetic field, leading to enhance the recording site density without any need for additional electrodes. The magnetic tilting of 3D liquid metal-based electrodes expands the detectable area within the brain organoids. Mapping the recorded high-spatial resolution signals from different spatiotemporal points of the organoid during cultivation on our device is expected to reveal the electrophysiological development in brain organoids.

Keywords : Brain organoid, Electrophysiological analysis, Magnetic actuation

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Abstract No. : **PO-S14-0613**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Metal-organic Framework ZIF-67 Electrocatalyst on 3D Graphene Sheets for Efficient Oxygen Evolution Reaction

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The effectiveness of water electrolysis is largely reliant on the oxygen evolution reaction (OER). Overcoming the persistent challenge of developing electrocatalysts that exhibit high current density, low overpotential, and long-lasting performance is crucial. In this regard, we present a potential electrocatalyst for water oxidation in alkaline environments. This catalyst is a composite material consisting of ZIF-67 and 3D-graphene sheets, specifically referred to as ZIF-67@3D graphene. 3D vertical graphene (VG) sheets were affixed onto nickel foam (NF) utilizing an inductively coupled plasma chemical vapor deposition (ICP CVD) system. ZIF-67 was synthesized via mechanical stirring, using cobalt metal ions as the coordinating species with 2-methylimidazole (2-MIM) acting as a ligand. The as-deposited 3D-graphene sheets on nickel foam (NF) were integrated with a solution of ZIF-67 and subjected to stirring to produce the composite material. Our electrochemical analysis disclosed that the ZIF-67@3D graphene composite exhibits superior catalytic performance compared to ZIF-67@NF. The composite demonstrated an overpotential of 220 mV at a current density of 10 mA cm^{-2}, along with a Tafel slope of 170 mV dec^{-1}, contrasting with 290 mV at 10 mA cm^{-2} and a Tafel slope of 174 mV dec^{-1} for ZIF-67/NF alone. Furthermore, the ZIF-67@3D graphene/NF composite attained a current density of 50 mA cm^{-2} with an overpotential of only 380 mV. This significant performance enhancement is ascribed to the synergistic interactions between the metal-organic framework (MOF) and graphene, which lead to augmented current density and reduced overpotential.

Keywords : ZIF-67, OER, 3D vertical graphene sheets, heterostructure, MOF, ICP CVD

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Abstract No. : **IN-S11-0612**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Invited**

Ultrafast extreme thermal-chemical-electrical waves for fabricating multi-material/interface structures toward energy harvesting and storage devices

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Rationally designed multi-element/interface materials (M-EIM) enable precise control of physicochemical properties, improving energy conversion. Among them, hybridizing multi-metal(or semiconductor)/metal oxides and carbon-based materials (MMO-CBM) have emerged as an effective strategy for boosting energy harvesting/storage performances because a combinatorial approach to low-dimensional materials can provide an unusual electrochemical characteristics which are not exhibited by single-element materials. However, their conventional synthesis inevitably involves phase/interface segregation, and requires complex procedures involving high costs and long processing times. Here, we introduce ultrafast extreme thermal-chemical-electrical waves (UTEW) as a tunable-scalable fabrication technique of MMO-CBM toward high-performance energy harvesting and storage devices. UTEW is an instant thermal-electrical-chemical conversion that induces thermochemical reactions among precursor mixtures, implementing unusual thermodynamic decomposition and recombination for fabricating engineered M-EIM. It is capable of supplying tremendous thermochemical pulse waves through entire precursor mixtures within a few milliseconds to seconds, while the overall temperature ranges and heating-cooling rates are controllable by tuning processing parameters. We present recent researches utilizing UTEW for advancing energy harvesting/storage materials. An electrothermally tunable morphological and redox design of heterogeneous Pd/PdxOy/carbon is devised to develop humidity-driven energy harvesters. Then, we report a humidity-thermoelectric bimodal energy harvester for sustainable and complementary power generation, overcoming thermal saturation or the temporal absence of thermal gradient in thermoelectricity and the low power output in humidity-driven energy harvesting. Furthermore, UTEW-driven fabrication strategies are extended to bi-, tri-, and high-entropy metal oxides involving unique structures for energy storage devices. Morphological/structural traps capturing metastable states and wetted interfaces of the constituents are demonstrated through the unconventional combination/arrangement of materials, thereby completing facile fabrication of hybrids that do not previously exist. The UTEW-based design strategy will inspire extremely rapid, yet precisely controlled fabrication routes to sorting and optimizing heterogeneous materials for energy harvesters, electrochemical cells, catalysts, electromagnetic shielding, and sensors, potentially useful in self-powered electronics.

Keywords : Humidity-driven energy harvester, Electrothermal process, Combustion synthesis, Thermoelectrics, Electrochemical electrodes, Disruptive manufacturing

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Abstract No. : **OR-S18-0611**
Symposia : **The Korea-USA International Symposium on Nanomaterials for Advanced Brain-Machine Interfaces**
Abstract Preference : **Oral**

Neuromodulation of Cortico-Basal ganglia-Thalamic Activities with Magnetic Nanoactuator

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Deep brain stimulation (DBS) is a conventional surgical therapy for Parkinson’s disease (PD), involving the direct delivery of electrical current to deep brain regions. However, this method necessitates chronic electrode implantation, leading to acute tissue damage and patient reluctance. Additionally, challenges arise in sustaining therapeutic effects over time and targeting specific cells. To address these issues, we present magnetogenetic (MG) DBS, employing nanoscale magnetic actuators as an innovative alternative. These magnetic nanoactuators modulate the motor function of PD mice by applying torque force under rotating magnetic fields, activating pre-encoded target neurons. This novel approach enables wireless and cell-specific DBS, and extends the duration of motor recovery.

We examine the therapeutic effects of MG DBS through electrophysiology. PD is characterized by excessive oscillatory synchronization of cortico-basal ganglia-thalamic (CBT) circuits. We collect electrophysiological signals from the entire CBT circuits in PD mice and analyze neuronal oscillations, focusing on their oscillatory synchronization. Moreover, to minimize tissue damage and preserve neuronal connectivity within CBT circuitry regions, we utilize a liquid-metal-based soft neural probe. This soft probe exhibits mechanical properties similar to neuronal tissue, facilitating a comprehensive examination of functional connectivity in the CBT circuit. Additionally, we integrate biodegradable temporal stiffener with the soft neural probe to support stable device implantation and eliminate the need for surgical removal of the insertion shuttle.

Our results provide interdisciplinary evidence supporting the effectiveness of MG DBS and contribute to advancements in the field of neuroscience.

Keywords : neuromodulation, magnetic nanoactuator, electrophysiology

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Abstract No. : **PO-S15-0610**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Assessing the Antibacterial Effects of Silver Nanoparticles synthesized by two different methods

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Metal-based nanoparticles present a challenge to pathogens in developing resistance due to their non-specific bacterial toxicity mechanisms. Furthermore, they are gaining traction as antibacterial agents due to their ability to expand the spectrum of antibacterial activity. Among them, silver nanoparticles are gaining attention in various fields such as biology, cosmetics, and medicine due to their potent antibacterial function. However, conventional chemically synthesized AgNPs pose risks to both the environment and human health. Alternatively, the green synthesis method employs plant biomass as both a capping and reducing agent for nanoparticle synthesis, offering advantages such as simplicity, reduced toxicity, and eco-friendliness. In this study, the antibacterial efficacy of silver nanoparticles was evaluated using two synthesis methods: chemical synthesis and green synthesis utilizing green tea extracts. We conducted qualitative assessments through agar well diffusion assays, while quantitative measurements, including minimum bactericidal concentration (MBC) and IC50, were obtained through cell growth curve analysis. The findings revealed that AgNPs produced through green synthesis exhibited superior antibacterial effects at significantly lower concentrations compared to those synthesized chemically. These findings highlight the potential application of AgNPs derived from green synthesis using green tea extract in the biomedical field.

Keywords : Silver nanoparticles (AgNPs), Antibacterial activity, Green nano synthesis

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Abstract No. : **PO-S15-0609**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Improving the Stability of Hemoglobin by Encapsulating it in Elastin-Like Polypeptide Nanoparticles to combat blood shortages

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The global shortage of blood supply has become a significant concern, leading to extensive research on various types of hemoglobin-based artificial blood to address this issue. However, free hemoglobin in the bloodstream can readily dissociate, leading to adverse effects such as the production of reactive oxygen species (ROS), cytotoxic heme, renal failure, and vasoconstriction. To enhance hemoglobin stability, this study encapsulated hemoglobin within elastin-like polypeptide (ELP) nanoparticles. The ELP block copolymer, E50A40E50, was synthesized using an Escherichia coli expression system and purified through invert transition cycling (ITC). ELPs possess unique phase transition properties and biocompatibility, making them suitable for nanoparticle formation. Particularly, the amphiphilic triblock copolymer E50A40E50 demonstrated the ability to form vesicular nanoparticles, providing an optimal environment for hemoglobin encapsulation. The hemoglobin-encapsulated ELP nanoparticles (Hb-ELP NPs) were thoroughly characterized and evaluated for their oxygen binding and releasing capabilities. This research highlights the potential of ELP encapsulation as a promising strategy for stabilizing hemoglobin and developing hemoglobin-based artificial blood.

Keywords : artificial blood, encapsulation, ELP, nanoparticle

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Abstract No. : **IN-S19-0608**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Invited**

Surface Passivation of 2D Electronics through Atomic Layer Deposition (ALD) of Uniform Al_2O_3 Thin Films

Taekjib Choi*[1], Sangwoo Lee[1]

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In semiconductor products, a passivation layer is a thin film utilized to shield a material from environmental factors that may degrade its properties. Our study focuses on the passivation layers in semiconductor products to protect 2D piezoelectric materials from environmental degradation. These layers must exhibit high chemical resistance and a low surface recombination rate to provide effective protection for the semiconductor surface. Aluminum oxide is a suitable material for these layers due to its excellent chemical resistance, etch selectivity, density, and low dielectric constant. We investigate the properties of aluminum oxide through atomic layer deposition (ALD) parameter control and post-treatment methods like rapid thermal annealing (RTA) and UV treatment.

Keywords : ALD, Aluminum oxide, Passivation, 2D piezoelectric material

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Abstract No. : **OR-S19-0607**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Achieving High SNR FOM with 2D MoS2-based MEMs Microphones

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The piezoelectric microphone is a key device that converts acoustic energy, or sound waves, into electrical signals through the piezoelectric effect, facilitating the capture and transmission of audio. As we look ahead, the future of microphone technology holds tremendous innovation potential, spurred by advancements in various key areas including miniaturization, sensitivity, noise reduction, AI integration, wireless connectivity, sustainability, and durability. These next-generation technologies are poised to significantly enhance user experiences and unlock new possibilities in audio recording, communication, and interaction. Among the emerging technologies, (Micro-Electro-Mechanical Systems) microphones stand out as promising candidates for next-generation microphone development. These MEMS microphones offer the potential for miniaturization while maintaining high quality through regulated MEMS engineering, as well as exceptional durability.

In this study, we explore the use of MoS_2 as a 2D piezoelectric material for MEMS to achieve high sensitivity and durability. 2D MoS_2 offers several advantages, including atomic-scale thickness, high surface area, flexibility, and durability, which can significantly enhance microphone performance. Notably, 2D MoS_2 exhibits a high strain ratio in the in-plane direction, leading to improved sound quality and controllable sensitivity, particularly in the low-frequency range. To evaluate the performance of 2D MoS_2-based MEMS microphones, we employ Signal-to-Noise Ratio Figure-of-Merit (SNR FOM) as a key metric for sensory properties. Achieving low dielectric losses (tanδ), high dielectric constant (ε11), and high piezoelectric coefficient (e11) are crucial for obtaining high SNR values. These properties are assessed through measurements using an LCR meter and Piezo Force Microscopy (PFM) in the in-plane direction. We anticipate that the development of 2D-based MEMS microphones will yield high SNR values, representing a significant advancement in microphone technology. This research opens new horizons for the future of microphone technology, paving the way for enhanced audio capture and communication capabilities.

Keywords : MEMS, microphone, MoS2, SNR

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Abstract No. : **IN-S11-0606**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Invited**

Compliant thermoelectric generators for sustainable self-powered wearables

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Softening of thermoelectric generators (TEGs) allows conformal contact with arbitrary-shaped heat sources, which offers an opportunity to realize self-powered flexible applications. However, existing rigid/flexible thermoelectric devices inevitably exhibit reduced thermoelectric conversion efficiency due to the parasitic heat loss in high-thermal-impedance polymer substrates and poor thermal contact arising from rigid interconnects. In this talk, I would like to introduce our recent efforts to improve the thermoelectric performance of compliant TEGs, which facilitate achieving high energy conversion efficiency in TEGs capable of conforming to 3D surfaces of heat sources simultaneously. In addition, skin-like thermoelectric devices with magnetically self-assembled thermoelectric particles will be presented for realizing fully soft energy harvesting devices.

Keywords : thermoelectrics, soft electronics, self-powered devices

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Abstract No. : **PO-S02-0605**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Stability analysis of metal thin films according to repeated tensile deformation for flexible devices

Taehyeon Kim[1], Sangwoong Baek[1], Keumhwan Park[1], Youngmin Kim[1], Chan-Jae Lee[*1]

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Recently, the devices requiring flexibility and elasticity, such as flexible displays, bio sensors, and wearable devices, have been developed actively. To make such devices, it is necessary to develop stretchable electrodes, and various electrode structures have been proposed such as nanowire, graphene, wavy structure, porous mesh etc. However, these electrodes still show higher resistance, lower reliability, and rougher surface properties compared to metal thin films made by vacuum deposition.

In this study, we analyzed the stability of a metal thin film formed on a polymer film using a conventional vacuum deposition method against repeated deformation. Changes in resistance were continuously measured while repeatedly stretching 1-10% using Mo and Al with different modulus values. In addition, the process by which cracks occur and progress on the surface during the deformation stage was analyzed. In the case of Al, the increase in resistance in the stretched state and the range of change in resistance when returned to the original state were not large, but in Mo, a high increase in resistance was observed even with 1% tension. And even when returned to the original state, the resistance did not return to the original value.

Keywords : flexible, modulus, tensile, electrode

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Abstract No. : **PO-S02-0604**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Enhancing flexible organic light emitting diodes with a work function tunable Zn-Doped InSnO electrode and metal inter-layer

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The demand for flexible OLED devices has necessitated the development of conductive electrodes with superior electrical and optical properties. This study introduces multilayer transparent conductive electrodes prepared on flexible substrates at room temperature using an RF/DC magnetron co-sputtering system. These electrodes incorporate metal layers, specifically silver (Ag), which offer lower electrical resistance than the widely used indium tin oxide (ITO). Ag was used as an inserted layer in a Zn-doped ITO thin film to enhance electrical conductivity while adjusting the work function according to the Ag metal layer thickness. We investigated the optical and electrical properties of these multilayer structures, focusing on the effects of varying the thickness of the Ag inter-layers.

The optimized Ag film thickness resulted in a high-quality conductive thin film with a ultra-low sheet resistance and a high optical transmittance of over 90% in the visible range, coupled with a surface roughness (RRMS) value of less than 1 nm.

The achieved high work function (~5.3 eV) and high hole mobility indicate effective hole injection into the light-emitting layer, allowing the multilayer to function simultaneously as an electrode and hole injection layer (HIL). The fabrication of an OLED device using this multilayer transparent conductive thin film was followed by the evaluation of its I-V-L characteristics, confirming stable operation on a flexible substrate. This study underscores the potential of optimized multilayer electrodes in enhancing the performance and flexibility of OLED devices, promising advancements in flexible electronics.

Keywords : transparent conductive electrodes, multi-layer electrodes , work function, OLED

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Abstract No. : **PO-S02-0603**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Stress analysis by bending direction in foldable display three-layer simulated structure using FEM simulation

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In this study, we investigated the deformation characteristics of three-layer films including optical clear adhesive (OCA) layer, which are used as important components in flexible displays. First, we attempted to analyze the deformation caused by bending of a three-layer attached film using FEM (Finite Element Method) simulation. Through this, the stress and strain of the multilayer film were evaluated, and the yield of the material was determined based on the radius of curvature and the thickness of each layer. Using Abaqus CAE, we performed a bending deformation simulation of a three-layer structure applied to an actual flexible display. To improve analysis speed and optimize calculation volume, we designed a 1/2 y-axis symmetric model and applied 2D implicit and explicit analysis methods.

We make three models to simulation for a flexible display panel, CPI(50㎛)-OCA-CPI(50㎛) (symmetric model), PET(50㎛)-OCA-CPI(50㎛) (out-folding model) and CPI(50㎛)-OCA- PET (50㎛) (in-folding model). Here, the OCA layer was simulated by varying the conditions from 10 to 30㎛.

As a result of the simulation, it was possible to confirm the difference between the in-folding and out-folding models depending on the thickness. In the out-folding model, the stress generated in the PET layer tended to increase as the thickness of the OCA layer increased. In addition, it was confirmed that in both models, the stress applied to the film increases as the radius of curvature becomes smaller, and that elastic deformation is possible without yielding the material when the R value is greater than 1.5.

Keywords : FEM, Foldable display, bending, stress

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Abstract No. : **PO-S02-0602**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

A study on the characteristics of ITO hybrid electrodes to enhance flexibility in PDLC devices

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Polymer-dispersed liquid crystal(PDLC) devices require high conductivity and transparency along with flexibility, and ITO (Indium Tin Oxide) transparent electrodes are well known for their high electrical conductivity and excellent optical transparency. However, ITO-based electrodes have limitations in their application to transparent flexible electrodes due to disadvantages such as reduced electrical conductivity due to mechanical stress and deformation and chemical instability.
In this study, we propose a hybrid electrode with the conductive polymer PEDOT:PSS to overcome the flexibility limitations of ITO electrodes. PEDOT:PSS was doped with DMSO for conductivity, and its thickness was optimized by evaluating electrical conductivity, transmittance. The PEDOT:PSS/ITO hybrid electrode further improves the flexibility of ITO while simultaneously improving the relatively low electrical conductivity of the PEDOT:PSS. The flexibility of the hybrid electrode, optimized in thickness and applied to the flexible electrode, was confirmed through a bending test. Optimal characteristics were also verified by measuring the transmittance at different voltages applied to the PDLC device.
Flexible and transparent PEDOT:PSS/ITO electrodes used in the fabrication of PDLC devices demonstrate the outstanding flexibility and durability of hybrid electrodes, promising reliable and efficient applications in electronic devices.

Keywords : PDLC, ITO, PEDOT:PSS, Transparent electrode

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Abstract No. : **PO-S05-0600**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Insights into Contact Physics: Exploring Type-II Weyl Semimetals in Comparison to Dirac Semimetals

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The requirement for low contact resistance in two-dimensional (2D) nanoelectronics has been successfully achieved by using semimetal as contact materials due to low metal-induced gap states (MIGS). Although contact physics, especially in terms of Ohmic contact using Dirac semimetal bismuth (Bi) and antimony (Sb), has been well discovered, type-II Weyl semimetal remains unexplored so far. Herein, we demonstrate the physics behind the interface between MoS_2 and type-II Weyl semimetal, especially 1T'-WTe_2 and 1T'-$MoTe_2$, comparing the results with Sb and Bi by performing a comprehensive first-principle density functional theory. Vacuum level shift (VLS) caused by charge redistribution at the interface is investigated to interpret the band shift of the heterostructure contact system. Moreover, we discovered a downward expansion of the conduction band minimum induced by MIGS of MoS_2 at the contact region. Due to structural symmetry differences in type-II Weyl semimetals, unlike Dirac, orbital hybridization is highly affected by the relative orientation of the interfaces between the semiconductor and the semimetal. We calculated the effective Schottky barrier height by applying the modified Schottky-Mott rule, which considers the effects of VLS and band expansion. Our work provides fundamental insights into semimetal contact physics suggesting a direction for interpreting 2D electronics.

Keywords : 2D electronics, MoS2, Semimetal, Schottky barrier, DFT

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Abstract No. : **IN-S13-0599**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Interfacial Design in Halide Perovskite Solar Cells

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Halide perovskite solar cells (PSCs) exhibit a thin-film device architecture wherein the light-absorbing perovskite layer is sandwiched between n-type and p-type semiconducting layers. The electric field within the light-absorbing layer can be finely tuned not only through the implementation of charge-transporting layers (CTLs) but also via meticulous interfacial design between the perovskite and CTLs. Additionally, the optimization of radiation from stacked perovskite layers within the entire device, achieved by minimizing non-radiative recombination processes, holds the potential to enhance performance through mechanisms such as photon recycling and scattering. Consequently, the strategic interfacial design on both sides of the perovskite layer, addressing both electrical field distribution and optical radiation characteristics within the thin-film solar cell architecture, emerges as a crucial factor in approaching the radiative efficiency limit. This presentation will delve into our recent efforts in interfacial design, aimed at bolstering the photovoltaic performance of PSCs through refined electrical and optical strategies.

Keywords : perovskte solar cells, interfacial, electric field

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Abstract No. : **IN-S19-0598**
Symposia : **Nanomaterials for MEMS microphone**
Abstract Preference : **Invited**

Advancing Piezoelectric MEMS Microphone Design with FEM Simulation and Deep Learning

Jaichan Lee[*1], Minsu Choi[1], Myungho Lee[1]

[1]*Compaid*

The geometric configuration of MEMS microphone critically influences their inherent physical characteristics and consequent performance metrics. The comprehensive exploration of potential designs via numerical simulation is resource-intensive, often restricting researchers' ability to assess a broad spectrum of promising configurations. This is especially relevant for piezoelectric MEMS microphones, where optimal performance depends on precisely tuning structural parameters such as thickness, shape, and aperture dimensions. This study introduces an innovative methodology employing deep learning algorithms to predict the physical outcomes of extensive design variations, thereby expediting the engineering cycle of piezoelectric MEMS microphones. Our approach enables rapid evaluation of various design alternatives, facilitating a robust, data-driven framework for MEMS structural optimization.

Keywords : MEMS Microphone Design , FEM Simulation , Deep Learning

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Abstract No. : **PO-S09-0597**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Transparent conductive oxides thin films and their applications with photochromic and thermochromic films

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We are all familiar with photochromic glasses, light-adaptive glasses that turn reversibly into sunglasses under strong solar irradiance. This type of eyeglasses has been commercialized successfully during decades. However, the same concept for building windows is failed to achieving commercialize. Unfortunately, the photochromic approach that works well for eyeglasses is not easily transferred to the window industry. If it is possible, a photochromic window would allow us to take control of the solar irradiance in a dynamic way, preventing an overheating of the building and promising larger energy saving than a conventional static window. Moreover, photochromic window would increase the thermal and visual comfort of the building's users. Most photochromic materials have been applied and commercialized are based on organic material, and hence do not have an adequate durability to be used in building windows. Photochromic inorganic materials, such as silver halides, are stronger candidates than their organic counterparts for this purpose. However, silver halides are not compatible with the float glass fabrication method. In this talk, it will be discussed that the inorganic photochromic thin films, which can be representative rare earth oxyhydrides, such as yttrium, gadolinium, and lanthanum, prepared using reactive sputtering. Furthermore, the inorganic thermochromic thin films also discussed which is promising materials for chromogenic windows.

Keywords : TCO; ITO; YHO; VO2

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Abstract No. : **OR-S01-0596**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Oral**

A heuristic approach for transforming nickel-rich hydroxide precursors into fast-charging cathodes for next-generation lithium-ion batteries

Arul Saravanan Raaju Sundhar[1], Keyru Serbara Bejigo[1], Sang-Jae Kim*[1]

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The widespread demand for high-performance Li-ion batteries (LiBs) has driven increased interest in Ni-rich cathode materials (Ni > 80%).[1,2] These materials offer the potential for enhanced volumetric energy density and fast-charging capabilities. However, existing material optimization techniques struggle to achieve both goals simultaneously. We report a novel, heuristic doping approach applicable to a broad range of Ni-rich cathode precursors, resulting in demonstrable improvements in fast-charging performance and cycling stability. Employing crystal lattice and grain boundary modifications simultaneously, this technique yields cathodes with enhanced structural integrity, as evidenced by in-situ XRD and HR-TEM analysis. Electrochemical testing demonstrates ~99% capacity retention at 5C for 200 cycles. This approach is notable for its versatility, as it was successfully applied to precursors with varying Ni content (including >90% Ni compositions). This strategy can potentially streamline the production of high-performance LiBs by offering a universal modification technique that addresses the limitations of traditional doping methods.

Keywords : Ni-rich cathode; Transition metal oxide cathode; Fast-charging; Li+ diffusion

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Abstract No. : **PO-S15-0595**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Analysis of Defects and Traps in Various Carrier transfer Layered-Structure of Perovskite Solar Cells by Deep Level Transient Spectroscopy (DLTS)

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Halide segregation is a temporary phenomenon that must be detected by real-time spectroscopic techniques because of its time-dependence mechanisms. In addition, since this Halide segregation is very closely related to the migration of mobile ions and carriers, it is necessary to observe the mobility of ions and carriers through defect analysis in the material. In this study, we observed the Halide segregation in perovskite solar cells as a new Carrier Transfer Layer was added using real-time spectroscopic technology called RTJAS. Concurrently, we conducted defect analysis using Deep Level Transient Spectroscopy (DLTS). DLTS allows the analysis of defect levels and concentrations within the solar cell through capacitance-based measurements. By utilizing both methods, we explained the phenomenon of Halide segregation and its correlation with Ion defects. While the addition of Layer 1 improved the Voc of the solar cell, it was observed that photostability decreased, and DLTS revealed the presence of two hole defects. Based on these findings, we opted for Layer 2 instead of Layer 1, removing one of the two hole defects and reducing the trap density of the remaining one. Furthermore, analysis using RTJAS indicated that Halide segregation was suppressed, resulting in both high performance and photostability.

Keywords : DLTS, real-time spectroscopy, mixed halide perovskite, halide segregation

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Abstract No. : **OR-S16-0594**
Symposia : **ICYRAM Young Researcher Symposium**

Abstract Preference : **Oral**

Exceptional thermochemical stability of graphene/N-polar GaN for remote homoepitaxy for exfoliation and deformable device

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Graphene (Gr) has drawn great attention as an epitaxial template for production of single-crystalline, freestanding semiconductor membranes through remote epitaxy. This emerging epitaxy facilitates the growth of single-crystalline epi-layers and utilization of easy delamination of epi-layers without causing significant damage, due to the weak van der Waals interaction between epi-layer and mother substrate. Various material systems, such as compound semiconductors, complex oxides, halide perovskites, etc., have been extensively studied for remote epitaxy. However, metal–organic vapor deposition (MOCVD)-based GaN remote homoepitaxy remains unaccomplished due to the poor thermochemical stability of Gr/Ga-polar GaN substrates. III–nitrides (i.e., GaN and AlN) are conventionally grown using MOCVD at high temperatures under a hydrogen atmosphere for commercial purposes. However, the harsh conditions potentially lead to thermochemical decomposition of Gr and underlying substrate, making it difficult to take the full advantages of remote epitaxy. Thus, the remote homoepitaxy of GaN and successful exfoliation of GaN overlayer have remained as challenges. Our work shows a new finding that Gr on N-polar GaN substrate exhibits a better thermochemical stability than Ga-polar GaN substrate. N-polar GaN substrate enable the remote homoepitaxy, subsequent delamination, and flexible device fabrication. The comparisons of N- and Ga-polar GaN substrates through annealing test, remote epitaxy, and epi-layer delamination suggest that the N-polar GaN substrate exhibited robustness against the high-temperature hydrogen ambient required of MOCVD. Furthermore, Raman spectroscopy, electron microscopic analyses, and molecular dynamics (MD) simulations indicate no decomposition of graphene on N-polar GaN during remote homoepitaxy using MOCVD. MD simulations and experiments complementarily confirm that the thermochemical stability of graphene depends on the polarity of GaN due to varying hydrogen reaction behavior at high temperatures. We successfully applied the microcrystal overlayer formed by remote homoepitaxy to fabricate flexible p–n junction light-emitting devices after delamination and device fabrication process that leverages the advantages of remote epitaxy.

Keywords : remote epitaxy, polarity, N-polar GaN, thermochemical stability, deformable light-emitting diode

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Abstract No. : **PO-S11-0593**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Structural Optimization of Glycine for Enhanced Piezoelectric Performance

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Piezoelectric materials, renowned for their ability to generate electric charge under mechanical stress and mechanical deformation under an electric field, exhibit significant promise in various technological applications such as sensors, energy harvesting devices, health monitoring, and so on. However, traditional piezoelectric materials like lead zirconium titanate (PZT) and barium titanate (BaTiO3) face challenges in bio-applications due to toxicity and brittleness. In recent years, there has been growing interest in bio-piezoelectric materials derived from biomolecules such as collagen, amino acids, and DNA[1]. While these biomaterials offer biocompatibility advantages, their piezoelectricity tends to be lower compared to conventional materials.
This study focuses on glycine, an amino acid renowned for its high piezoelectricity in the β -phase, reaching d16=196 pm/V, comparable to or exceeding that of conventional piezoelectric materials [2]. Despite its promising properties, the β-phase glycine is thermodynamically unstable, posing challenges in selectively synthesizing beta-phase crystal structures in large areas. To address this, we propose a fabrication approach utilizing the meniscus-driven dip-coating process, originally introduced for aligned peptide nanotubes [3]. By controlling the mixing ratio of glycine solvent and antisolvent and drying speeds of solution on the substrate, we aim to optimize the formation of β phase glycine. Phase confirmation was conducted using X-ray diffractometer patterns and Raman spectroscopy, while piezoelectric properties were evaluated using a piezoelectric force microscope (PFM). Additionally, we fabricated glycine-based piezoelectric nanogenerators (PENGs) to assess the practical piezoelectric performance of the β phase glycine. This research not only advances our understanding of bio-piezoelectric materials but also addresses practical barriers to their adoption. By potentially surpassing existing materials in piezoelectric performance, this work could revolutionize the use of bio-piezoelectric materials in various applications.

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Keywords : Glycine, Piezoelectric material, Energy harvesting, biomaterial

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Abstract No. : **IN-S11-0592**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Invited**

Synergistic performance enhancement of nanogenerators based on hybrid nanostructures

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With the development of Internet of Things (IoT) technology, energy-harvesting technologies that generate electrical energies from the environment regardless of time and place have attracted much attention. Energy-harvesting technologies enable the operation of mobile devices or wireless sensor networks for the realization of IoT by collecting the wasted energy in various forms, such as mechanical, optical, and thermal energies, and converting them into the form of electrical energy capable of operating widely spread, small electronic devices. Recently, energy scavenging technologies based on energy conversion from various wasted ambient energies to electrical energy have received much attention for self-powering and renewable energy applications. Harvesting abundantly available wasted ambient mechanical (e.g., from human activity, machinery vibration, noise or sound waves, airflow, and water flow), optical (solar, photonic, and radioactive), and electrochemical energies has been a long-standing dream and is being widely investigated for use in sustainable and self-powering systems. In this presentation, the fabrication and applications of various organic-inorganic multi-dimensional nanomaterials will be introduced based on recent developments. In addition, a demonstration of fiber-based nanomaterials for energy conversion devices will be presented. The synergistic enhancement of nanogenerator performances has been verified, and its mechanism was suggested based on hybrid nanostructures. More details about the performances of the devices will be discussed in the presentation.

Keywords : Triboelectric nanogenerator, Nanofiber, Hybrid nanostructures, Synergistic effect

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Abstract No. : **IN-S05-0591**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

All Solid-State Synapse Device Arrays Using 2D Channel/LiSiOx Electrolyte for Next-Generation Neuromorphic Edge Computing

Yonghun Kim*[1]

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High-precision artificial synaptic devices are essential for realizing robust neuromorphic hardware systems with reliable parallel analogue computation beyond the von Neumann serial digital computing architecture. In this talk, we will present a robust three-terminal two-dimensional (2D) MoS_2 artificial synaptic device combined with a lithium silicate (LSO) solid-state electrolyte thin film is proposed for neuromorphic edge computing applications. Critical issues related to reliability and variability, such as nonlinearity and asymmetric weight updates, have been great challenges in the implementation of artificial synaptic devices in practical neuromorphic hardware systems. The rationally designed synaptic device exhibits excellent linearity and symmetry upon electrical potentiation and depression, benefiting from the reversible intercalation of Li ions into the MoS_2 channel. Also, the ultra-flexible synapse device arrays using this heterostructures is also introduced.

Keywords : laser lift-off (LLO) process, neuromorphic edge computing, solid-stateelectrolyte-gated synaptic transistors, van der Waals layered materials,wearable synaptic devices

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Abstract No. : **OR-S14-0590**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Hybrid photothermal–photocatalyst sheets for solar-driven overall water splitting coupled to water purification

Chanon Pornrungroj[*2], Ariffin Bin Mohamad Annua[1], Qian Wang[3], Motiar Rahaman[1], Subhajit Bhattacharjee[1], Virgil Andrei[1], Erwin Reisner[1]

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Photocatalytic water splitting converts sunlight directly into storable hydrogen, but commonly involves the use of pure water and land for plant installation while generating unusable waste heat. Here we report a hybrid device consisting of a photocatalyst (PC) and a solar vapour generator (SVG) for simultaneous overall water splitting and water purification from open water sources. Specifically, an ultraviolet light-absorbing $RhCrO_x$–Al:$SrTiO_3$ PC is deposited on top of a floating, visible and infrared light-absorbing porous carbon SVG, which produces green fuel with a solar-to-hydrogen efficiency of 0.13 ± 0.03% and 0.95 $kg\,m^{-2}\,h^{-1}$ of water vapour as the feed for the PC and collectable purified water. This integrated system maintains operational stability in seawater and other aqueous waste streams for over 154 h due to the isolation of the PC from contaminants in the liquid feedstock. This work provides a new concept for developing an off-grid energy production/storage solution and is a first step towards alleviating both energy and water supply challenges.

Reference: Pornrungroj, C., Mohamad Annuar, A.B., Wang, Q. *et al.* Hybrid photothermal–photocatalyst sheets for solar-driven overall water splitting coupled to water purification. *Nature Water* **1**, 952–960 (2023). https://doi.org/10.1038/s44221-023-00139-9

Keywords : Water splitting, solar desalination, solar thermal, green hydrogen, solar fuels

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Abstract No. : **IN-S19-0589**
Symposia : **Nanomaterials for MEMS microphone**
Abstract Preference : **Invited**

Overview of MEMS Microphones Based on Nanomaterials

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The advancement of electronic devices has increased the significance of audio input interfaces between humans and devices. With the recent development of AI and voice recognition technologies, there is a growing demand for high-performance, miniaturized microphones. However, conventional ceramic-based microphones exhibit low sensitivity within the human acoustic frequency range and face limitations in size due to the properties of the materials. To overcome these limitations and introduce a next-generation microphone, we propose the development of a 2D piezoelectric material-based Micro Electro Mechanical Systems (MEMS) microphone.
In this talk, we aim to provide a comprehensive introduction to MEMS microphones based on 2D piezoelectric materials. We will discuss the method for the growth of wafer-scale 2D piezoelectric materials, MEMS processes, and a detailed analysis of the properties and performance of the developed MEMS microphone.

Keywords : Microphone, 2D materials, Piezoelectric material, Micro electro mechanical systems

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Abstract No. : **PO-S06-0588**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

In-situ MnO decorated Carbon as Bifuncitonal electrode for high performance supercapacitor and hydrogen evolution reaction

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Electrochemical energy conversion- and storage devices/technologies have attained much interest owing to the huge demand of energy supplies. In this research work, we synthesized MnO-decorated carbon (MnO@C) via a one-step pyrolysis process using biowaste as a carbon source and $KMnO_4$ as a precursor. Physicochemical characterizations such as X-ray diffraction, laser Raman, and field emission scanning electron microscopic analyses confirmed the formation of MnO@C. The electrochemical analysis for MnO@C was investigated using 1 M Li_2SO_4 as electrolyte for the supercapacitor and 1M KOH electrolyte for the hydrogen evolution reaction (HER). The MnO@C electrode possesses high specific capacitance compared to the other MnO-based electrodes for supercapacitor applications. In addition, the HER analysis was also studied for MnO@C electrodes, which shows relatively low overpotential value with high stability. Overall, the results show a new pathway of bifunctional electrode materials for next-generation energy storage/conversion devices.

Keywords : Supercapacitor; hydrogen evolution reaction; cyclic voltammetry; bio-waste carbon.

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Abstract No. : **OR-S11-0587**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Tungsten Disulfide: Wire-Type Self-Charging Supercapacitor Power Cell for Next-Gen Smart Application

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The development of self-charging supercapacitor power cells has gained significant interest for their ability to efficiently convert and store energy within a single integrated device. In this work, we have fabricated a wire-type self-charging supercapacitor power cell (WT-SCSPC) using tungsten disulfide as an electrode and PVA/KOH/$BaTiO_3$ as a piezogel electrolyte. Physico-chemical characterization techniques, including X-ray diffraction, laser Raman, X-ray photoelectron spectroscopy, and field-emission scanning electron microscopic analyses, confirm the formation of tungsten disulfide nanosheets. Electrochemical characterization, such as cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS), were conducted to analyze the charge-storage properties of the WT-SCSPC device. The energy harvesting characteristics of the PVA/KOH/barium titanate were analyzed via fabricating a piezoelectric nanogenerator device. Finally, WT-SCSPC was tested via applying continuous bending to the device, which shows the self-charging capability of the fabricated device. Our experimental results confirm the potential of the WT-SCSPC device for next-generation flexible smart electronic applications.

Keywords : Tungsten disulfide, self-charging supercapacitor, wire-type supercapacitor, piezogel electrolyte.

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Abstract No. : **PO-S11-0586**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Control Biodegradability of Piezoelectric Dipeptide Nanotubes Incorporated with Porphyrin

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Piezoelectric biomaterials, such as amino acid, peptide, collagen, and protein, emerged as an attractive candidate for bio-implantable devices owning to high biocompatibility, biodegradability, and low dielectric constant. Among them, diphenylalanine (FF) is well known materials for piezoelectric nanogenerators (PENGs) owing to both strong in-plane piezoelectric response and the characteristic of self-assembly. Also, remarkable mechanical and chemical stabilities are shown by forming horizontally aligned hexagonal crystal structures of dipeptides. However, FF has severe limitations to apply for body implantable device, due to its low solubility (0.76g/L) in water. FF could dissolve at least 5 minutes in vivo. To solve this problem, we utilized tetra(p-hydroxyphenyl) porphyrin (THPP) to improve degradability of dipeptides.

We synthesized FF/THPP nanostructures via a meniscus-driven self-assembly process to form unidirectionally aligned hexagonal tubes uniformly controlled by THPP concentration. THPP was incorporated into FF nanotubes during FF self-assembly, and the hydrophobic characteristic prevent FF from dissolving in body fluids. We confirmed the improvement of degradability immersing in phosphate-buffered saline (PBS) through optical appearance and normalized XRD intensities. FF incorporated hydrophobic porphyrins remained their crystal structures over 80% after 1 hours of PBS immersion compared with bare FF. The piezoresponse measurement revealed FF/THPP provided strong piezoelectric coefficient compared to FF shown in previous study (d_{15}=62.3pm/V). Furthermore, when we applied in PENGs, the output performance was stable after 15 min of PBS immersion. This study demonstrates that THPP could control the degradability of dipeptide in vivo maintaining their piezoelectricity and we believe this work could utilize in the field of bio-piezoelectric nanogenerators.

Keywords : Biomolecular piezoelectric, Diphenylalanine, Biocompatible, Piezoelectric nanogenerator

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Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Self-powered Acceleration Sensor for Distance Prediction via Triboelectrifications

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Accurately predicting the distance an object will travel to its destination is very important in various sports. As a means of real-time monitoring, acceleration sensors are increasingly gaining attention in sports. Due to the low energy output and power density of triboelectric nanogenerators (TENGs), recent efforts have focused on developing various acceleration sensors. However, these sensors suffer from significant drawbacks due to large size, complexity, high power input requirements, or high cost. Here, we described a portable and cost-effective real-time refreshable strategy design comprising a series of individually addressable and controllable units based on TENGs embedded in a flexible substrate. This results in a highly sensitive, low-cost, and self-powered acceleration sensor. Putting, which accounts for nearly half of the strokes played, is obviously an important component of the golf game. The developed acceleration sensor has an accuracy controlled within 5%, capable of displaying the initial velocity and acceleration of the forward movement of a rolling golf ball after it is hit by a putter, and quickly calculating and predicting the stopping distance of about 7 seconds. We ultimately demonstrated the application of this portable TENG-based acceleration sensor. This research paves the way for designing portable, cost-effective, scalable, and harmless ubiquitous self-powered acceleration sensors.

In this study, we present a self-powered acceleration sensor based on TENGs for predicting the distance a golf ball travels before reaching the hole. We systematically explored the performance of the acceleration and distance monitoring sensor from both theoretical and experimental perspectives. Attaching the sensor to the bottom of a golf practice mat results in the generation of varying voltage signals when an object moves over the hidden sensors. The object's acceleration and the predicted distance to its stopping point are automatically calculated based on the time difference between these voltage signals.

References

Keywords : triboelectric nanogenerator; self-powered; acceleration sensor; distance prediction

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Abstract No. : **OR-S06-0584**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Investigation of high strain rate induced hierarchical deformation structure CrCoNiSi0.3 medium entropy alloy under ballistic impact.

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CrCoNiSix medium entropy alloys (x = 0, 0.15, 0.3), processed through hot rolling to 70% reduction at 1000°C and subsequent annealing, were subjected to ballistic tests at strain rates exceeding 10^6 s^{-1}. Among these, the $CrCoNiSi_{0.3}$ alloy demonstrated the highest energy absorption, achieving 82%, markedly higher than the 76.7% for CrCoNiSi**0.15** and 68.9% for CrCoNi. This research delves into the microstructural changes of the $CrCoNiSi_{0.3}$ alloy after impact, analyzing three specific areas based on their proximity to the bullet impact and the degree of deformation observed. The first area, 25 mm from the impact site, showed no deformation twins, reflecting the minimal strain experienced. The second area, located 10 mm from the impact, contained intersecting deformation twins around 5 nm thick, which formed submicron blocks ranging from 100 nm to 300 nm in width. The third and closest area, 5 mm from the impact site, exhibited ultra-fine deformation nanotwins below 2 nm that segmented the submicron blocks into even smaller nanoblocks under 50 nm across due to varying twin formations. Detailed high-resolution scanning transmission electron microscopy (HRSTEM) further revealed the dynamic formation of these nanoblocks, induced by deformation twinning during the impact process.

Keywords : ballistic impact; twining induced plasticity; high resolution scanning transmittion electroscopy; deformation twining; medium entropy alloy

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Abstract No. : **OR-S19-0583**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Observation of In-Plane Piezoelectricity in Free-standing MoS_2 via SiO_2 Etching

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Various 2D semiconducting materials has been widely studied due to their superior optical and electrical performances to apply optoelectronic and electronic electronics. Indeed, transition metal dichalcogenides (TMDs) have both excellent piezoelectric properties and mechanical flexibility, which is attractive for microelectromechanical systems (MEMS) and energy harvesters. Specifically, Molybdenum disulfide (MoS_2) in odd-layer is a noncentrosymmetric material exhibiting strong piezoelectric properties, while its even-layer is expected to exhibit inversion symmetry. Previous studies showed the theoretical calculation of piezoelectric coefficient for monolayer MoS_2 provided higher compared with bulk wurtzite materials. However, only few studies were reported on the experimentally measured piezoelectric properties of monolayer MoS_2. Furthermore, the synthesis of single-layer MoS_2 is a challenge task.

In this study, we synthesized three layers MoS_2 and measured piezoelectric properties in free standing to solve these problems. The previous PFM measurement could not avoid the negative effects between 2D materials and substrates such as doping effect, parasitic charges, and clamping effect and so on. We transferred MoS_2 on SiO_2 which was etched at the constant thickness and confirmed improvement of in-plane piezoelectric response (d_{11}) through the free-stand crystals. This approach suggests a practical way to directly obtain and detect the in-plane piezoelectric coupling in free-standing three-layer MoS_2.

We believe this work can widely utilized in the field of flexible electromechanical systems based on semiconducting 2D materials and self-powered piezoelectric electronics.

Keywords : Molybdeum disulfide, Piezoelectricity, Nanogenerator, Piezoresponse force microscopy

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Abstract No. : **OR-S11-0582**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Tungsten Disulfide: Wire-Type Self-Charging Supercapacitor Power Cell for Next-Gen Smart Application

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The development of self-charging supercapacitor power cells has gained significant interest for their ability to efficiently convert and store energy within a single integrated device. In this work, we have fabricated a wire-type self-charging supercapacitor power cell (WT-SCSPC) using tungsten disulfide as an electrode and PVA/KOH/$BaTiO_3$ as a piezogel electrolyte. Physico-chemical characterization techniques, including X-ray diffraction, laser Raman, X-ray photoelectron spectroscopy, and field-emission scanning electron microscopic analyses, confirm the formation of tungsten disulfide nanosheets. Electrochemical characterization, such as cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS), were conducted to analyze the charge-storage properties of the WT-SCSPC device. The energy harvesting characteristics of the PVA/KOH/barium titanate were analyzed via fabricating a piezoelectric nanogenerator device. Finally, WT-SCSPC was tested via applying continuous bending to the device, which shows the self-charging capability of the fabricated device. Our experimental results confirm the potential of the WT-SCSPC device for next-generation flexible smart electronic applications.

Keywords : Tungsten disulfide, self-charging supercapacitor, wire-type supercapacitor, piezogel electrolyte

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Abstract No. : **IN-S15-0581**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Real Time Observation of Halide Segregation and defect chatacterization in Mixed Halide Perovskite Solar Cells

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In this work, we introduce a novel real-time current-voltage (J–V) absorbance spectroscopy (RTJAS) setup for directly observing halide segregation in mixed halide perovskite solar cells under broadband light illumination, simulating solar exposure. The setup incorporates a broadband light source calibrated to one sun irradiation and a CMOS camera for simultaneous capture of all diffracted wavelengths. J–V measurements are performed concurrently with absorbance spectra collection, enabling in situ analysis of light-induced degradation due to halide segregation, including bandgap shifts and cell performance data. Comparison of photoluminescence measurements with RTJAS data reveals differing rates of bandgap decrease, underscoring the advantages of real-time measurement techniques. The work highlights the importance of accounting for experimental conditions, such as humidity and voltage injection, which can accelerate halide segregation, ultimately emphasizing the need for careful consideration of experimental conditions to accurately characterize perovskite solar cell behavior under realistic conditions. Additionally, we extend our investigation to defect characterization through the integration of Deep Level Transient Spectroscopy (DLTS) and Photoinduced Current Transient Spectroscopy (PICTS). These techniques are employed to observe deep levels, providing critical insights into the electronic trap states that challenge the performance and stability of metal halide perovskite (MHP) optoelectronic devices.

Keywords : Real time spectroscopy; Perovskite solar cells, halide segregation, DLTS, RTJAS

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Abstract No. : **OR-S19-0580**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Wafer-Scale Growth and Precise Layer Control of Transition Metal Dichalcogenides for MEMS Microphone

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Wafer-scale growth of transition metal dichalcogenides with precise control over the number of layers, and hence the electronic state is an essential technology for expanding the practical application of 2D materials. Herein, a new growth method, wafer-scale growth of transition metal dichalcogenides, is proposed for the precisely controlled growth of molybdenum disulfide (MoS2) films consisting of one to eleven layers with spatial uniformity on a 4 in. wafer. In this method, an energetically unstable amorphous MoSxOy (a-MoSxOy) phase is effectively converted to a thermodynamically stable crystalline MoS2 film. The number of MoS2 layers is readily controlled layer-by-layer by controlling the amount of Mo atoms in a-MoSxOy, which is also applicable for the growth of heteroatom-inserted MoS2. This growth method is suitable for micro electro mechanical system (MEMS) processes and can simplify the fabrication of complex structures such as microphones.

Keywords : Transition metal dichalcogenide, Molybdenum disulfide, Wafer-scale, Phase transition

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Abstract No. : **PO-S15-0579**
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Abstract Preference : **Poster**

Synthesis of 2D Metallic Nanoplates and their Applications for Ultra-Thin Inner-electrodes of Next Generation MLCCs

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As the demand for sensors and electronic devices in daily life is rapidly increasing, especially with the rise of autonomous vehicles and 5G communication technology. This necessitates multilayer integration of Multilayer Ceramic Capacitors (MLCCs) for compactness, high capacity, and reliability in electronic devices. Achieving high integration requires thinning both the dielectric layers and inner-electrodes constituting the multilayer structure.

In this study, we propose a novel process for ultra-thin inner-electrode formation utilizing electrospray deposition (ESD) of 2D metallic nanoplates. The ESD process employs electrostatic focusing to pattern even on insulator substrates, enabling the uniform formation of electrodes with thicknesses in the hundreds of nanometers. This effective ESD process, coupled with proper synthesis of 2D metallic nanoplates, presents an attractive strategy for achieving high-level uniformity and connectivity of the inner-electrodes with reduced thickness.

Following the fabrication of the multilayer structure through stacking of these thin electrodes and dielectric layers, the entire structure undergoes a sintering process. This sintering process is crucial for densification and enhancing the electrical properties of the final MLCC. After sintering, the microstructure and electrical properties of the resulting sintered body were meticulously analyzed to assess the effectiveness of the proposed approach.

Keywords : MLCC (Multilayer Ceramic Capacitor), 2D metallic nanoplates, electrospray deposition (ESD)

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Abstract No. : **IN-S19-0578**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Invited**

Green Polymer nanocomposites for energy harvesting

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Eco-friendly triboelectric nanogenerator (eco-TENG) is considered as a next-generation renewable kinetic energy-harvesting technology, especially for its potential use as a power supply unit for self-powered electronics. For eco-TENGs, nature-derived bionanomaterials, which are non-toxic to human and environment, highly biocompatible, and abundant in nature, are used for tribopositive or tribonegative materials, or both. The quality of human life has improved thanks to the rapid development of wearable electronics. Previously, bulk structures were usually selected for the fabrication of high performance electronics, but these are not suitable for wearable electronics due to mobility limitations and comfortability. Fibrous material-based triboelectric nanocomposites can provide power to wearable electronics due to their advantages such as light weight, flexibility, stretchability, wearability, etc. In this presenation, various fiber materials, layer-by-layer fabrication methods, and fundamentals of energy harvesters are described. Furthermore, nature-derived bionanomaterials explore for eco-TENGs and their energy-harvesting performances are shwon.

Keywords : layer-by-layer, hydrogel, ion-pump, nanocomposite, energy harvesting

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Abstract No. : **KN-S10-0577**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Keynote**

Microneedle-Mediated Chemoimmunological Intervention of Crosstalk between Tumor and Lymph Node for Improved Cancer Immunotherapy

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Tumor-draining lymph node (TDLN) is the primary site in which tumor-driven antigens are presented to the immune cells. It facilitates the activation of T cells and other immune cells, which can then migrate to the tumor site to elicit anti-tumor effects. However, tumors can also exploit the TDLN to render immune suppressive microenvironment favorable for the migration of tumor cells from the primary tumor site. The TDLN serves as a niche for metastatic tumor cells to survive and proliferate before they spread to distant organs. Herein, we develop amphiphilic tri-block copolymer-based dissolving microneedles (dMN) that generate self-assembled nanomicelles (NMCs) upon their dissolution after cutaneous application, which enable the drug encapsulation in NMCs and their subsequent migration to the TDLN. The dMN was employed for the delivery of SKKU-06, a natural pleiotropic immune modulator derived from fungi, which exhibits both anti-cancer and immunomodulatory properties in melanoma. The dMN-assisted intradermal administration of SKKU-06 to the melanoma site achieved enhanced anticancer effects, including immunogenic cancer cell death, enhanced the activation and maturation of antigen-presenting cells (APCs), and stimulated CD8+ T cell proliferation within both the tumor and TDLN. Notably, SKKU-06@dMN shifted the tumor microenvironment (TME) from immune suppressive (cold) to inflammatory (hot), which was further evidenced by combining it with anti-PD-1 treatment. This combined treatment significantly decreased Treg populations, altered macrophage polarization (increasing the M1/M2 ratio), and improved intratumoral infiltration CD8+ T cells, leading to the efficient growth inhibition of established primary and metastatic melanoma and increased overall survival of tumor-bearing animals.

Keywords : Cancer Immunotherapy, Drug delivery, Microneedle, Tumor-draining lymph node, Immune modulator

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Abstract No. : **PO-S03-0576**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Poster**

Flexible Photoluminescent Paper of In(Zn)P@ZnSe@ZnS Qauntum Dot

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InP quantum dot (QDs) has taken many attractions for its applicability to quantum dot light emitting displays (QLED) or biomarkers for detecting cancers or viruses. In this study, we focused the control of bandgap energy of the quantum dots of In(Zn)P@ZnSe@ZnS QDs. We modified the QDs by ligand-exchanging with mercaptopropionic acid (MPA) for the water solubility. The water-soluble QDs were incorporated into agarose solution for the synthesis of film and then dried to produce paper. We evaluated the photoluminescent properties of the paper containing the QDs. We hope that the QD papers can be applied for display or biomarker.

Keywords : InP, quantum dot, QLED, core/shell, flexible paper

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Symposia : **ICYRAM Young Researcher Symposium**

Abstract Preference : **Oral**

Graphdiyne Encapsulated Cupric Oxide Photocathode for Accelerating Solar-to-Hydrogen Conversion

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In recent times, there has been a significant focus on the advancement of eco-friendly renewable energy technologies, driven by the potential to utilize readily available resources like water and sunlight. The transition from fossil fuels to renewable energy sources is gaining momentum, spurred by recent innovations. This surge in the development of renewable energy technologies is particularly fueled by strides in creating highly efficient solar-powered devices. Research in this area highlights the potential of photoelectrochemical devices in harnessing solar energy to produce chemical energy through artificial photosynthesis.

In this study, we detail the fabrication process of CuO foam via a straightforward oxidation method employing scalable Cu foam, followed by the encapsulation of graphdiyne onto the CuO foam surface. The resulting photoelectrode's performance, a graphdiyne-encapsulated CuO foam, is evaluated and found to have an impressive hydrogen evolution rate of 80 μmol/hcm^2 under 1 sun illumination, surpassing both Pt-SACs/CuO foam and the initial CuO foam. This enhancement in performance is attributed to the encapsulation strategy and the surface-to-volume ratio of the graphdiyne-encapsulated CuO foam photoelectrodes, which contribute to improved charge carrier separation.

Acknowledgement

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Keywords : Hydrogen production, PEC water splitting, CuO photoeclectrode, Graphdiyne Encapsulation

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Abstract No. : **PO-S03-0573**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Bandgap Tuning and Quenching Effects of In(Zn)P@ZnSe@ZnS Quantum Dots

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InP quantum dot (QDs) has taken many attractions for its applicability to quantum dot light emitting displays (QLED) or biomarkers for detecting cancers or viruses. These days, the surface control or interface control of InP QD core/shell enhanced quantum efficiency greatly, 100% of quantum yield by the introduction of HF for the inhibition of oxide generation. In this study, we focused the control of bandgap energy of the quantum dots by the change of Zn/(In+Zn) ratio of In(Zn)P core. The zinc incorporation can change the photoluminescent light colors of green, yellow, orange and red. The dilution of as-synthesized QDs solution by more than 100 times does not show any quenching effects by Förster resonance energy transfer phenomenon between neighboring QDs.

Keywords : Keywords: InP, quantum dot, QLED, core/shell, FRET

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Abstract No. : **PO-S02-0572**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

All-solution processed green quantum-dot lighting device with PEDOT:PSS:PMA p-type conducting layer

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Quantum dot light-emitting diodes (QLEDs) have attracted considerable attention in recent decades as a promising component for large-area display technologies due to their exceptional quantum efficiency, vivid and pure RGB color expression, and versatile processing capabilities. The fabrication of QLEDs typically involves spin-coating colloidal quantum dots (QDs) to form an emissive layer (EML) sandwiched between the hole and electron transport layers (HTLs and ETLs). Despite the simple fabrication method, QLEDs achieve high efficiency and durability, making them suitable for both practical applications and advanced displays. However, there is a carrier imbalance in QLEDs due to significant differences in the mobility of holes and electrons, which can lead to the accumulation of excess electrons at the interfaces and enhanced Auger recombination, additional fluorescence quenching and a consequent decrease in QLED efficiency. Therefore, addressing the carrier imbalance is critical to improving device performance.

In this presentation, we focus on the improved p-type conductivity of QLEDs by using a mixed solution of poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) and phosphomolybdic acid (PMA) as HTL. The ratio of PEDOT:PSS to PMA was systematically varied from 1:0 to 1:0.5 to identify the optimal mixture for maximizing the p-type conductivity and improving the efficiency of QLED lighting. Ultraviolet photoelectron spectroscopy (UPS) and -ray photoelectron spectroscopy (XPS) were used to analyze the energy level adjustments in the HTLs and explore the influence on the work function and energy levels by redox of molybdenum in different valence states. Analyze result illustrated optimization of energy levels reduces the hole transport barrier and increases the electroluminescence efficiency. The improved p-type conductivity of the blend was further confirmed by hole-only devices. This method of improving hole conduction has the potential to be widely applied to the fabrication of various other solution processed QLEDs, thereby advancing practical display applications.

Keywords : quantum dot LEDs, p-type modification, energy level shifting

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Abstract No. : **PO-S14-0571**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Transition metal based hydroxide electrocatalyst for anion exchange membrane water electrolyzer

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Electrochemical water splitting is a promising technology to renewably produce hydrogen (H2) energy from water (H2O). There are various technologies to produce large-scale H2 such as Alkaline water electrolyzer (AWE), proton exchange membrane (PEM) water electrolyzer, and anion exchange membrane (AEM) water electrolyzer. The recently developed AEM electrolyzer exhibits both the advantages of AWE and PEM electrolyzers mentioned above, which allow the use of non-precious metals as electrocatalysts. Although the cost of hydrogen production can be reduced by using non-precious metal electrocatalysts, the performance of AEM water electrolyzers is still lower than that of PEM electrolyzers. To overcome this obstacle, it is strongly necessary to develop high-performance and cost-effective OER electrocatalysts. This study manufactured a transition metal-based catalyst for OER and demonstrates electrodes fabricated to apply to AEM electrolyzers.

Keywords : electrolysis, Anion exchange membrane water, Electrocatalysts, Water splitting

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Abstract No. : **PO-S06-0570**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Facile Hydrothermal Conversion of Binder-Free Cobalt Oxide to Cobalt Sulfide as Positrode for High Performance Supercapacitor

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Improving the energy density of the supercapacitor is necessary for its practical utilization. Recent research focused on metal sulfides over metal oxides due to their excellent electrochemical properties and good conductivity. In this work, we prepared binder-free cobalt sulfide on nickel foam by hydrothermal sulfurizing binder-free cobalt oxide and investigated its electrochemical performance. The phase formation and chemical states were studied using Raman, X-ray diffraction and photoelectron spectroscopy. The cobalt oxide and sulfide surface morphology were studied using FE-SEM analysis. The electrochemical properties of the as-grown binder-free electrode materials are investigated by methods such as cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS). The duck and plateau-like response obtained from CV and GCD reveals the faradaic reaction takes place, i.e., battery-type behavior. Hydrothermal sulfurization increased the conductivity, which was revealed by the reduction of solution and Warburg impedance calculated from the EIS data. The binder-free cobalt sulfide electrode possesses a higher specific capacity and long-term stability than the binder-free cobalt oxide electrode. These overall experimental results confirm that binder-free cobalt sulfide is the potential candidate for the future generation of high-energy-density supercapacitors.

Keywords : Hydrothermal sulfurization; Cobalt oxide; Cobalt sulfide; Binder-free electrode; Supercapacitor.

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Abstract No. : **PO-S01-0569**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Hydrothermal Synthesis of Carbon-Coated $LiFePO_4$ for Enhanced Lithium-Ion Battery Performance

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Lithium-ion batteries (LIBs) play a pivotal role in various energy storage applications, including portable electronics, electric vehicles, and renewable energy grids. To meet the demand for high-performance LIBs with enhanced energy density and safety, lithium iron phosphate ($LiFePO_4$) has emerged as a promising cathode material due to its theoretical capacity and thermal stability. However, $LiFePO_4$'s low electronic conductivity poses a challenge for high-power LIB applications.

In this study, we scrutinize the impact of hydrothermally synthesized carbon coating on $LiFePO_4$. The hydrothermal method presents a facile and scalable route to fabricate carbon-coated $LiFePO_4$ composites ($LiFePO_4$/C) with controlled carbon content and distribution. This approach ensures uniform coating of $LiFePO_4$ particles by the carbon precursor, leading to improved electrical conductivity. The selection of carbon source significantly influences the properties of $LiFePO_4$/C. Glucose, an abundant and cost-effective carbohydrate, affords a uniform and continuous carbon layer on $LiFePO_4$ particles. This layer enhances electrical conductivity and serves as a protective barrier, mitigating direct contact with the electrolyte and diminishing side reactions. Moreover, the hydrothermal process facilitates uniform coating of $LiFePO_4$ particles by the carbon precursor, ensuring adhesion and promoting synergistic effects. Comprehensive electrochemical characterization elucidates the electrochemical behavior, specific capacity, rate capability, and charge transfer kinetics of $LiFePO_4$/C. This study aims to refine $LiFePO_4$-based battery performance and commercial viability through optimized carbon coating processes and comprehensive material characterization, offering insights for advancing next-generation energy storage systems.

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Keywords : Lithium iron phosphate, Hydrothermal method, Carbon coating, Glucose

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Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Invited**

Beyond the conventional MRAM: magnon valve based MRAM

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Magnons, a collective excitations of spin in crystal lattice, can be existed even in insulators nowadays is expected to be a potential carrier of information in magnetoresistive random access memory (MRAM) instead of electrons. By using magnon, many limitations of the electronic based MRAM can be solve such as low barier raliability, weak thermal stability, Joule heating loss, and high operation current. This study introduces a novel architecture termed magnon valve MRAM (MV-MRAM), constructed from all-oxide materials with electrodes composed of BiSb, specifically BiSb/$Y_3Fe_5O_{12}$(YIG)/NiO/$Y_3Fe_5O_{12}$/$CoFe_2O_4$(CFO)/Substrate. Our investigation focuses on the individual materials components, assessing their critical factors essential for the high performance of MV-MRAM. Initially, utilizing facing sputtering techniques, we achieve tunable compositions of BiSb films, exhibiting a remarkable spin Hall angle of 3.32, surpassing that of conventional metals by two orders of magnitude. Subsequently, we examine the CFO/YIG structure, demonstrating an exchange bias field exceeding 10 Oe at room temperature. Lastly, we fabricate a magnon valve structure, YIG/NiO/YIG, boasting an On/Off ratio exceeding 500%. These discoveries provide foundational insights towards realizing a functional magnon valve MRAM device, as envisaged herein.

Keywords : Magnon valve; MRAM; Topological insulator; Exchange bias; On/Off ratio

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Abstract No. : **PO-S13-0567**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Investigation of ternary chalcongenide AgBiS2 Thin film via thermally co-evaporated

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AgBiS2 photovoltaic devices have recently garnered considerable attention in the field of photovoltaics due to their ideal bandgap and high absorption coefficient. However, their production has been limited to a solution-based process, posing challenges for scalability and the manufacture of large-area devices. This study investigated the moderate precursor powders of Ag2S and Bi2S3 required to achieve the optimal composition ratio. The precursors were co-evaporated thermally. The thermal co-evaporation method with powders was fine-tuned to achieve the ideal Ag/Bi composition ratio. Nevertheless, despite optimizing the precursors, sulfur was insufficient to achieve Ag:Bi:S = 1:1:2 (at%). So, we carried out sulfurization to address the sulfur deficiency. Additionally, the sulfurization process can enhance crystallinity. Sulfurization at 200℃ for 10 minutes showed the highest crystallinity, resulting in a notable power conversion efficiency of 1.52% and an open-circuit voltage of 346 mV. These findings lay the groundwork for the fabrication of AgBiS2 thin film photovoltaic devices using the thermal co-evaporation method, both in academic research settings and for commercial purposes.

Keywords : AgBiS2 thin film, Sulfurization, Thermal co-evaporation, Composition ratio

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Abstract No. : **IN-S03-0566**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Invited**

Zinc oxide based heterostructured hollow microspheres for formaldehyde detection at room temperature

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The hollow Zinc oxide microspheres heterostructured with TiO_2 and In_2O_3 were synthesized by hydrothermal method using carbon nanospheres as sacrificed templates. With UV activation, the response of ZnO-TiO_2 based chemiresistive-type sensors to 10 ppm formaldehyde is 11.02 at room temperature which is 5.48 times larger than that of the pure hollow ZnO. The response and recovery time of the sensor were significantly reduced to 14 s and 16 s. With Au and In_2O_3 incorporation, the response of the Au-ZnO@-In_2O_3 sensor exhibited a further increase to 14.8 when exposed to 10 ppm formaldehyde at room temperature. However, the response/recovery times became longer with 32 s and 42 s, respectively. The sensing mechanism of the sensor to formaldehyde have been investigated by AC impedance spectroscopy, in-situ DRIFTS, and DFT theoretical calculation. It reveals that “electronic sensitization” would plays major role in enhancing the response whereas “chemical sensitization” would improve the kinetic features making the sensor have a faster response/recovery rate. Selectivity, stability and repeatability of the hollow ZnO based heterostructured microspheres based sensor under UV-activation have also been examined.

Keywords : Zinc oxide based heterostructured hollow microspheres, Formaldehyde sensor, UV activattion, Sensing mechanisms

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Abstract No. : **OR-S06-0565**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

High-entropy effects on phase transformation behavior of CuNiTiHfZr high-entropy shape memory alloys

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By incorporating the concept of high-entropy alloys into traditional Ni-Ti shape memory alloys (SMAs) through the addition of Cu, Hf, and Zr, it is possible to obtain high-entropy shape memory alloys (HESMAs) with higher operating temperatures and broader application ranges. The macroscopic behavior obtained through differential scanning calorimetry (DSC) can be compared with the microscopic behavior observed through in-situ X-ray diffraction (XRD), X-ray nano-diffraction (XND), and X-ray fluorescence (XRF). The influence of the core-shell structure formed by an uneven distribution of alloying elements on the phase transformation behavior of CuNiTiHfZr enables to explain the mismatch between the macroscopic and microscopic behaviors, providing a better understanding of the combined effects of high-entropy and shape memory.

Keywords : High-entropy shape memory alloys, in-situ X-ray diffraction, in-situ X-ray fluorescence (XRF), core-shell structure, gradient structure, phase transformation, thermodynamics.

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Abstract No. : **IN-S08-0564**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Nanoscale studies of complex oxides via Scanning Probe Microscopy

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Complex oxides are one of the main foci of condensed matter research due to the plethora of emergent phenomena such as ferroelectricity, metal-insulator transitions, and magnetism that can be exploited as novel functionalities for technological applications. The complex interplay of multiple degrees of freedom including spin, charge, orbital and lattice gives rise to such phenomena, resulting in novel functional properties of complex oxides. Therefore, understanding fundamentals of how complex oxides behave with their own structures and functional properties is key for development of next generation technologies.

For this, nanoscale characterization via scanning probe microscopy (SPM) has played a crucial role to probe and characterize materials, spatially correlate local responses, and manipulate and write features directly, offering fundamental insights to develop novel functionalities and nanodevice concepts. In this presentation, I will talk about SPM-based studies to show nanoscale structures and functional properties associated with phase transitions, electronic and ionic conduction, and piezoelectricity under illumination [1-4]. These results unveil fundamentals of structure-related functionalities of complex oxides for their potential implementation in next-generation nanoelectronics.

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Keywords : Complex oxides, ferroelectrics, scanning probe microscoy, atomic force microscopy

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Abstract No. : **PO-S09-0563**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Effects of O_2 Plasma Ashing on the Properties of SiOxCy Films Deposited by PE-CVD

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Recently, as the form of electronic devices such as mobile devices and TVs has changed, the need for flexible devices has been highlighted. In particular, flexible, foldable, and expandable displays are leading this change in design paradigm. When flexible devices are exposed to moisture and oxygen in the atmosphere, there is a risk that functional organic polymers or single molecule materials may be oxidized and the performance of the device may deteriorate. In order to overcome this vulnerability, it is essential to develop an effective encapsulation film that can protect the device.

In this study, a SiOxCy thin film polymerized using plasma chemical vapor deposition (PECVD) was formed on a flexible substrate based on polyethylene naphthalate (PEN) at low temperatures below 95°C. To optimize the physical and chemical properties of the thin film, various deposition conditions were tested, and the properties of the formed thin film were evaluated by measuring residual stress and water vapor transmission rate (WVTR). Additionally, there are cases where residual carbon remains as an impurity during the low-temperature deposition process and becomes a problem. To solve this problem, O_2 plasma ashing treatment was performed.

As a result of O_2 plasma ashing treatment, the carbon content in the thin film was significantly reduced. And, water vapor transmission rate (WVTR) was 4×10^{-4} g/m²·day, a 25% increase compared to before treatment, confirming that the water vapor barrier properties were improved. These results are expected to contribute to improving the reliability and life time of flexible devices.

Keywords : Thin film, Water vapor transmission rate, gas barrier, SiO2, flexible

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Abstract No. : **PO-S06-0562**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

ANN modeling for creep strength of high-Cr steels and its application on heat-resistant alloy design with reduced Co content

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Ferritic-martensitic (FM) steels with 9-12% Cr have been considered promising materials for thick-section components in next-generation ultra-supercritical (USC) power plants, because of their high thermal conductivity, low coefficient of thermal expansion, and superior creep resistance. The required service temperature is getting higher because the rise in demand for decreased CO_2 emissions requires higher efficiency of power plants. From many recent studies, addition of 3-6% Co has been found effective in increasing the service temperature limit by reducing the diffusion rate and preventing the formation of delta-ferrite. However, due to high Co price and its volatility, addition of such a high Co content is not desirable for making cost-effective products. In this study, we investigated the alloy design of creep-resistant FM steels with reduced Co content by partly replacing Co with other elements. For this, we developed a prediction model for creep strength of high-Cr FM steels. Predicting creep property is highly required in developing heat-resistant steels since its actual measurement takes much time and cost. While several physics-based models predicting microstructural change and creep strength have been developed in the past, there is a limitation on explaining various effects from many kinds of alloying elements. Therefore, we aimed to develop an artificial neural network (ANN) model through learning data from publicly available NIMS creep data sheet for high-Cr steels and data published in papers related to heat-resistant steels.

Keywords : heat-resistant steels, ferritic-martensitic, creep, artificial neural network, modeling

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Abstract No. : **PO-S11-0561**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Exploring the Energy Harnessing and Ferroelectric Properties of Lithium Niobate/PDMS Composite Films for Self-Powered Humidity Sensor

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Nanogenerators have attracted considerable attention for harvesting biomechanical energy and powering smart electronics applications. This study showcases the application of lithium niobate ($LiNbO_3$) synthesized through a solid-state reaction for hybrid (piezo-/triboelectric) energy harvesting. The physicochemical characterization, including XRD, FT-IR, and SEM, validates the formation of lithium niobate. LCR, P-E loop, and d_{33} piezoelectric coefficient analyses of lithium niobate/PDMS composite films reveal their outstanding dielectric and ferroelectric properties. The hybrid nanogenerator (HNG) device was fabricated using a lithium niobate/PDMS composite film with polyethylene oxide (PEO) as tribo-negative and tribo-positive layers, respectively. When tested for energy-harnessing capabilities, the HNG device exhibits high voltage and remarkable stability. Notably, the HNG device shows excellent voltage variation in response to varying humidity levels, making it a promising candidate for a self-powered humidity sensor. In conclusion, our findings suggest that lithium niobate holds great potential as a promising ferroelectric material and in developing self-powered sensors.

Keywords : Lithium niobate, PDMS, nanogenerator, dielectric constant, humidity sensor

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Abstract No. : **PO-S17-0560**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Synergy of Li-ion concentration and triple doping improves ionic conductivity of $Li_7La_3Zr_2O_{12}$ solid-state electrolyte

Hai Minh Nguyen[1], Sangbaek Park*[1]

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Cubic $Li_7La_3Zr_2O_{12}$ (LLZO) is a promising solid electrolyte for all-solid-state batteries. Herein, we investigate the change in the structural properties and Li-ion conductivity of LLZO pellets by triple doping with Al, Ga, and Ta and modulating the variation in initial Li concentrations. Interestingly, the proportion of the conductive cubic phase increased with increasing Li stoichiometry by 1.1 times, and this tendency was further accelerated by triple doping. The synergetic effects of triple doping and Li concentration also minimized Li loss during sintering. Accordingly, it provided a high-quality LLZO pellet with good ionic conductivity (3.611×10^{-4} S cm^{-1}) and high relative density (97.8%). Notably, the LLZO pellet was obtained using a very short sintering process (40 min). Considering that the most time-consuming step is the sintering process for LLZO, this study can provide guidelines for the fast production and commercialization of LLZO electrolytes with high ionic conductivity.

Keywords : Solid electrolytes; LLZO; Li-ion concentration; triple doping; Li-ion conductivity

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Abstract No. : **PO-S01-0559**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Synthesis and Characterization of Olivine-Structured $LiFePO_4$/Carbon Composites via a Modified Two-Step Solid-State Reaction

Minho Kim[1], Hyunjae Kang[1], Jin Woo Yang[1], Chang-Sik Son[1], Donghyun Hwang[*1]

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In this work, olivine-structured $LiFePO_4$/carbon composites with varying carbon contents were synthesized using a modified two-step solid-state reaction. Iron citrate served as both the iron and carbon sources, resulting in the formation of carbon coatings on the olivine particles. The mixed precursors underwent initial-step heating at temperatures of 200 °C, 250 °C, 300 °C, 350 °C, 400 °C and 450 °C, followed by a second-step annealing at a moderate temperature of 650 °C. The obtained powders were systematically analyzed using thermo-gravimetric analysis, X-ray diffraction (XRD), and field-emission scanning electron microscopy (FE-SEM). These characterization techniques were employed to determine the structural and calcination effects on the electrochemical properties of the composites. FE-TEM images revealed that the morphology of the $LiFePO_4$ composites consisted of agglomerated particles surrounded by carbon as a conductive material. Among the prepared samples, the $LiFePO_4$/carbon composite calcined at an initial-step temperature of 350 °C exhibited the highest discharge capacity and the best rate capability in the voltage range of 2.5–4.2 V. This finding suggests that the initial-step temperature during the synthesis process significantly influences the electrochemical performance of the composites, with optimal performance achieved at 350 °C.

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Keywords : Lithium iron phosphate, Solid-state synthesis, Cathode materials, Lithium-ion batteries

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Abstract No. : **KN-S09-0558**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Keynote**

Chalcogenide based Conductive Bridge Resistive Device for Universal Storage Memory – Opportunities and Challenges

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The rapid growth of Internet-of-Things cum Artificial Intelligence applications has created an urgent and strong demand for a new storage class memory that can address the shortcomings of current mainstream memory technologies, namely DRAM and Flash memory, developed several decades ago. Because DRAM is volatile and its capacity is limited by cost, data must be frequently transferred to and from the non-volatile Flash memory. While the latter is relatively inexpensive and has a large capacity, it is much slower by about 105-106 times. This large speed difference is a major challenge for data center applications.

Therefore, new memory devices are currently being developed to address the above challenge. To be able to address the DRAM-Flash latency gap, or eventually replacing both as a universal memory, the new memory device must be non-volatile, has a program speed and voltage comparable to DRAM (10 ns, 1 V) and a memory density comparable to Flash memory (>10 Gb/mm2). Among the emerging memory devices, the resistive random access memory or ReRAM device stands out as a promising candidate capable of fulfilling these requirements. However, two major obstacles must be overcome, namely performance variability and the lack of a suitable selector that can enable 3D integration.

In this talk, I will summarize the current progress of our research on silver-gated chalcogenide conductive bridge resistive memory devices and show that these devices have good prospects in overcoming the abovementioned challenges. Key characteristics include highly uniform switching behavior and ultralow DC switching voltages (which can facilitate 1 V pulsed switching with a low program/erase latency of ~30 ns). In addition, stack engineering may allow one to achieve volatile switching at milliampere current level, enabling a similar device to be deployed as a selector, providing compact integration with the memory counterpart.

Keywords : Resistive random access memory, ReRAM, RRAM

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Abstract No. : **PO-S11-0557**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Wireless Physio Health Monitoring System enabled Green Triboelectrification

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Green energy from the ambient environment is crucial for reducing global pollution and moving toward sustainable development goals for the future. Triboelectric nanogenerators (TENG) have gained immense attention in recent years owing to their ease of fabrication and wide range of applications. Recently, the incorporation of edible materials for triboelectric applications has gained popularity [1]. Here, different starches such as Potato, tapioca, corn, and arrowroot are used to make films. The starch film acts as the active layer of the triboelectric nanogenerator, and the opposite layer is made from Polydimethylsiloxane (PDMS). The device has a good output performance of 266V and 0.4μA of 4x3 cm^2 device. The physiochemical characterization for all the films was carried out. The electrical output performance for the triboelectric nanogenerator has been performed along with impedance matching, capacitor charging with three different capacitors such as 1μF, 4.7μF and 10 μF, and stability test has been run for 2000 seconds and force analysis. Low-power electronic devices such as green LEDs and LCDs were powered. The device was further used in self-powered sensors for Wireless Physio Health Monitoring, which can track the calories burnt when performing different exercises and display the output in a mobile app via Bluetooth.

Keywords : Nanogenerator, Triboelectric, Green energy and Edible Materials.

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Abstract No. : **PO-S11-0556**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

High-Performance moisture electric energy harvester for miniatured electronics

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Amidst the global energy crisis, there is an increasing urgency to explore alternative energy supply and production technologies. Although significant research has been dedicated to fluidic water-based energy systems, the potential of moisture, in its gaseous form, remains relatively underexplored. Moisture-involved electricity generation (MIEG) technology, based on directional ion migration or selective transportation, can convert potential energy during moisture sorption or latent heat during natural evaporation into electricity, showing the potential to alleviate the energy shortage problem1–3. Exploring this, we have developed a moisture electric generator with a sandwich structure, incorporating graphene oxide and biopolymers such as sodium alginate and lignin. Hydrogel was used for the continuous water supply, and the porous electrode was used on one side to facilitate evaporation. This device has demonstrated remarkable performance, facilitated by its hygroscopic design. Moreover, the integration of biopolymers presents a sustainable and environmentally friendly avenue for energy production, harnessing the ubiquitous atmospheric moisture. These moisture electric generators offer promising prospects for powering low-voltage miniature electronics, thus presenting a viable solution for diversifying energy sources in a resource-constrained world.

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Keywords : Moisture generator, green energy, hydrogel

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Abstract No. : **IN-S13-0555**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Invited**

Large-area CIGS Solar Cells with Non-toxic Buffer Layer and Microgrid Electrode

Inchan Hwang[1], Ahreum Lee[1], Inyoung Jeong[1], Soomin Song[1], Donghyeop Shin[1], Joohyung Park[1], Ara Cho[1], Young-Joo Eo[1], Jinsoo Yoo[1], Seung Kyu Ahn[1], Jihye Gwak[1], Sejin Ahn[1], Kihwan Kim*[1]

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The efficiency of copper indium gallium selenide (CIGS) solar cells using transparent conductive oxide (TCO) decreases significantly with increasing the device area due to TCO's poor electrical properties. Developing high-efficiency large-area CIGS solar cells requires a novel top electrode that has high transmittance and conductivity. In this study, a microgrid/TCO electrode is developed to minimize optical and resistive losses for developing highly efficient large-area CIGS solar cells. Also, the buffer layer of the CIGS solar cells is changed from the CdS buffer to a ZnMgO (ZMO) buffer to increase device efficiency by reducing parasitic absorption in the short-wavelength region. By applying the ZMO buffer and the microgrid electrode, the CIGS solar cell with an increased device area of up to 20 mm × 70 mm exhibits an efficiency of up to 19.7%.

Keywords : CIGS solar cells, Cd-free, Microgrid electrode, Large area, Electrode design

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Abstract No. : **PO-S01-0554**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Study on Fe_2O_3 Thin Films as an Anode Replacement for High-Performance Lithium-Ion Batteries

Gyu Hwang Lee[1], Seung Jun An[1], Jeong Hun Park[1], Chang-Sik Son[1], Donghyun Hwang[*1]

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Electrochemical lithium cells have garnered significant attention for energy storage, yet the utilization of lithium metal as the negative electrode in rechargeable batteries presents challenges such as dendrite deposition during charging, leading to poor cycle life. Substituting the lithium metal electrode with an anodic material capable of storing and exchanging lithium ions could alleviate these limitations. While carbon in its various forms is widely used, recent exploration has focused on alternative materials, including tin oxide, recognized for its high-capacity lithium storage potential.

This study investigates Fe_2O_3 thin films deposited via RF magnetron sputtering as a carbon based anode alternative for lithium ion batteries. The fabrication process of these amorphous thin layers and their chemical and physical attributes are delineated. X-ray diffraction (XRD) analysis reveals the amorphous nature of Fe_2O_3 thin films, transitioning to single crystal structures with increased substrate temperatures. Field emission scanning electron microscopy (FESEM) elucidates the surface morphology of the thin films, while analysis of absorption and transmission spectra provides insights into their optical properties. By leveraging thin film technology, this research seeks to address the demand for novel electrode materials in lithium ion batteries. The utilization of Fe_2O_3 thin films offers a promising alternative to conventional carbon-based anodes, potentially overcoming challenges associated with lithium metal electrodes and enhancing battery performance and longevity. Through comprehensive characterization, this study contributes valuable insights into the advancement of energy storage systems.

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Keywords : Fe2O3 thin films, Lithium-ion batteries, Anode materials, Sputtering

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Abstract No. : **PO-S01-0553**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Enhancing Performance of Lithium Iron Phosphate Batteries through Manganese Doping: Experimental Synthesis and Electrochemical Characterization

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Recent advancements in lithium iron phosphate (LFP) battery research have focused on element doping to enhance performance, particularly addressing challenges related to low temperature and rapid charging conditions. This study investigates the potential of manganese (Mn) doping to mitigate performance degradation in LFP batteries. Mn doping is anticipated to enhance lithium ion diffusion rates and electrical conductivity, thereby improving battery performance, especially under low temperature conditions. The experimental synthesis involved $LiPO_4$, $FeSO_4{\cdot}7H_2O$, $MnSO_4{\cdot}H_2O$, and $NH_4H_2PO_4$, with hydrothermal treatment at 180 °C for 6 hours. Structural characterization via X-ray diffraction (XRD), field-emission scanning electron microscopy (FE-SEM), energy dispersive X-ray spectroscopy (EDS), and X-ray photoelectron spectroscopy (XPS) revealed significant impacts of Mn doping on the crystal structure and chemical composition of LFP cathode materials. Electrochemical characterization utilizing charge/discharge system and electrochemical impedance spectroscopy (EIS) demonstrated improved electrochemical properties and stability under rapid charging conditions with Mn-doped LFP batteries. This study underscores the potential of Mn doping as a strategy to enhance the performance and stability of LFP batteries, offering valuable insights for the development of advanced energy storage systems.

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Keywords : lithium iron phosphate, hydrothermal method, manganese doping, cathode, LFP batteries

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Abstract No. : **PO-S01-0552**
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Abstract Preference : **Poster**

Nanocrystalline Fe_2O_3 Thin Films Deposited by RF Magnetron Sputtering for Application as Anodes in High-Performance Lithium-Ion Batteries

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Lithium-ion batteries (LIBs) have garnered immense interest due to their ubiquitous use in portable electronics and electric vehicles. Transition metal oxides (TMOs) have emerged as promising anode materials for LIBs owing to their high theoretical specific capacity and enhanced safety profiles compared to traditional carbon-based counterparts. Among TMOs, Fe_2O_3 has gained significant attention due to its abundant resources, low cost, and environmental friendliness. However, challenges such as volume expansion during lithiation and de-lithiation processes hinder its practical application, leading to capacity fading and poor cycling stability. To address these challenges, various nanostructured forms of Fe_2O_3 have been investigated.

In this work, we prepared nanocrystalline Fe_2O_3 thin films via RF magnetron sputtering and evaluated their performance as LIB anodes. The resulting thin films exhibited an average grain size in the tens of nanometers range, enabling efficient lithium-ion insertion and extraction. Electrochemical characterization revealed high reversible capacity and excellent rate capability, highlighting the potential of nanocrystalline Fe_2O_3 thin films for high-performance LIBs. These findings underscore the significance of nano-structuring approaches in enhancing the electrochemical properties of Fe_2O_3 for LIB applications. The developed nanocrystalline Fe_2O_3 thin films hold promise for utilization in advanced LIB configurations, including all-solid-state thin film batteries, paving the way for next-generation energy storage devices.

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Keywords : Fe2O3 thin films, Lithium-ion batteries, Anode materials, Sputtering

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Abstract No. : **OR-S05-0551**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Metal-insulator transition in graphene/twistedWSe$_2$ van der Waals heterostructures

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Understanding the metal-insulator transition (MIT) in moiré superlattices of van der Waals (vdW) two-dimensional materials is an intriguing problem in condensed matter physics because the interplay between strong Coulomb interaction and kinetic energy leads to novel types of quantum phase transitions. However, an exact analysis of diverse quantum phases in MIT is still underway in the case of the moiré heterostructures. In this work, we demonstrate the MIT in high-quality hexagonal boron nitride encapsulated graphene/1.5^o twisted-WSe$_2$ vdW heterostructures through electrostatic doping. A crossover in the temperature-dependent longitudinal resistance *versus* back gate voltage at a particular electrostatic doping indicates the MIT in the graphene/1.5^o *t*-WSe$_2$ vdW heterostructure. We observed different metallic and insulating phases as a function of electrostatic doping. Particularly in the metallic phases, we observe both T^2 and T-linear dependence of longitudinal resistance with electrostatic doping, corresponding to Fermi-liquid and non-Fermi liquid metallic behavior, respectively. Our analysis suggests that the T^2 and T-linear dependence of resistance is due to electron-electron and electron-phonon scattering, respectively.

Keywords : Graphene, twisted vdW heterostructures, WSe2, dual gate, Metal-insulator-transition,

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Abstract No. : **PO-S14-0550**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Designing and Surface Functionalization of Photo-reactive Heterostructure from a Multicomponent Amorphous Alloy

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Metallic glasses represent a new class of structural materials with many outstanding properties such as high yield strength and large elastic limit, along with several superior chemical and physical properties. Recently, as another effort to exploit metallic glasses in engineering field, new attempts for application of metallic glasses have been carried out in functional materials. In this study, metallic glass is designed tunable for promising functional applications via a facile and stable, one-step process. Creative approach about alloy design and process is based on the unique properties of the Ti-Cu-Ni-Sn metallic glass that are afforded by the varying oxygen affinities of the four constituent elements. This metallic glass exhibits homogeneous nucleation of oxides and uniform formation of the various metal oxides. The alloy design and hydrothermal synthesis to customize the metallic glasses are the most critical factors that determine the characteristics of the metal oxides and the resulting nanostructures and photoelectrode properties. This enables the desired element to be selectively grown via a facile single-step process. These results provide a promising road map for the application of metallic glasses to photoelectrochemical (PEC) solar water splitting, as well as various other new possibilities.

Keywords : Alloy design; Amorphous; hydrothermal synthesis; metal oxides; water splitting

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Abstract No. : **KN-S04-0549**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Keynote**

Materials and device designs toward motion artifact-free bioelectronics

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Bioelectronics needs to continuously monitor mechanical and electrophysiological signals for patients. However, the signals always include artifacts by patients' unexpected movement (such as walking and respiration under approximately 30 hertz). The current method to remove them is a signal process that uses a bandpass filter, which may cause signal loss. We present an unconventional bandpass filter material—viscoelastic gelatin-chitosan hydrogel damper, inspired by the viscoelastic cuticular pad in a spider—to remove dynamic mechanical noise artifacts selectively. The hydrogel exhibits a frequency-dependent phase transition that results in a rubbery state that damps low-frequency noise and a glassy state that transmits the desired high-frequency signals. It serves as an adaptable passfilter that enables the acquisition of high-quality signals from patients while minimizing signal process for advanced bioelectronics.

Keywords : motion artifact, bioelectronics, materials, hydrogel

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Abstract No. : **OR-S15-0547**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Enhancing Dielectric Properties of BT-BNTN Ceramic through Core-Shell Microstructure Formation using Fast Firing Sintering

TaeYeong Song[1], NaYeon Kwon[1], Sangun Park[1], JunWon Lee[1], Juha Kim[1], Do-kyun Kwon[*1]

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$BaTiO_3$-$(Bi_{0.5},Na_{0.5})TiO_3$ (BT-BNT) with a rich BT composition is well known as a ceramic with stable high-temperature dielectric properties due to its significantly higher ferroelectric-paraelectric transition temperature compared to pure BT. Various doping studies based on BT-BNT ceramic are being conducted to ensure stable dielectric characteristics up to 200°C. Currently, these dopants are provided in the form of oxides, which differ in size and shape from the BT-BNT powder, leading to inherent compositional non-uniformity even during a homogeneous mixing process, directly impacting electronic device stability. To overcome compositional heterogeneity in this study, Nb doping into BNT was used to form a two-dimensional nanosheet-type dopant, and a wrapping process was further employed to address the compositional non-uniformity. Forming a core-shell microstructure using fast firing sintering process for $BaTiO_3$-$(Bi_{0.5},Na_{0.5\text{-}x})(Ti_{1\text{-}x}Nb_x)O_3$ (BT-BNTN) ceramic is a very intriguing idea. When forming a core-shell structure using fast firing sintering process for BT-BNTN composite, several key factors should be considered. Firstly, adjusting the sintering conditions to achieve the appropriate temperature and duration is crucial. Rapid sintering speed facilitates the formation of the desired core-shell structure by promoting reactions at high temperatures within a short period. Lastly, appropriate characterization techniques should be employed to analyze the formation and properties of the core-shell structure. This may include scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and other characterization methods. Through these processes, it is possible to apply fast firing sintering process to BT-BNTN composite to form a core-shell structure and evaluate its properties.

Keywords : Ferroelectric, BT-BNTN, core-shell, Electroceramic

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Abstract No. : **PO-S01-0546**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Nitrogen-Doped Graphene Derived from Spent Graphite: A high performance lithium storage material

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Graphite was recovered from spent Li-ion battery black mass with minimized energy consumption. The graphite, sourced from a blend of mobile device and power tool batteries, underwent conversion into graphene oxide and subsequent pyrolysis at varying temperatures in the presence of a nitrogen source under an argon atmosphere. The resulting nitrogen-doped graphene (NG) was thoroughly characterized using XRD, Raman spectroscopy, and SEM analysis. This material has been employed as an anode material for lithium-ion batteries. At a current density of 1 A g^{-1}, the NG7 sample demonstrates an impressive capacity of 507 mA h g^{-1} after the 250th cycle, retaining 87.8% of its initial capacity (577 mA h g^{-1}) measured after cell stabilization. The coulombic efficiency remains consistently high, hovering around 100% throughout the measured cycles. In contrast, the counterpart rGO7 displayed a lower capacity of only 210 mA h g^{-1} at 1 A g^{-1}. Additionally, the NG samples demonstrated excellent rate capability and high lithium diffusion compared to undoped material. Our findings underscore the effective significance of nitrogen doping in enhancing the performance of upcycled graphite, showcasing its potential for efficient waste utilization in renewable energy applications.

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (2021R1A4A2000934, 2023R1A2C3004336).

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[2] Bejigo et al, J. Cleaner Prod. 384 (2023), p. 135520
[3] Bejigo et al, J. Energy Chem. 82 (2023) 148–157

Keywords : Lithium Ion batteries; Lithium storage; Nitrogen-doping; Spent graphite; Recycling

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Abstract No. : **PO-S02-0544**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Device Interfacial Engineering of Perovskite-based Back-Contact Photovoltaics

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Back Contact Perovskite Solar cell (BC-PSC) is a promising structure that can improve performance of devices by increasing light absorption at the surface of an active layer. However, previous research has focused only optimization of device structure in the back-contact perovskite solar cells, not reducing defects at interface between perovskite and charge transport layer. In this study, we modified SnO_2 as Electron Transport Layer (ETL) that has excellent charge extraction while balancing with NiO_x as a Hole Transport Layer (HTL) in Quasi-interdigitated electrode (QIDE) structures. We applied on SnO_2 as ETL that is made in three different ways. By comparing J-V curves of SnO_2 based BC-PSCs between Sol-gel processed, Colloidal processed and Bilayer (stacked with colloidal and Sol-gel) processed interlayers, we analyzed interfacial defect properties of the fabricated perovskite BC-PSCs based on hysteresis of J-V curves and charge transport property. While there is an increase of J_{sc} on Sol-gel processed SnO_2 layers, V_{oc} is increased on Colloidal processed SnO_2 layers. Especially on Bilayer SnO_2 layers, it appeared enhancement in both parameters. In dark I-V curves, We confirmed the highest conductivity on Bilayer SnO_2 appearing non-linear inclination proving the highest PCE. Further we plan to simulate to find out a cause of variation of V_{oc}. All of these processes are based on 5um sized patterned electrodes enhancing the completeness of the electrodes so that they can't affect any properties of charge extraction. This study marks a pioneering optimization of ETLs in BC-PSCs, providing a promise for next-generation optoelectronic devices.

Keywords : solarcells, perovskite

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Abstract No. : **PO-S07-0543**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

3D simulation of Solid Phase Crystallization Process in Polycrystalline Semiconductor Films using Phase Field Method.

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In this study, we simulated the solid-state crystallization process of polycrystalline Si thin films used in the channel material of 3D NAND flash memory. we developed a custom C++ code implementing the phase filed method. Through the simulation of the grain growth process, we can observe characteristics such as grain size and the evolution of grain boundaries, which impact the electrical properties of the device. By adjusting parameters related to nucleation density, size, interfacial energy, and grain growth rates, we enhanced the simulation results to better align with actual situations. We confirmed the alignment of grain sizes between practical experiments and simulation results for the 20nm film thickness. This indicates that this model has the capability and accuracy to predict microstructure evolution. Additionally, we confirmed a tendency for the grain size to increase as the film thickness increased.

Keywords : Polycrystalline films, Phase field model, microstructrue

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Abstract No. : **PO-S05-0542**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Polarity-induced stacking order control of epitaxial vdW bilayer

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Single-crystalline transition metal dichalcogenides (TMDs) is an ideal platform for studying both physical and electronic phenomena. Recently, reconstructing the substrate surface can be exploited for the epitaxial growth of single crystalline monolayer TMDs. But, above the monolayer, the orientation difference between the layers defines the new parameter, called stacking order. In case of bilayer TMDs, there are two stable stacking orders: 0° stacked 3R phase and 60° 2H phase. This polymorphic nature of bilayer TMDs forms the defects at the grain boundary and impedes us to focus on the intrinsic properties of TMDs. In this poster, I will discuss the approaches how to control the stacking order and synthesize the single-crystalline bilayer TMDs film. As an example, the presence of polarization in 3R phase can be utilized to manipulate the thermodynamical energy landscape. Lower symmetry of 3R phase than 2H phase breaks the inversion symmetry and induces the electrical polarization which is able to control the electrostatic potential. Considering these approaches will contribute to not only successful growth of high-quality bilayer TMDs but also give insights how to synthesize the twisted TMDs for realizing the twistronics in industry.

Keywords : Transition metal dichalcogenides, epitaxial growth, stacking order

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Abstract No. : **PO-S01-0541**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Optimizing Electrochemical Performance of $LiFePO_4$ Cathode via Hydrothermal Synthesis for High-Performance Lithium-Ion Batteries

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Lithium-ion batteries (LIBs) play a crucial role in various energy storage applications, prompting continuous efforts to enhance their performance and sustainability. $LiFePO_4$ (LFP) has emerged as a promising cathode material due to its high theoretical capacity, thermal stability, and cost-effectiveness. However, achieving optimal electrochemical properties necessitates precise control over synthesis conditions and structural characteristics. This study focuses on synthesizing $LiFePO_4$ (LFP) cathode material using the hydrothermal method to enhance the electrochemical performance of LIBs. LFP synthesis was conducted at 180 °C for 6 hours under hydrothermal conditions to ensure crystalline uniformity and phase purity. To further enhance battery performance, the slurry mixing ratio of LFP: Super B: Polyvinylidene Fluoride (PVDF) was systematically varied to determine the optimal combination. The impact of different mixing ratios on the morphology, particle size distribution, and electrochemical properties of the synthesized LFP cathode materials was thoroughly investigated. Through comprehensive characterization techniques and electrochemical tests, the study identifies the ideal slurry composition that maximizes the battery's specific capacity, cycling stability, and rate capability. These findings offer valuable insights into developing high-performance LFP-based LIBs, highlighting the importance of optimizing synthesis parameters for tailored cathode materials in energy storage applications.

Acknowledgment: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2018R1A5A1025594) and was supported by “Regional Innovation Strategy (RIS)” through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (No. 2023RIS-007).

Keywords : lithium iron phosphate, hydrothermal synthesis, cathode materials, lithium ion batteries

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Abstract No. : **PO-S09-0540**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Area-Selective Atomic Layer Deposition of Ru Thin Films by Chemo-Selective Inhibition of Alkyl Aldehyde Molecules on Nitride Surfaces

Jieun Oh[2], Jinseon Lee[2], Jiwon Kim[1], Hongjun Oh[1], Bonggeun Shong[1], Woo-Hee Kim*[2]

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Area-selective atomic layer deposition (AS-ALD) on pre-defined areas is of crucial importance nowadays in significantly reducing complexities associated with current top-down fabrication processes. In this work, we report the effects of surface modification using various alkyl aldehyde inhibitors with different chain lengths—hexanal, decanal, and undecanal—on nitride surfaces such as TiN and SiN to achieve AS-ALD. Based on density functional theory calculations and experimental analysis, including water contact angle and X-ray photoelectron spectroscopy, it is evident that aldehydes would chemo-selectively react with the $–NH_2$ functional groups present on the nitride surfaces. Then, we further investigate their blocking ability against subsequent Ru ALD, a promising next-generation electrode material. It is worth noting that the Ru deposition thickness decreased by 4 to 10 nm with undecanal adsorbed on SiN and TiN substrates. Finally, we successfully demonstrate AS-ALD of Ru thin films over 8 nm on a patterned TiN/SiO_2 substrate. These results hold potential for applications in bottom-up nanofabrication techniques for next-generation nanoelectronic applications.

Keywords : Area-selective atomic layer deposition, Ruthenium, Aldehyde inhibitor, Chemo-selective adsorption, Nitride-blocking capability

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Abstract No. : **PO-S14-0539**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Surface modification of core-shell Co_3O_4/$CoWO_4$ architecture by 2-D reduced graphene oxide sheets for electrocatalysis of water

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Cobalt has emerged as one of the best non-noble metals electrocatalysts for water splitting. However, practical applications of cobalt-based materials depend on several factors affecting electrochemical activity such as morphology, chemical composition, and structure. These factors need to be optimized to facilitate easy charge transfer between electrode material and electrolyte. Herein, we report the composite core-shell architecture of Co_3O_4 and $CoWO_4$-rGO for overall water splitting. The macropores formed from a uniform coating of spherical nanoparticles with rGO sheets create catalytic material with high porosity and short diffusion passages, facilitating fast electrolyte flow, and thereby enhancing the mass transport capability. The prepared core-shell material demonstrated good catalytic activity with an overpotential of 240 mV at a driving current density of 50 mA cm^{-2} for OER. This has been contributed by the excellent mass transport attributed to mesoporosity. For Co_3O_4/$CoWO_4$-rGO, a Tafel slope of 89 mV dec^{-1} was observed.

Keywords : Electrocatalysis; Heterostructure; Water splitting

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Abstract No. : **PO-S09-0538**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Properties of SnO_x thin films for EUV MOR at varying temperatures

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As the size of semiconductor devices decreases, the importance of lithography has led the semiconductor industry to introduce extreme ultraviolet (EUV, λ~ 13.5 nm) as the main next-generation lithographic technology. The metal oxide photoresist (MOR) is a promising type of non-chemically amplified resist (Non-CAR) for use in extreme ultraviolet lithographic patterning. Compared to CARs, MORs exhibit higher EUV absorptivity and shorter blur lengths. Tin-based MORs are considered for application as EUV photoresists due to its relatively high absorption cross section at 92 eV. Tin-based MORs can increase absorbance for EUV radiation and enable higher resolution patterning. In this study, amorphous SnO_x thin films were deposited by plasma-enhanced chemical vapor deposition (PECVD) using the tin isopropoxide precursor at varying temperatures. The films have been characterized as-deposited and after patterning. As deposition temperature increases, refractive index increases. Deposited below 50 °C, SnO_x thin films show an amorphous phase, while SnO_x thin films deposited over 100 °C show crystalline phases. In chemical properties, as the temperature increases, the intensity of the Sn-O bonding peak increases. Tin-based MOR can enable finer patterns to be formed, but can also lead to development in lithographic technology.

Keywords : EUV, MOR, PECVD, Lithography

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Abstract No. : **PO-S07-0537**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Phase Field Modeling of Strain Induced PhaseTransformations in $MoTe_2$

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Electrocatalytic water splitting has gained significant attention as a sustainable method for clean hydrogen fuel production. While platinum-based electrocatalysts have shown promise, their high cost has hindered large-scale implementation. Low-cost noble metal free electrodes for hydrogen evolution reaction (HER), such as 1T' $MoTe_2$ single crystals have been reported as excellent replacements (Y. He et al, J. Phys. Mater. 4 014001, 2021). In this study by leveraging the phase field method, we simulate the novel method of producing 1T' phase from the 2H phase in pre-strained $MoTe_2$ (Y. Lee et al, ACS Energy Letters 8 (11), 4716-4725, 2023). Our simulation model considers the $MoTe_2$ flake as a two-phase mixture, where the 1T' phase is encased within a rectangular 2H phase matrix. An order parameter,

Keywords : Phase field, modelling, simulations, HER, TMD

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Abstract No. : **OR-S06-0536**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Exploring the Frontiers of Aluminum-Based Electrochemical Energy Systems: A Catalyst-Free Approach

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Aqueous aluminium-air (AAB) batteries hold immense promise for next-generation high-energy-density storage systems. However, their widespread practical application is impeded by the inherent hydrogen side reactions of aluminium in the anode and sluggish oxygen reduction reaction (ORR) at the cathode. To address these challenges, we propose the Al-Na2S2O8 system as a viable alternative to AAB. The introduction of Na2S2O8 eliminates the need for a cathode catalyst while concurrently raising the system's voltage to 2 V and suppressing the hydrogen evolution reaction (HER). Three configurations of the aluminium electrochemical energy system (Al-EES) with Na2S2O8 have been developed: static, flow, and gel types. The understanding of the reaction mechanism in Al-EES and corrosion inhibition is substantiated through sophisticated characterizations, such as TOF-SIMS AFM, and XPS. The static setup notably surpasses the performance of AAB by 1.7 times, illustrating the significant role of Na2S2O8 in the Al-EES system. Additionally, the flow-type Al-EES demonstrates a discharge duration of 77 hours, which is 3-4 times longer than AAB, achieving an impressive energy density of 2,650 Wh/kgAl. This newly discovered technology promises the next step in revolutionizing electric vehicles with its potent, efficient, cost-effective, and resilient power generation capabilities in the future.

Keywords : Chemical electron acceptor; Catholyte; Corrosion studies; Aluminium battery/fuel cell; Corrosion inhibition efficiency; Hydrogen evolution rate; Batteries for electric vehicles; Flexible battery.

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Abstract No. : **PO-S01-0535**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Effect of Hydrothermal Synthesis and Calcination Process on Improving the Electrochemical Performance of $LiFePO_4/C$

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Lithium ferro phosphate ($LiFePO_4$) is recognized as a promising cathode material for lithium-ion batteries due to its stability, cost-effectiveness, and high energy density. To enhance the conductivity of active materials in lithium-ion batteries, hydrothermal synthesis has emerged as an economical and eco-friendly method, leading to improved discharge and charge efficiency, capacity, and cycle stability. Calcination plays a pivotal role in optimizing the composition, crystal structure, and particle size of battery materials, thereby refining their electrochemical performance and enhancing capacity, energy density, and cycle life.

In this study, $LiFePO_4$ was synthesized using hydrothermal synthesis, with two additional samples prepared for comparison: one with carbon black added during synthesis and another without any carbon addition. Furthermore, the impact of carbon coating on the performance of $LiFePO_4$ in lithium-ion battery cathodes was investigated. Various analytical techniques, including X-ray Diffraction (XRD) and scanning electron microscope (SEM), were employed to evaluate the properties of the synthesized samples. Our findings underscore the significant influence of hydrothermal synthesis and carbon coating on the electrochemical performance and charge-discharge cycles of $LiFePO_4$.

Acknowledgment: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2018R1A5A1025594) and was supported by “Regional Innovation Strategy (RIS)” through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (No. 2023RIS-007).

Keywords : Lithium iron phosphate, hydrothermal synthesis, calcination process, cathode, lithium ion batteries

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Abstract No. : **OR-S14-0534**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Toward Highly Accessible Fe-N_4 Sites: Rational Engineering of a Single-Source Precursor to Tailor a Highly Dispersed Single-Atom Catalyst for Direct Methanol Fuel Cell and Green Hydrogen Production

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The development of simplified precursors for tailoring atomically dispersed single-atom catalysts (SACs) remains challenging due to complicated multistep synthesis routes. Herein, we introduce metal-chelated ionic liquid (M-IL) as a single-source precursor containing fundamental components such as metal (Fe, Co, Cu, and Ni), nitrogen, and carbon. Physicochemical and electrochemical characterization suggests that the optimized catalyst possesses optimal graphitization, balanced defects, and enhanced high atomic coordination, resulting in a higher electrochemical surface area. Among the single atoms developed, IL-Fe-SAC-8 exhibited a higher half-wave potential (0.902 V vs. RHE) towards ORR and lower overpotentials of -127 mV for HER and 281 mV for OER in 1.0 M KOH, achieving 10 mA/cm2. Furthermore, a flexible DMFC fabricated with IL-Fe-SAC-8 showed 2.5 times increase in power density compared to a Pt/C-based cathode. Additionally, the bifunctional electrolyser developed using IL-Fe-SAC-8 electrode required only 1.58 V@10 mA/cm^2. Moreover, the integrated electrolyser with the wind turbine nearly delivered H_2 and O_2 gases in line with theoretical ratios. Furthermore, the produced green hydrogen successfully powered the lab-scale real-time hydrogen fuel cell vehicle.

Keywords : Ionic liquids, Single source precursor, direct methanol fuel cells, Green hydrogen productions

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Abstract No. : **PO-S10-0533**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Collagen matrices coated with composite chitosan nanoparticles: production under pressure in carbonic acid

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In modern biomedical technologies, great attention is paid to the creation of new hybrid biomaterials with improved functional properties. Biomaterials with polymer coatings obtained in biocompatible, self-neutralizing solvents are particularly interesting [1].

The research aimed at developing and optimizing methods for producing and applying chitosan nanoparticles under pressure in carbonic acid to the xenopericardium and studying the effect of coating on the functional properties of modified biocomposites. Stable chitosan nanoparticles doped with vancomycin were obtained with d ~80 nm. Fourier IR analysis of the isolated nanoparticles indicated the loading of the drug into the polymer nanoparticles. Using radioactive indicators, it was found that at a P_{CO2}=30 MPa, a maximum yield of y ~ 85% of nanoparticles was observed and an η ~ 30% loading efficiency into nanoparticles was achieved.It was also determined that lowering the pH of the medium to levels typical of an infectious environment stimulates the release of the antibiotic by ~15%. After application mechanical strength characteristics were maintained, and growth of pathogenic biofilms on the surface of implants was completely inhibited. Histological analysis revealed absent any disruption of the histological architecture of the pericardium, but rather enhances its integrity.

A study using an animal model found that, after 12 weeks of the experiment, approximately 50% of the vancomycin and approximately 25% of the chitosan, out of the total amount of medication that was incorporated, remained in the composite material. This suggests reliable encapsulation of vancomycin within polymer nanoparticles.

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Keywords : Biomaterials, xenopericardium, chitosan nanoparicles, vancomycin, tritium label, Fourier IR analysis, AFM, SEM, in vivo biodegradation, drug release

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Abstract No. : **PO-S11-0532**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Dielectric and Energy storage properties of $BaTiO_3$ ceramics according to the addition of Sm_2O_3

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Dielectric materials are fundamentally required to possess not only high permittivity and low dielectric loss but also high electrical field and temperature stabilities at room temperature (RT) for applications such as multilayer ceramic capacitor (MLCC). $BaTiO_3$ (BTO) ceramics are representative ferroelectric materials that undergo a change in the polarization direction under an external electric field. However, pure BTO ceramics have limitations for use in high-temperature components due to their Curie temperature (T_c). Additionally, significant change in the dielectric properties at RT hinder the utilization of pure BTO ceramics in practical applications. By incorporating suitable additives into BTO, these limitations can be overcome, allowing excellent and stable dielectric properties. In this study, Sm_2O_3-doped BTO ceramics were fabricated via a solid-state synthesis method, and the dielectric and ferroelectric properties and energy storage characteristics were investigated with respect to Sm_2O_3 content. As the Sm_2O_3 content increased, the overall dielectric constant increased, and simultaneously, the dielectric loss decreased. A shift in T_c from 129 to 79 °C, causing an increase in the dielectric constant at RT. Additionally, addition of Sm_2O_3 significantly increased the dielectric breakdown strength (DBS) from 8 to 10 kV/mm, ensuring the safety and durability of the dielectric characteristics even at high electric fields without dielectric failure. The energy storage density increases from 0.29 to 0.46 J/cm^3 as the Sm_2O_3 contents increase. Thus, BTO ceramics with added Sm_2O_3 showed higher dielectric stability and energy storage properties than pure BTO, suggesting their potential utilization in high-energy-density energy storage capacitors.

Keywords : BaTiO3, Sm2O3, dielectric properties, energy storage, capacitors

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Abstract No. : **OR-S07-0531**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

The theoretical insight into the effect of Ce-doping on Pt/ZrO_2 catalyst for CO oxidation through Density Functional Theory

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Understanding the structure-activity relationship in heterogeneous catalysts plays a pivotal role in controlling the catalytic performance for various chemical reactions. The Strong Metal-Support Interactions (SMSI) that affect the catalytic activity are influenced by factors such as the type of metal, the type of support material, and the size variation of the metal nanoparticles. This study employs Density Functional Theory (DFT) to explore SMSI between Pt nanoparticles and Ce-doped ZrO_2 support. ZrO_2, prized for its high-temperature stability, is commonly used in many catalytic reactions but faces limitations due to its low oxygen-donating capability as a non-reducible oxide. Ce doping of ZrO_2 has emerged as a solution, enhancing its oxygen-donating capacity and facilitating redox reactions. By using DFT calculations, we conducted research on a simple catalytic reaction, CO oxidation, to investigate how the modified SMSI affects catalytic performance. The Pt nanoparticle constructed with 10 atoms supported on Ce-doped ZrO_2 catalyst shows enhanced catalytic performance compared to being supported on pristine ZrO_2. Additionally, the Pt_{10}-$CeZrO_2$ system shows a lower activation barrier for CO oxidation than the Pt_1-$CeZrO_2$ and Pt_1-ZrO_2 systems. These results originate from the change in interaction with Pt nanoparticles and support oxide materials. Through this study, we observed changes in electronic interactions between Pt and ZrO_2 due to Pt size and Ce doping, and proposed the optimal Pt size that can enhance the catalytic performance of CO oxidation in this system

Keywords : Heterogeneous catalyst, Density Functional Theory, Strong Metal Support Interaction(SMSI)

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Abstract No. : **PO-S02-0529**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Structural and crystallographic analysis of 4-inch $LiTaO_3$ single crystal for improving process condition

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Radio Frequency (RF) filters play a important role in communication systems, especially in mobile phones and IoT devices. RF filters are essential for selectively accepting specific frequencies from multiple bands or eliminating unwanted frequencies. Common wafer materials for RF filters include Silicon On Insulator (SOI), Lithium niobate ($LiNbO_3$), and especially Lithium tantalate ($LiTaO_3$). Among these materials, $LiTaO_3$ is commonly used for various industry field. Presently, RF filters made from $LiTaO_3$ single crystals are mostly manufactured using 4-inch wafers. However, there is a growing need to increase productivity by transitioning to 6-inch wafers. Consequently, our study focuses on analyzing the physical properties of basic 4-inch $LiTaO_3$ single crystal ingots for improving productivity of 6-inch wafers.

The crystallinity of the produced ingot was evaluated using X-ray diffraction (XRD) analysis, the strongest peak observed at approximately 23° corresponding to (012) plane. An additional peak was observed in the (024) plane, confirming the single crystal form of the $LiTaO_3$ ingot without any secondary phases. RAMAN spectroscopy revealed varying peak intensities across different positions of the ingot, yet consistent characteristic shifts were identified. Peaks of similar intensity were observed at all locations, indicating uniform bond stress within the ingot regardless of position. Transmission Electron Microscope (TEM) analysis was conducted to determine the growth plane and crystal information of the ingot from the High-Resolution TEM (HR-TEM) image, and a diffraction pattern obtained using Fast Fourier Transform (FFT). Furthermore, properties such as dislocation density, defects, and elemental analysis were assessed through Energy Dispersive X-ray Spectroscopy (EDX) and line scanning.

Keywords : RF filter, LiTaO3, single crystal, ingot, wafer

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Abstract No. : **PO-S13-0527**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Fabrication of $MAPbI_3$-based perovskite solar cells by using antisolvent method

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Perovskite solar cells have gained attention for their simple and cost-efficient manufacturing process, yielding high power conversion efficiency. The solvent engineering method has been considered reliable for the fabrication of highly crystalline and pinhole-free perovskite solar cells. Herein, we used a two-stage spin coating method to produce high-quality $MAPbI_3$ perovskite films within a glow box environment using chlorobenzene as an antisolvent. Chlorobenzene was selected for its ability to regulate the crystallization process of $MAPbI_3$. Further, the fabricated $MAPbI_3$ thin films were analyzed using Scanning electron microscopy (SEM), X-ray diffractometry (XRD), and UV-Vis spectroscopic techniques. The fabricated perovskite device exhibited power conversion efficiency (PCE) of 7.47 % (V_{OC}= 0.83 V, J_{SC}= 13.82 mA/cm^2, and FF = 65.17 %) for a small area of 0.09 cm^2.

Keywords : Perovskite solar cells, MAPbI3, antisolvent technique, efficiency.

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Abstract No. : **PO-S13-0526**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Relatively wider bandgap absorber and buffer materials to further increase CIGSe solar cell efficiency

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Zn-based wide bandgap buffer has shown potential possibilities to substitute a conventional CdS buffer. However, unoptimized properties of Zn-based buffer occasionally disturb a fair comparison to CdS buffer, and the stereotype optimal bandgap of 1.15 eV in CIGSe absorber related with the limited bandgap of CdS buffer has hindered in achieving a higher performance of CIGSe solar cell until now. In other words, there are possibilities of performance enhancement if a controllable wide bandgap buffer is utilized with a wider bandgap CIGSe absorber since the open-circuit voltage can be increased as increasing the bandgap of CIGSe as far as the current density remains constant. Here, we suggest a materials strategy to further increase CIGSe solar cell efficiency. To make a fair comparison of solar cell performances with different materials and to investigate the possibility of efficiency enhancement, we compare CIGSe solar cells with CdS and ZnMgO buffer and wider bandgap CIGSe solar cells with CdS and ZnMgO buffer. In the fabrication, the conduction band offset is also considered in optimizing CIGSe solar cells with ZnMgO buffer. These comparisons suggest the potential efficiency increase of CIGSe solar cells utilizing a relatively wider bandgap absorber and relatively wider buffer. More investigation needs to be carried out regarding even larger bandgaps in CIGSe absorber and ZnMgO buffer in the future.

Keywords : CIGSe, solar cell, CdS, ZnMgO

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Abstract No. : **OR-S14-0525**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Fabrication and characterization of heterostructure $WO_3/BiVO_4/TiO_2$ Photocatalyst for efficient performance of photoelectrochemical water splitting

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Hydrogen evolution by photoelectrochemical water splitting with semiconductor photocatalysts using solar energy is a promising method for alternative energy production. Combination with tungsten trioxide (WO_3) and bismuth vanadate ($BiVO_4$) is one of the promising heterostructure photoanodes for photoelectrochemical (PEC) applications because of its availability, cost-effectiveness, and proper bandgap energy. However, their stability in an aqueous solution is poor, and therefore the performance is not efficient. Using TiO_2 as the top layer can enhance the photoanode's stability by preventing direct contact with the electrolyte. Here, a triple-layered heterostructure $WO_3/BiVO_4/TiO_2$ was fabricated by hydrothermal and spin coating methods on the FTO substrate. Then, the crystal structure, morphology, optical properties, and PEC performance of the photoanodes after each fabrication step were examined systematically. WO_3 synthesized by 2 h hydrothermal reaction time exhibited the nanorod morphology with the highest photocurrent density of 0.15 mA/cm^2 than 4 h and 6 h. $BiVO_4$ formed as the particles and placed between the nanorod. As the thickness of the deposited layer increased, the absorption edge extended to 589 nm possessing the photocurrent density of around 1.5 mA/cm^2 at 1.8 V vs. RHE, having the best performance than single photoanodes. After depositing TiO_2 by varying the amounts of precursor, two absorption regions were found; revealing that these photoanodes can be applied in the visible and UV regions. However, dependent on the light source, the photocurrent density of the $WO_3/BiVO_4/TiO_2$ exhibited lower than that of $WO_3/BiVO_4$. According to the stability test results, WBT-50 μL showed less decreasement than the others and can protect the underlayer from photo corrosion without changing their preferential direction and intensity.

Keywords : Photoelectrochemical water splitting, WO3, BiVO4, TiO2

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Abstract No. : **PO-S14-0524**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Enhancing Photoelectrochemical Performance of $BiVO_4$ Photoanodes via Co-catalyst Integration

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Hydrogen is an energy-rich and clean fuel with enormous potential. Utilizing the most abundant resources like water, and solar power, photoelectrochemical (PEC) water splitting enables us to produce hydrogen. Bismuth vanadate ($BiVO_4$) has been a potential photoanode candidate in the recent decade due to its favorable outstanding features like moderate bandgap, visible light activity, better chemical stability, and cost-effective synthesis methods. Despite a suitable bandgap of $BiVO_4$ for visible light absorption, most of the photogenerated holes in $BiVO_4$ photoanodes vanish before reaching the surfaces for oxygen evolution reaction due to the poor charge separation efficiency in the bulk. This work demonstrates a simple approach to generating oxygen vacancies for designing efficient planar photoanodes for solar hydrogen production. The X-ray diffraction study confirmed the formation of a monoclinic phase of BiVO4 after annealing at 500 0C. The FE-SEM micrograph reveals the formation of the dense closed-pack $BiVO_4$ grains on the substrate surface. EDAX results verify the $BiVO_4$ composition with stoichiometric Bi, V, and O contents. The optical band gap values about 2.4 eV reveal the absorption of broader visible light. Also, the PEC performance and charge transport properties have been explained in detail.

Keywords : Photoelectrochemical Water Splitting, Bismuth Vanadate, Oxygen vacancy, Co-catalyst coating

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Abstract No. : **PO-S06-0523**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Development of low-pressure die-cast Al-Zn-Mg-Cu alloy propellers using numerical simulation

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In recent years, there has been a rapid growth in the leisure boat industry, accompanied by a sharp increase in demand for propellers used in boat propulsion systems. The propellers for leisure boats are typically manufactured from stainless steel or Al-Si based aluminum alloys. Stainless steel products exhibit superior mechanical properties and relatively high performance but suffer from the drawback of being expensive due to the demanding manufacturing process. aluminum alloys, on the other hand, have a relatively lower unit cost but face limitations in improving mechanical properties. In this study, we aim to manufacture propeller products using high-strength aluminum alloys of the Al-Zn-Mg-Cu system to enhance mechanical properties and ensure competitiveness in pricing. Al-Zn-Mg-Cu alloys have significant shrinkage during solidification and a wide solidification temperature range, posing challenges in quality assurance when using conventional gravity casting processes. Therefore, we conducted product development using low-pressure die-casting processes to effectively control casting defects. To effectively apply the new alloy system, numerical simulations were conducted instead of traditional trial and error methods in the mass-production line to derive the optimal alloy composition and process conditions for controlling casting defects, particularly hot tearing. The simulation results were successfully applied to the production process, resulting in the development of high-quality, high-strength aluminum propellers with controlled casting defects.

Keywords : Al-Zn-Mg-Cu alloy, low-pressure die-casting, propeller, simulation

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Abstract No. : **OR-S14-0522**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Chlorine-repellent Fe@NC cathode catalyst for indirect Mg-CO2 saline batteries for desalination plants

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Starting with the EU's carbon border adjustment system in 2023 and the US Inflation Reduction Act (IRA), the issue of carbon neutrality is changing into a conflict of interest from an environmental issue to a direct economic issue. In particular, seawater desalination facilities consume a lot of energy, resulting in a large amount of CO_2 and concentrated seawater is generated during the desalination process. Therefore, an indirect Mg-CO_2 seawater batteries is an eco-friendly and cost-effective solution to reducing CO_2 using concentrated seawater and produce electricity at the same time. In general, the use of a metal catalyst is essential to boost the performance of air cathode of Mg-CO_2 battery. On the other hand, the metal catalysts are easily corroded and deteriorated due to the present of Chloride (Cl^-), especially in concentrated seawater after desalination process. In this study, we have successfully designed and fabricated a chlorine-repellent Fe@NC as cathode catalyst *via* plasma engineering for indirect Mg-CO_2 seawater batteries. The home-made seawater battery demonstrated a decent power density of 36 mW/cm^2 and stable operation for over 50 hrs even under concentrated saline seawater with 7 wt.% NaCl. Based on preliminary study, a Mg-CO_2 seawater battery single cell with an active area of 400cm^2 is expected to provide an average power density of 4 Wh and a continuous reduction of 0.8g CO_2 / hr. This research is expected to provide a sustainable and economical solution for global seawater desalination plants with simultaneous benefits on CO_2 reduction, energy production and recycle of concentrated seawater.

Keywords : Chlorine-repellent, CO2 reduction, Mg-CO2 batteries, electrocatalyst, Plasma engineering

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Abstract No. : **PO-S07-0521**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Pt single-atom catalyst for Preferential Oxidation of CO under the H_2-rich conditions

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Preferential oxidation, PROX, of residual CO in a hydrogen-rich synthetic gas is the final stage of industrial hydrogen production and purification. However, selectively oxidizing around 1 vol. % of CO without consuming hydrogen is technically challenging. Here, we use Pt single-atoms (SAs) stabilized on CeO_x-TiO_2 supporting oxides toward PROX of CO. Based on a combined study of density functional theory calculations and *in situ* spectroscopic analyses, we identified the delicate electronic state of the reaction centers. The bifunctional nature of the spatially separated Pt-O-Ti and Pt-O-Ce sites promoted selective PROX of CO. The preferentially adsorbed hydrogen at the Pt-O-Ti site behaves as an activity regulator, donating electrons to Pt, thus reducing Pt-SAs. The oxygen ion at the Pt-O-Ce interface actively oxidizes the weakly adsorbed CO on reduced Pt-SAs. The unique structural and electronic ensembles at the Pt-CeO_x-TiO_2 interfaces suppress hydrogen consumption but, instead, promote the PROX of CO under hydrogen-rich conditions with high specific mass activity and 100% selectivity for CO_2 at below 100 ˚C. We present a representative case of utilizing electronic modulation of Pt-SAs under the reaction conditions enabled by the unique structural ensemble of Pt-oxide interfaces for dynamic catalytic activation of Pt-SAs.

Keywords : PROX, Single atom catalysts, Density Functional Theory

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Abstract No. : **PO-S13-0520**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Synthesis and characterization of $MAPbI_3$-based inverted perovskite solar cells

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Inverted perovskite solar cells (IPSCs) offer advantages like low-temperature processing, device stability, simplified fabrication, and potential for tandem device integration in contrast to the traditional configuration. Due to its exceptional optoelectronic qualities, which support high-efficiency photovoltaic performance. Herein, we used solution process and optimized film morphology, crystallinity, and interface properties for superior photovoltaic performance. Current-voltage (J-V) measurements under 1 sun sunlight illumination conditions are conducted to evaluate key photovoltaic parameters, including open-circuit voltage (Voc), short-circuit current density (Jsc), fill factor (FF), and power conversion efficiency (PCE). The $MAPbI_3$-based inverted device shows 1.84 % PCE (Voc of 0.85V, Jsc of 5.53 mA/cm^2) with 40 % FF.

Keywords : Photovoltaic, MAPbI3, Inverted perovskite solar cell, Solution process

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Abstract No. : **PO-S13-0519**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Dynamic hot air assisted $CsPbI_2Br$ perovskite thin films for highly efficient all inorganic perovskite solar cells

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All inorganic and lead perovskite solar cells ($CsPbX_3$) exhibit an excellent thermal stability compared with organic-inorganic hybrid perovskite devices. Generally, the perovskite solar cells are fabricated in a glovebox to prevent moisture, as the perovskite materials are easily degraded in water. Herein, we used a dynamic hot air (DHA) method to achieve pinhole-free compact morphology and uniform $CsPbI_2Br$ films in ambient conditions. These $CsPbI_2Br$ thin films samples were characterized using X-ray diffraction (XRD), Scanning electron microscope (SEM), and UV-Vis spectroscopic techniques. The resulting DHA processed $CsPbI_2Br$ perovskite device showed the power conversion efficiency (PCE) of 13.63 % (V_{OC}= 1.23 V, J_{SC}= 14.92 mA/cm^2 and FF = 74.16 %) for small area (0.09 cm^2).

Keywords : All-inorganic perovskites, CsPbI2Br perovskites, dynamic hot-air technique

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Abstract No. : **PO-S13-0518**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Exceptionally transparent HTLs for inverted planar perovskite solar cells fabricated over optically engineered nickel oxide films

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Under ambient conditions, inverted planar perovskite solar cells (PSCs) are fabricated utilizing nickel oxide (NiO) as a hole-transporting layer. After oxidation at 580°C, nickel (Ni) films synthesized under optimized evaporation conditions employing economical thermal evaporation became compact porous thin films of NiO. The synthesis of pristine transparent NiO films is validated by the use of energy-dispersive X-ray analysis and UV-visible spectroscopy. These optically engineered NiO films have an island-like morphology and are conceived to absorb less visible light than compact porous thin films. Compared to compact porous NiO thin films, the NiO island-like films coated with a single cationic $CH_3NH_3PbI_3$ perovskite overlayer in ambient circumstances using a modified two-step technique demonstrated better hole quenching. Comparing PSCs made of NiO island-like films to compact porous NiO thin films, the former demonstrated a 41.4% increase in current density (J_{SC}) and a 39.3% improvement in power conversion efficiency (PCE). Overall, the current methodology of employing optically engineered island-like inorganic films in conjunction with a single cationic $CH_3NH_3PbI_3$ perovskite overlayer has unlocked a new avenue for the advancement of high-performance optoelectronic devices produced in the air.

Keywords : NiO islands morphology; Inverted perovskite solar cell; Ambient process; Thermal evaporation; PL

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Abstract No. : **PO-S09-0517**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Area-Selective Atomic Layer Deposition of SiO_2 Thin Films using Self-Assembled Monolayers on Amorphous Carbon versus Silicon

SeoHyun Lee[1], Jeong-Min Lee[1], Woo-Hee Kim[*1]

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The miniaturization of semiconductors has led to the necessity for the development of new patterning methods to replace conventional optical lithography, which is unable to cope with sub-10 nm patterns and incurs increased costs due to the complexity of the process steps. Previously used multiple patterning has further increased the complexity of the process by requiring the repetition of the deposition-etching process. In order to overcome this, we introduce an area selective atomic layer deposition (AS-ALD) method for self-aligned deposition directly on both sides of mandrel regions, which can allow the simplified process. More specifically, AS-ALD using three different self-assembled monolayers is mostly focused on the selective deposition of SiO_2 thin films on an amorphous carbon substrate, while not on a silicon substrate. As a result, we were able to achieve significant deposition selectivity over 5 nm for ALD SiO_2 on the amorphous carbon vs. silicon substrates, paving the way for more efficient multiple patterning.

Keywords : Area-selective ALD, ASD, SiO2 ALD

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Abstract No. : **PO-S13-0516**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Enhancing the efficiency of $MAPbI_3$-based perovskite solar cells through antisolvent method

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Perovskite solar cells (PSCs) have attracted a lot of interest because of their potential for low-production costs and high efficiency. Methylammonium lead iodide ($MAPbI_3$) stands out among other perovskite materials as an extremely effective light absorber. However, problem with stability and repeatability impede the commercial viability of $MAPbI_3$-based PSCs. In this study, we present a comprehensive approach to enhance the efficiency of $MAPbI_3$-based PSCs through antisolvent methods. The $MAPbI_3$-based device shows power conversion efficiency (PCE) of 11.54 %, open circuit voltage (V_{OC}) of 0.95 V, and short circuit current density (J_{SC}) of 20.46 mA/cm^2 for a small area (0.09 cm^2) with 72.79 % fill factor (FF). Overall, our findings underscore the importance of device optimization in realizing high-performance $MAPbI_3$-based PSCs, paving the way toward next-generation photovoltaic technologies.

Keywords : Perovskite solar cells, MAPbI3, antisolvent method.

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Abstract No. : **OR-S11-0515**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Mechanically robust photocurable graded materials via AI-driven grayscale-digital light processing 3D printing

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Photopolymerization-based additive manufacturing enables the production of prototypes, customized parts, and complex designs with high accuracy. Digital Light Processing (DLP) is known for its rapid process capabilities by layer-by-layer printing. Recent studies in DLP 3D printing have focused on developing innovative resin materials and designing optimal structural layouts that incorporate specific functionalities. In this presentation, a two-step strategy is introduced to enhance the mechanical robustness of manufactured components. This approach involves developing advanced materials and applying a geometric gradient. First, we focus on developing a photopolymer with mechanical tunability and improved toughness, utilizing a resin composition based on HEDS containing Polyurethane acrylate (HPUA). Second, we present an Artificial Intelligence(AI)-driven design strategy for creating graded structures that effectively reduce stress concentrations. This step involves performance prediction and optimization, considering both material and structural characteristics. The AI-driven structure is fabricated using a specialized technique known as Grayscale DLP (G-DLP). G-DLP technology enables the effective manufacturing of graded materials, in which the mechanical properties gradually change across the printing region by varying light intensities. These 3D-printed graded structures are applicable in diverse fields such as metamaterials, bioengineering, and energy harvesting.

Keywords : 3D printing, Digital light processing, Graded structure, Photocurable resin, Artificial intelligence

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Abstract No. : **PO-S14-0514**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Multiple redox cycles deposit atomic-scale Pt on Cu_2O-based photocathodes under light for improved solar-to-hydrogen energy conversion

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Research on solar-to-hydrogen energy conversion via photoelectrochemical (PEC) devices presents a vital alternative to traditional fossil fuels, with significant recent advancements in water splitting efficiency due to enhanced photo-absorption layer engineering. Despite this, there has been minimal focus on the techniques used for catalytic deposition, which offer substantial potential for improving PEC device performance. The catalyst plays a crucial role in significantly reducing the activation energy at the interface between the photoelectrode and the electrolyte, and platinum (Pt) remains superior in its inherent activity for the hydrogen evolution reaction (HER). In our study, we have uniformly coated the photocathode surface with atomic-scale Pt catalyst using a photo-illuminated cyclic voltammetry approach. This method halved the Pt usage compared to traditional vacuum and solution-based processes, increased the number of catalytic active sites, and created specific selectivity sites on the photoelectrode surface. The introduction of atomic-scale Pt deposition enhances the charge transfer area, leading to a marked improvement in the hydrogen production performance of the PEC water splitting process. The newly developed Cu_2O/Al-ZnO/TiO_2/atomic-scale Pt photocathode achieved a mass activity 3.35 times greater than samples prepared using conventional Pt deposition techniques at 0 V vs. RHE. The atomic size of Pt effectively lowers the carrier recombination rate and fosters a strong surface reaction, facilitating hydrogen gas production. We anticipate that this novel catalytic deposition strategy will similarly optimize the unique characteristics of other noble metal catalysts.

Keywords : Water splitting, atomic-scale Pt, hydrogen, redox process

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Abstract No. : **PO-S09-0513**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Multiphysics simulation for analysis of thermal disturbance in three-dimensional stacked phase-change memory

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Among emerging non-volatile memory devices, phase-change memory (PCM) stands out as a successfully commercialized technology. However, its operation involving heat presents a significant challenge when continuously downsizing the device. Thermal disturbance (TD) arises due to the proximity of cells, leading to data retention failures in unselected neighboring cells caused by temperature increases during reset programming of the selected cell. Therefore, we propose a multiphysics simulation model to find ways to avoid TD in three-dimensional (3-D) stacked PCM with two or more heaters. By coupling electrothermal and phase-field simulation in COMSOL Multiphysics, we were able to simulate partial crystallization in the neighboring cell and the resulting change in cell resistance due to TD. Based on simulation results, we confirmed that reducing the heater thickness and employing a confined structure through the heater recess can effectively help mitigate TD while consuming less energy.

Keywords : Phase-change memory (PCM), Thermal disturbance (TD), Multiphysics simulation, Electrothermal, Phase-field, Crystallization

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Abstract No. : **OR-S14-0512**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Cu_2O-based photocathodes with Rh_2P nanoparticles deposited through photo-illuminated redox processes for durable hydrogen production in acidic conditions

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Photoelectrochemical (PEC) cells are emerging as a viable method for the solar-driven production of green hydrogen, yet the enhancement of their hydrogen generation efficiency through varied light-absorbing multi-layer coatings remains limited. The kinetics of the hydrogen evolution reaction (HER) are improved in acidic conditions, which also help in minimizing overpotential losses. Nevertheless, the extended exposure to acidity can lead to deactivation of noble metal electrocatalysts, compromising their long-term operational stability. Addressing the issue of catalyst degradation is crucial for developing stable and efficient acidic PEC systems. In this context, we introduce a methodological design utilizing the photo-illuminated redox deposition (PRoD) technique. This method facilitates the growth of crystalline Rh_2P nanoparticles (NPs) with diameters ranging from 5 to 10 nm on 30 nm thick layers of TiO_2, without annealing. The process involves precise atomic control during several cycles of cyclic voltammetry, synchronized with light exposure, to optimize the system's catalytic performance. Our advanced photocathode structure, which includes layers of $Rh_2P/TiO_2/Al–ZnO/Cu_2O/Sb–Cu_2O/ITO$, achieved an impressive photocurrent density of 8.2 mA cm^{-2} at 0 V_{RHE} and sustained the water-splitting process effectively in a highly acidic environment. Notably, the photocathode loaded with Rh_2P demonstrated a 5.3-fold increase in mass activity compared to a configuration using only a Rh catalyst. Additionally, we employed in-situ scanning transmission electron microscopy (STEM) to monitor the real-time formation of Rh_2P NPs within a liquid cell.

Keywords : Water splitting, photoelectrochemical, hydrogen, Rh2P catalysts

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Abstract No. : **PO-S14-0511**
Symposia : **Water splitting, CO2 reduction**
Abstract Preference : **Poster**

Pt engineered Co(OH)$_2$ Mott-Schottky heterojunction electrocatalysts for highly efficient ammonia oxidation reaction.

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Developing highly efficient electrocatalysts for renewable and sustainable energy systems holds immense importance across various industrial sectors. One such system, electrochemical water splitting (EWS), relies on these electrocatalysts to produce hydrogen (H_2) as a clean fuel source. By utilizing transition metals, these electrocatalysts increase the number of active sites, thus enhancing their performance. Modulating the electronic structure of electrocatalysts through the construction of Mott-Schottky heterojunctions emerges as an effective strategy to improve their electrochemical performance. In this study, we synthesized hybrid Mott-Schottky electrocatalysts consisting of metallic platinum nanoparticles deposited on cobalt hydroxide (Co (OH)$_2$) nanosheets, employing a hydrothermal method followed by platinum sputtering. The Mott-Schottky effect facilitates self-driven charge carrier transfer at the heterointerfaces of Co (OH)$_2$ and platinum, resulting in a built-in electric field, accelerated charge transfer rates, and enhanced chemisorption free energies of reaction intermediates. Consequently, this promotes the dissociation of water molecules. The Pt @ Co (OH)$_2$ nanosheets electrocatalysts prepared in this manner exhibit a low overpotential of 320 mV for oxygen evolution reaction (OER) performance at 50 mA cm-2 in 1 M KOH electrolytes, along with the lowest Tafel slope of 110 mV dec^1.Furthermore, this electrode demonstrates excellent performance in the ammonia oxidation reaction, requiring a low overpotential of 240 mV at 50 mA cm-2. These advancements set the stage for establishing a sustainable infrastructure for clean, renewable energy.

Keywords : water splitting , Mott-Schottky effect ,oxygen evolution reaction ,Ammonia oxidation reaction , Nanosheets

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Abstract No. : **PO-S02-0509**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Mixed material analysis and pretreatment material property evaluation for $LiTaO_3$ single crystal

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Mobile devices that utilize communication functions utilize various frequency bands.
Radio frequency (RF) filter products help selectively accept certain frequencies or filter out adjacent unwanted frequencies. The wafer material typically used is lithium tantalate, which grows into a predominantly polycrystalline form during the mixing process of the oxide form of the material. Therefore, growing a single crystalline formation with a uniform lattice is a very important issue. In addition, $LiTaO_3$ single crystal wafers which are an essential material for RF components for 5G wireless network configurations, have been produced in 4-inch sizes to date, but when produced in 6-inch sizes, many elements can be processed at once, can be added at once, hence increasing the productivity. Also, since this material is mainly dependent on imports, it is essential that it should be produced domestically. Therefore, in this study, we conducted basic research to analyze $LiTaO_3$ mixed materials and evaluate the physical properties of single crystal pretreated materials. In order to optimize growth conditions such as temperature and time, defects and crystallinity of each part of the ingot were analyzed. As a result, it was confirmed that the ingot grew preferentially in the (012) direction as a whole, and more defects were generated in the tail than in the ingot seed.

Keywords : LiTaO3, Ingot, wafer, Single crystal, SAW Filter

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Abstract No. : **PO-S13-0507**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Vapor-Transport-Deposition of SnS_xSe_{1-X} Thin-Films Solar Cells via Single Source Evaporation

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Orthorhombic tin chalcogenide, i.e., SnS_xSe_{1-x}, has recently emerged as a promising absorber material for thin-film solar cells (TFSCs). SnS_xSe_{1-x} provides suitable optoelectronic properties, including a high optical absorption coefficient (10^4 cm^{-1}) and a suitable bandgap (~1.0–1.4 eV). By changing the value of x in SnS_xSe_{1-x}, the Se/S compositional ratio, and bandgap of the SnS_xSe_{1-x} compound can be altered. However, reports on synthesizing mixed-phase SnS_xSe_{1-x} (00.70$Se_{0.30}$ absorber using double source evaporation (i.e., SnS and SnSe).
This study synthesized ternary SnS_xSe_{1-x} thin films through VTD using single-source evaporation. A SnS_xSe_{1-x} source powder with a Se/Se+S ratio of 0.30 was used as the evaporation source. The influence of growth duration on the formation of secondary phases, preferred orientation, and solar cell performance was investigated. The structural, morphological, and compositional properties were studied using XRD, SEM, and EDAX analysis. It was observed that, with an increase in growth duration from 3 to 7 hours, the thickness of deposited films increased from ~1.05 to ~2.0 μm. The device fabricated using a growth duration of 5 h has shown the highest efficiency of 3.57% with a short-circuit-current density (J_{SC}) of 24.50 mA cm^{-2}, an open-circuit-voltage (V_{OC}) of 0.284 V, and a fill factor (FF) of 51.3%. The device exhibited high stability, retaining up to 99.9% of its initial efficiency. Furthermore, the estimated band alignment at the $SnS_{0.7}Se_{0.3}$/CdS heterojunction revealed the presence of a cliff-like conduction band offset (CBO) of -0.07 eV, which promotes further research on improving the CBO at the $SnS_{0.7}Se_{0.3}$/CdS heterojunction interface.

Keywords : vapor-transport-deposition, thin-film solar cells, tin chalcogenides, efficiency

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Abstract No. : **PO-S08-0506**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Electric field cyclic effects on amorphous $Hf_{1-x}Zr_xO_2$ thin films

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Ferroelectric materials based on hafnium oxide (HfO_2) exhibit strong ferroelectric properties even at very thin thicknesses, contrasting with traditional perovskite-based ferroelectrics. Current research is focused on enhancing the ferroelectric properties of HfO_2, and recent attention has been directed towards the crystallization of amorphous hafnium zirconium oxide (HZO) induced by electric field cycling. This process of electric-field-induced crystallization holds promise for operation at lower temperatures compared to conventional methods. To understand the mechanism behind electric-field-induced crystallization, investigation into nanoscale ferroelectric behavior is necessary. However, conventional methods such as polarization-electric field hysteresis loop measurements are limited in their ability to uncover nanoscale mechanisms due to interference from leakage currents. In our study, we used piezoresponse force microscopy to explore the nanoscale electric-field-induced crystallization of HZO thin films. Our research contributes to a deeper understanding of the mechanisms behind electric-field-induced crystallization and the fundamental origin of ferroelectricity in thin films based on HfO_2.

Keywords : Atomic force microscopy(AFM), Piezoresponse force microscopy(PFM), HZO, Electrical cycling

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Abstract No. : **PO-S02-0505**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Fabrication of n-Doped GaN Nanorod Arrays via Metal-Assisted Chemical Etching Process

Seong Won Lee[1], Kyu Young Kim[1], Tae Gue Yoon[1], Min Hyeok Kim[1], Tae Rim Ko[1], Young Jin Choi[*1]

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Researchers have recently shown considerable interest in developing high-brightness light sources utilizing GaN nanorods photonic crystals. To achieve this, the implementation of doped GaN nanorods is essential. Traditional plasma-based dry etching techniques employed for GaN nanorod fabrication encounter challenges such as high fabrication costs and damage to sidewalls of GaN nanorod. Meanwhile, Metal Assisted Chemical Etching (MACE) has been explored in previous studies for creating silicon (Si) nanorod structures. MACE selectively oxidizes Si regions using metal catalysts and oxidants, followed by acid etching of the oxidized areas. This method has garnered attention for its cost-effectiveness and absence of plasma-induced damage during Si nanorod formation.

In this study, we applied MACE to doped GaN to fabricate nanorods, employing UV excitation to induce wide-bandgap in GaN for hole formation. Initially, to comprehend the MACE tendency of doped GaN, we examined the MACE behavior of undoped GaN and n-doped GaN(n-GaN) using $K_2S_2O_8$ (oxidant) and HF (oxide remover). We found that under the same MACE conditions, the vertical etch rate of n-GaN decreased by approximately 7 times compared to undoped GaN. To address this, we increased the etchant concentration, but encountered decreased anisotropy in n-GaN etching alongside increased etch rate. This is attributed to the suppression of hole formation by oxidants, due to the high free electron density of n-GaN. To enhance the efficiency of hole formation in n-GaN, we systematically adjusted the concentration ratio of the oxide remover and the oxidant to improve etch rate and etching anisotropy. We successfully fabricated n-GaN nanorod arrays with micrometer-scale heights and aspect ratios exceeding 2 using optimized MACE conditions and KOH treatment to form 90-degree sidewalls.

The technique lays the groundwork for a cost-effective new manufacturing process of GaN nanorod arrays with potential for high-brightness light source applications.

Keywords : GaN, Nanorods,Nanostructure,Photonic crystal, MicroLED, NanoLED, Plasma-free, Metal assisted chemical etch,MACE,Etch,doped GaN, n-GaN

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Abstract No. : **PO-S08-0504**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Studying effects of eddy current in electrical steels using atomic force microscopy

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Due to their ability to minimize heat generation during electrical energy conversion and their low power loss at high frequencies, electrical steels find widespread use in electromagnetic applications like transformers and electric motors. However, when subjected to an external magnetic field, these steels generate eddy currents in various forms, which can distort power waveforms and lead to power loss. While significant research has focused on macroscopic understanding of eddy current effects, there remains a dearth of microscopic insights. This study utilized multidimensional magnetic force microscopy (MMFM), a type of atomic force microscopy, to visualize eddy currents in electrical steels. While MMFM demonstrated its potential in exploring eddy currents in soft magnetic composites, commercially available electrical steels exhibited limited visibility of eddy currents. Nonetheless, MMFM revealed locally distinct magnetic properties in the amplitude image. These findings suggest that MMFM holds promise for effectively studying local eddy currents and magnetic properties at the nanoscale, with potential applications in materials possessing complex magnetic behaviors.

Keywords : Electrical steels, Eddy current, Atomic force microscopy (AFM), Multidimensional magnetic force microscopy (MMFM), Nanoscale

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Abstract No. : **PO-S02-0503**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Fabrication of Narrowband Perovskite Photodetectors for Red Light Detection using Ambi-Functional Space Layer

Tae Gue Yoon[1], Kyu Young Kim[1], Seong Won Lee[1], Min Hyeok Kim[1], Tae Rim Ko[1], Young Jin Choi[*1]

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The expanding realm of organic-inorganic hybrid perovskite (OHP) materials has sparked significant interest in photodetector research, thanks to their remarkable optical properties. Past research on perovskite photodetectors (PePDs) has predominantly centered on broad-spectrum detection. However, there's been a growing interest in recent studies regarding the narrowband photodetection capabilities within specific wavelength ranges.

In this study, we investigated the narrowband optical characteristics of PePDs in the red region by leveraging the charge transport layer as an optical spacer. The PePD structure consisted of ITO/perovskite/C_{60}/ZnO/Ag, with C_{60} and ZnO serving dual roles as charge transport layers and optical spacers. Through systematic adjustment of the ambi-functional layers' thickness, we achieved distinct performance with selective charge collection characteristics in the red wavelength range. The observed performance can be attributed to intentional trap density augmentation in the short wavelength region and constructive interference facilitated by the photo-active layer in the long wavelength region
Moreover, we developed a narrow-band PePD with enhanced photo-response characteristics in the red wavelength range (600-800 nm) by fine-tuning the ambi-functional layers. Additionally, we validated that adjusting the perovskite photo-active layer within the same structure led to a shift in the EQE peak in the red wavelength range, attributed to interference effects.

In summary, this study presents novel findings on narrowband photodetection characteristics in the red region, achieved through a simple method of ambi-functional layer control, with the additional benefit of being manufacturable regardless of optical filters or specific materials. The research lays the groundwork for advancements in narrow-band detection technology based on perovskite materials.

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Keywords : organic-inorganic hybrid perovskite, narrowband perovskite photodetectors, red light detection, charge collection narrowing

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Abstract No. : **PO-S08-0502**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Deep learning for high speed acquisition of atomic force microscopy images

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Ferroelectric materials are among the most relevant materials for next-generation memory devices, such as ferroelectric random access memory (FeRAM) and ferroelectric field-effect transistor (FeFET). Piezoresponse force microscopy (PFM) has been recognized as a very powerful tool for analyzing ferroelectric properties at the nanoscale. However, since PFM is based on atomic force microscopy (AFM), it suffers from critical disadvantages in achieving fast image acquisition of ferroelectric domain images. To overcome this drawback, high speed scanning or multi-probe systems can be employed. However, this hardware is not readily implemented in a commercial AFM system. In this study, we utilized machine learning (ML) techniques to overcome the shortcomings. We obtained training data for ML from as-grown state as well as poled state in NBT-KBT-BT. Our results demonstrate the high speed image acquisition with maintaining its resolution. We anticipate that this approach can complement the lengthy analysis time of AFM and ferroelectric materials can be more effectively analyzed with PFM, leveraging its strengths in ferroelectric materials analysis.

Keywords : Ferroelectric materials, Atomic force microscopy (AFM), Piezoresponse force microscopy (PFM), Machine learning

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Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Invited**

Advancements in Robust Magnetoresistive Sensors for on-demand Applications

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Last 30 years, the widespread use of spintronics sensors have been indispensable for the big advancements in micro- and nanotechnologies in recording and non-recording areas. Up to date most of efforts has paid on the development of giant and tunnel magnetoresistance (GMR, TMR) for recording sensors. However Wheatstone type sensor in non-recording applications has an advantage to reduce the offset voltage and thermal drift in harsh environment. Here multi-batch fabrication procedures are required for bridge elements of GMR and TMR [1]. However, it is possible to fabricate a Planar Hall magnetoresistance (PHMR) bridge in cost effective single batch procedure. Notably, Planar-Hall magnetoresistive (PHMR) sensors stand out in this cost effective technology, offering exceptional sensitivity and ultra-low field detectivity. Their versatility makes them suitable across various industries, including the Internet of Things, mobile devices, space technologies, aeronautics, magnetic flux leakage detection, environmental monitoring, and healthcare. [2,3].

This study provides a comprehensive review of PHMR sensors, emphasizing their high thermal stability and tunable field sensitivity. Here, thermal drift is very low about 0.02 , compared to other MR sensors, which is around 10 . Another aspect involves the tunable field sensitivity, ranging from approximately a few μV/Oe for the cross-type configuration to 2 mV/Oe for the 7-ring sensor. This sensitivity is achieved through adjustments in the exchange coupling field by inserting a nonmagnetic Cu layer between NiFe and IrMn, and by varying the number of rings in the sensor. [4]. Furthermore, utilizing high resistive material (Ta, W) as a seed layer increases the output signal and sensitivity by 20% and 5%, respectively, by improving the crystallinity of the sensing layer.

Due to their robust nature, PHMR sensors can be deployed in many on-demand applications regardless of usage environments, including those in harsh environments and those that require high-accuracy measurements, such as lab-on-chip magnetometries integrated with micro-fluidic channels for biochips, flexible sensors, etc. [5]. These applications showcase the remarkable sensitivity of PHMR sensors, with a maximum magnetic moment resolution of ~ 10^{-14} emu in dried conditions, which is 10^4 orders of magnitude better than conventional SQUID magnetometers [6]. With their ability to be customized and miniaturized, and their cost-effective nature, PHMR sensors are uniquely competitive and offer significant potential for mass production and non-recording industrial applications.

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Keywords : Spintronics, Sensors, GMR, TMR, PHMR

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Abstract No. : **PO-S05-0500**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Self-aligned Atomically Thin Thermal Barrier for Highly Energy-Efficient Phase-Change Memory

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Phase-change memory (PCM) has been one of the prominent emerging nonvolatile memory candidates, mainly due to its great operational speed as a storage class memory. However, energy consumption required for electro-thermal programming is still enormous, so it is highly desired to reduce it with rational thermal design. Here, we improve the device energy efficiency by creating WSe_2 layer through thermal CVD at the interface between the phase-change material ($Ge_2Se_2Te_5$) and the bottom electrode heater (W) in semi-confined PCM. WSe_2-PCM devices have ~33% lower SET energy and ~55% lower RESET current compared to devices without WSe_2 layer. It is affirmed that the WSe_2 layer greatly contributes to boosting Joule heating effect via excellent thermal boundary resistance (TBR) characteristic in the direction of the out of plane. Also, since this selenization method is transfer-free selective surface treatment, it is confirmed that WSe_2 layer is perfectly formed at the bottom of the hole structure, which is interface between program region and heater through TEM analysis. Our new approach using TMD thermal barrier layer without transfer process can be a powerful option for the next-generation ultra-low energy and high-dimensional memory cell.

Keywords : Tungsten diselenide (WSe2), Phase-change memory, Joule heating, thermal boundary resistance

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Abstract No. : **OR-S06-0498**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Hydrogen-Charging Effects on Microstructure and Mechanical Behavior of Deformed Ti Alloy

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In this work, hydrogen is introduced into deformed Ti alloys via cathodic electrolysis under various charging conditions, and the microstructures and mechanical properties of the specimens are examined. The presence of hydrides is verified using X-ray diffraction, scanning electron microscopy, and electron backscatter diffraction analysis based on a rescanning approach using local pattern averaging. Vickers hardness tests are then performed to assess the extent of hydrogen penetration in the Ti alloys. Compression tests are conducted to further understand the impacts of hydrides on the mechanical reliability of hydrogen-charged Ti alloys. To reinforce the experimental findings, numerical simulations are conducted utilizing experimental data to comprehend hydrogen diffusion in the Ti alloys. Subsequently, the hydrogen diffusion mechanism in the hydrogen-charged specimens is verified through the obtained results.

Keywords : Ti alloys, electrochemical hydrogen charging, hydrides, microstructure, mechanical properties, hydrogen diffusion

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Abstract No. : **OR-S08-0497**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Oral**

Local probing of domain structures in multi-layered ceramic capacitors

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Multi-layered ceramic capacitor (MLCC) is one of the passive components with a structure in which internal metal electrodes and dielectric ceramic layers are stacked and is used in electronic devices such as mobile phones and electric vehicles. In general, the dielectric properties of MLCC have been analyzed on a macroscopic scale. However, nanoscale studies of dielectric properties are needed to understand underlying mechanisms for improving reliability of MLCC. In particular, while it is widely known that the domain structures affects capacitance of MLCC, it is not clearly understood yet what causes the change in capacitance associated with domain structures in MLCC. In this study, we investigated the change of domain structures associated with capacitance in sub-micrometer scaled areas using piezoresponse force microscopy. We analyzed multi-dimensional domain structures over a couple of micron-meter areas of the $BaTiO_3$ layers in MLCC and revealed the correlation between domain structure and capacitance. These results could provide insight on the improvement of MLCC performance.

Keywords : MLCC, PFM, Domain strucutres

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Abstract No. : **PO-S02-0496**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Optical Spacer-Assisted Narrowband Photodetection of Perovskite Photodetector in Green Wavelength Range

Tae Rim Ko[1], Kyu Young Kim[1], Seong Won Lee[1], Tae Gue Yoon[1], Min Hyeok Kim[1], Young Jin Choi[*1]

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Organic-inorganic hybrid perovskites are attracting attention not only in solar cells but also in optoelectronic devices, including photodetectors, due to their exceptional electrical and optical properties. Initially, perovskite photodetectors were broad-spectrum, covering a wide range of wavelengths. However, as the need for precise wavelength detection grew, researchers explored methods to achieve narrowband photodetection. One of such methods is utilizing the charge collection narrowing (CCN) mechanism, which involves increasing the thickness of the photoactive layer. Several studies have shown the feasibility of narrowband photodetection. However, manufacturing an extremely thick photoactive layer of several millimeters poses challenges, thus limiting its application as an array structure in practical devices.

This study introduces the concept of an optical spacer to overcome the limitations of existing CCN mechanisms and demonstrates its potential for achieving precise wavelength-selective narrowband photodetection. We developed a perovskite narrowband photodetector (PNPD) specifically tuned for green light detection and evaluated its performance. Our method utilizes the electron transport layer (ETL) as an optical spacer, simplifying the fabrication process. The structure of PNPD is ITO/Perovskite/PCBM/C_{60}/ZnO/Ag. By appropriately controlling the thickness of the ETL between the photoactive layer (Perovskite) and the top electrode (Ag) so that it also serves as an optical spacer, we achieved wavelength-selective narrowband photodetection. The optical spacer effect leads to a suppression of the external quantum efficiency (EQE) in the Beer-Lambert region of the device. In addition, the EQE in the wavelength range of approximately 600 to 650 nm could be enhanced due to constructive interference effect by adjusting the thickness of the optical spacer. As a result, we were able to achieve the PNPD with a full width at half maximum (FWHM).

Our study presents a straightforward and innovative approach to achieving narrowband photodetection in perovskite-based devices, paving the way for advancements in wavelength-selective photo-sensing technology.

Keywords : Perovskite photodetector, Narrowband, Wavelength-selective photodetection, Electron transport layer, Optical spacer

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Abstract No. : **OR-S19-0495**
Symposia : **Nanomaterials for MEMS microphone**

Abstract Preference : **Oral**

Performance prediction of piezoelectric microphone through the development of a multi-physics model and sensitivity improvements via acoustic metamaterials

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In this study, we develop a multi-physics simulation model of a piezoelectric microphone and its low frequency sensitivity enhancement through the use of acoustic metamaterials. A zigzag-shaped acoustic metamaterial was designed to have high acoustic characteristic impedance values, and was placed above the microphone's diaphragm, creating an air cavity layer between the membrane and the metamaterial. This structure induces Fabry-Perot resonance of acoustic waves in the air cavity, thus subjecting the microphone membrane to higher sound pressure levels. The effects of various parameters including design parameters of the acoustic metamaterial, height of the air cavity (distance between the membrane and metamaterial), etc., on microphone performance is explored.

Keywords : multi-physics simulation, microphone, sensitivity, acoustic metamaterial, acoustic characteristic impedance

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Abstract No. : **PO-S13-0494**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Effect of Counterion of Ionic Liquids on Perovskite Layer Formation for High-Performance Perovskite Solar Cells

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Organic-inorganic metal halide perovskites have been attracting tremendous attention for next-generation solar cells due to its excellent optoelectronic properties. Now, perovskite solar cells (PSCs) are facing issue for long-term stability against air, humid and light. Such stability issues are caused by defect sites such as under-coordinated Pb^{2+} ion and halide vacancy. Herein, we incorporated ionic liquid (IL) with large cation and dicyanamide (DCA) anion in perovskite precursor. The DCA anions passivate the under-coordinated Pb^{2+} ions to enhance stability. To confirm the effect of DCA anion, we compared with thiocyanate (SCN) anion with the same cation. Furthermore, we fabricated the PSCs in ambient air to confirm its applicability to actual commercial condition. Stability analysis of fabricated PSCs were conducted with AFM, in-situ GIWAXS and power conversion efficiency (PCE), which confirmed that IL contained DCA changes big PbI_2 grain to flake shape favorable for passivation and significantly enhances stability.

Keywords : Peorvkiste solar cell, Ionic liquid, Stability

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Abstract No. : **PO-S09-0493**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Phase Field Simulation of Bipolar Filamentary Resistive Switching Manufactured by Area-Selective Atomic Layer Deposition

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We interpreted the conductive filament behavior in devices fabricated by Area-Selective Atomic Layer Deposition (AS-ALD) using the resistance memory simulation available in our laboratory. Using AS-ALD, it is possible to deposit desired thin films at specific locations without the need for complex patterning processes such as photolithography or etching. Experimental confirmation has shown that utilizing Area-Selective Atomic Layer Deposition (AS-ALD) in resistive memory fabrication, specifically to confine the storage node, also known as the filament-switching material, to a narrow region, and reduces the variability of the device. In this study, we will investigate the fundamental causes using bipolar RRAM phase field simulation.

Keywords : AS-ALD, Phase Field Simulation, Resistive Memory

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Abstract No. : **PO-S02-0492**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Narrow-Band Blue Light Detection Using Wide-Bandgap Perovskite Photodiodes with a Mixed Anti-Solvent Bathing Process

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Organic-inorganic halide perovskites (PVSKs) have exceptional optoelectronic properties, including a tunable bandgap and high quantum efficiency. This has led to extensive research exploring their use as the photo-active layer in photodiodes (PDs). By adjusting the halide composition, perovskites with wide bandgaps can be synthesized, enabling the detection of blue light. These perovskite photodiodes (PePDs) for blue light detection can be applied to diverse applications in fields like optical communication, medical devices, and image sensors.

This study focused on wide-bandgap PePDs specifically designed for narrow-band blue light detection without the need for additional filters. Typically, perovskite films are produced using methods like drop-casting or bathing, with anti-solvents such as anisole. However, residual anisole left on the film surface due to its high boiling point often causes the formation of pinholes, affecting film quality. To tackle this challenge, a mixed anti-solvent bathing process was implemented. Films were created using a blend of anisole and IPA with varying ratios determined by the volume ratio of IPA. The mixed anti-solvent effectively removed residual anisole, thanks to IPA's lower boiling point and higher volatility. Consequently, high-quality, pinhole-free perovskite films were successfully synthesized and integrated into PePD devices.

These PePDs processed with the mixed anti-solvent bathing method exhibited low dark current density at the nA/cm² level and exceptional EQE surpassing 80%. Additionally, aluminum-doped zinc oxide (AZO) transparent electrodes were utilized as top electrodes, replacing traditional metal electrodes. The UV-filtering capability of AZO electrodes efficiently screened out short-wavelength light, allowing exclusive detection of blue light within the visible spectrum range of 380 nm to 500 nm. This study lays a solid foundation for future PePD research concentrating on precise blue-light detection within a narrow bandwidth.

Keywords : Perovskite, Photodiode, narrow-band, anti-solvent, transparent electrode

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Abstract No. : **PO-S05-0491**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

Epitaxial growth of $CrSe_2$ via metal organic chemical vapor deposition

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[1]*POSTECH*

Two-dimensional(2D) van der waals magnetic crystals attract great attention due to their atomically thin thickness and marvelous prospect of exploring magnetism in ultra-thin material system. However, most of 2D magnets are extremely air sensitive, showing severe degradation under ambient condition and usually obtained by mechanical exfoliation method. Also, low Curie temperature of 2D magnets make it hard to engineer magnetic order, which hinders application to industrial level. Recently, as a newly discovered transition metal dichalcogenide, chromium dichalcogenides suggested as a candidate for next-generation 2D van der waals magnetic materials. It is reported that chromium dichalcogenides have high Curie temperature up to room temperature, thickness dependent ferromagnetic, metallic characteristic, and retaining its magnetic property for 30 days. Nevertheless chromium dichalcogenides were grown by convensional chemical vapor deposition using powder precursors or by molecular beam epitaxy (MBE), which is hard to use in mass-production.

Here, we investigated synthesis of $CrSe_2$ via metal organic chemical vapor deposition(MOCVD). By using metal organic precursors and MOCVD growth system, we could obtain wafer-scale thin film growth of 2D van der waals magnetic material. In addition, by applying annealing treated vicinal sapphireas a substrate, we are expecting epitaxial growth of $CrSe_2$, which promotess wafer-scale, single crystalline, monolayer thin film growth. Our research suggests the strategy of large area growth of 2D van der waals magnets for application in next generation memory device, especially in MRAM(Magnetic Random Access Memory). Furthermore, air-stable, ferromagnetic $CrSe_2$ could offer fundamental study of 2D magnets and potential applications in magnetoelectronics and spintronic devices.

Keywords : 2D materials, 2D van der waals magnetic, transition metal dichalcogenide

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Abstract No. : **PO-S03-0490**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

NFC based Optoelectronic, Sensor Integrated with Colorimetric Dressing for Chronic wound monitoring

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Recent advancements in wound care have emphasized the importance of detailed monitoring for various types of wounds, including skin injuries and chronic ulcers, to improve patient quality of life. While conventional wound dressings provide protection and support lesion regeneration, they lack capabilities for tracking wound progression. Our study presents a novel approach: a wireless, battery-free optoelectronic diagnostic sensor integrated into a pH-sensitive, colorimetric wound dressing. This system aims to enhance wound care by offering real-time, user-friendly monitoring that does not require specialized knowledge.

The dressing, made from curcumin-polycaprolactone (C-PCL), not only protects wounds and promotes cellular regeneration but also has antimicrobial properties. Its colorimetric feature changes color from yellow to red, indicating different pH levels associated with varying wound conditions. This allows anyone to easily assess wound status. The core of this innovation is the combination of a green light-emitting diode (LED) and a photodiode, which together accurately detect these color changes, thereby refining the diagnosis process.

This integrated system enables quantitative, real-time data monitoring, making it convenient and efficient for patients to manage their wounds. By facilitating swift evaluations of wound status, our solution ensures timely medical interventions and optimal care, thereby setting a new standard in wound management technology.

Keywords : Chronic wound. Wireless, pH, Colorimetric

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Abstract No. : **OR-S09-0489**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Oral**

Area-Selective Atomic Layer Deposition of Al_2O_3 Thin Films for Metal versus Dielectric Selectivity Using Vapor-dosed Alkanethiols

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Area-selective atomic layer deposition (AS-ALD), a bottom-up approach, has garnered considerable interests for its capability of enabling precise and self-aligned deposition exclusively within specified areas, *i.e.* the growth areas. This method primarily uses self-assembled monolayers (SAMs) to deactivate non-growth regions, thereby enhancing deposition selectivity and alignment accuracy. AS-ALD is especially beneficial for integrating fully self-aligned vias (FSAV) in the back-end-of-line (BEOL) processes, where conventional misaligned vias are susceptible to potentially resulting in electrical shorting issues, primarily stemming from edge placement errors. To address this challenge, an alternative approach involves the application of AS-ALD to create a self-aligned dielectric barrier layer on the dielectric surface between metal lines. In this study, we employed a vapor-dosing process of alkanethiol-based small molecule inhibitors (SMIs) that thermally adhere to metal surfaces *e.g.* Co and Cu. Moreover, by redosing of inhibitors for further enhanced blocking ability, we were able to achieve sufficiently high enough deposition selectivity for ALD Al_2O_3 on metal/dielectric patterns. This approach we present here contributes to the advancement of bottom-up 3D nanofabrication for metal-dielectric patterns.

Keywords : Area-selective atomic layer deposition, Small molecule inhibitor, Short-chain alkanethiols, Vapor-dosing, Enhanced selectivity

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Abstract No. : **OR-S11-0488**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Optimizing Internal Polarization with High Permittivity CaCu3Ti4O12 Particles for Enhanced Performance of Triboelectric Nanogenerators

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In a resently reserch, the surface phenomenon of TENG has been intensively conducted, and various surface treatment methods for triboelectric materials have been proposed for high triboelectric output performance. Here, We propose a composite material based on the butylated melamine formaldehyde (BMF) and high permittivity $CaCu_3Ti_4O_{12}$ (CCTO) particles as a triboelectric dielectric material for stable high output triboelectric nanogenerators (TENGs) is proposed. CCTO particles, which have the high permittivity of 7500, can potentially result in the formation of strong internal polarization into the dielectric material under the electric field from triboelectric charges. We found that the CCTO particles were able to amplify the internal polarization within the dielectric polymer material under the electric field from triboelectric charges. The BMF–CCTO 1 wt% composite material formed three times higher internal polarization than pure BMF under the same electric field condition. A rotation-type freestanding mode TENG based on BMF–CCTO 1 wt% composite material demonstrates high performance power output of a root-mean-square voltage and current density with 268 V and 25.8 mA m^{-2}, respectively. Finally it was demonstrated that the incorporation of high permittivity CCTO particles into a polymer matrix could dramatically and effectively enhance power-generating performance of TENG without constraints of polymer matrix materials.

Keywords : High permittivity, CaCu3Ti4O12 (CCTO), Triboelectric nanogenerators (TENGs)

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Abstract No. : **PO-S13-0487**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Investigating the role of temperature ramping rate in vapor transport deposition to achieve enhanced efficiency for SnS thin-film solar cells.

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Herein, the ramping rate of vapor transport deposition (VTD) and its impact on the properties of SnS thin film solar cells (TFSCs) has been investigated. A comprehensive study of the effect of ramping rate on morphology, Crystallinity, and orientation of deposited SnS thin film and therefore on the performance of SnS/CdS thin film solar cell has done here. To achieve 600 °C deposition temperature, the temperature ramping rate was varied stepwise from 5 °C min^{-1} to 20 °C min^{-1}. The SEM and XRD analysis revealed that the crystalline size of SnS deposited with 5 °C min^{-1} of ramping rate has a nonuniform distribution with preferred crystal orientation along (111) direction. As we move toward the ramping rate of 20 °C min^{-1}, it is observed that the high ramping rate gives uniform growth across the film with (120) of preferred crystal orientation. After fabricating devices, the final structure became SLG/Mo/SnS/CdS/i-ZnO/Al-doped ZnO/Al (active area= 0.3cm^2). Dark J-V analysis of devices shows that the device with the highest ramping rate (20 °C min^{-1}) illustrated the best diode characteristics compared to other devices, resulting from improved crystal orientation, crystal structure, and surface morphology. Furthermore, the device fabricated with a ramping rate 20 °C min^{-1} showed the champion photo conversion efficiency (PCE) of 3.98% in all devices, with 0.34 V of open circuit voltage (V_{OC}) along with short-circuit current density (J_{SC}) of 20.16 mA cm^{-2} and the device got fill factor of 0.58, meanwhile device with 5 °C min^{-1} ramping rate achieved 2.45% PCE. The enhanced shunt properties provided a better fill factor and PCE, therefor attribution of the comprehensive improvement in the device's electrical, structural, and morphological characteristics goes to the high-temperature ramping rate.

Keywords : Vapor transport deposition; temperature ramping rate; SnS; thin film solar cell

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Abstract No. : **PO-S13-0486**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Effect of varying temperature on the crystallinity of Sb_2S_3 using vapor transport deposition and its photovoltaic performance

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In recent years Chalcogenide materials have emerged as promising photovoltaic materials due to their great potential as stable, abundant, low-cost, and high-efficiency photoactive materials to convert photonic energy to electrical energy with the lowest detrimental environmental impact. The performance of thin-film solar cells (TFSCs) accomplished using Sb_2S_3 is highly dependent on the orientation of the crystals. In the photovoltaic industry, vapor transport deposition (VTD) is a promising option for manufacturing scalable and uniformly deposited thin films. This study explores the use of temperature-modulated VTD-Sb_2S_3 deposition to improve the efficiency of carrier transport in photovoltaic cells. The VTD process involves altering the deposition temperature between 480 °C and 540 °C. The characteristics of the Sb_2S_3 thin films were evaluated at varying temperatures using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and atomic force microscopy (AFM). The study focuses on the key features of crystal structure and orientation, surface morphology, composition, and roughness. An important finding of the study is that the prominent crystal orientation changes from the (hk0) to the (hk1) plane after increasing the deposition temperature from 500 to 520 °C. Furthermore, the (211)- and (221)-planes become more prominent when the deposition temperature exceeds 520 °C. The device with the architecture SLG/Mo/Sb_2S_3/CdS/i-ZnO/AZO/Al, a substrate-configured TFSC, demonstrated a maximum power conversion efficiency of 0.22% when the VTD-Sb_2S_3 absorber film was deposited at 520 °C.

Keywords : Vapor transport deposition, Sb2S3 Thin-film solar cells, varying deposition temperature, crystal orientation

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Abstract No. : **PO-S14-0485**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Plasma-engineered Ni-coordinated composite as advanced oxygen evolution reaction (OER) electrocatalysts for direct seawater electrolysis

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Carbon neutrality aims to reduce greenhouse gas emissions and remove any remaining emissions to achieve a Net-Zero. Green hydrogen, generated by electrolyzing water, has emerged as a promising energy source. While purified water is typically used for hydrogen production via water electrolysis, utilizing abundant seawater on Earth could significantly reduce production costs. However, the high concentration of Cl ions in seawater leads to competing reactions between the OER and chlorine evolution reactions (CIER). To achieve selective OER, it is essential to minimize the overpotential of the OER, enabling to occur OER at a potential where the ClER does not take place.

In this study, 2D Ni-coordinated composite was synthesized using plasma engineering. This starting precursor consisted of Ni nodes that are linked to the C and N ends of the cyanide (-CN) groups, and resulted in porous structure of layered Ni-composite after thermal treatment, hereafter referred as $Ni(CN)_2$. At first, the catalyst was deposited onto a Rotating Disk Electrode (RDE) to confirm the intrinsic OER catalytic activity, and the overpotential was measured in a 1M KOH electrolyte and alkaline seawater electrolyte. The OER overpotential of $Ni(CN)_2$ was measured as 281mV and 382mV, respectively, at a current density of 10mA cm^{-2}. $Ni(CN)_2$ exhibited 32mV and 68mV lower overpotentials than the noble metal catalyst RuO_2 in their respective electrolytes. When catalysts were coated onto Ni foam and tested, $Ni(CN)_2$ exhibited significantly lower overpotential and greater stability at a current density of 500 mA cm^{-2}, with overpotentials of 630 mV and 760 mV compared to RuO_2. As a result, we successfully Ni-coordinated composite via plasma engineering and subsequently converting them into nanostructured $Ni(CN)_2$ through straightforward heat treatment. This novel catalyst demonstrates superior performance, offering promising advancements in OER applications.

Keywords : oxygen evolution reaction, seawater electrolysis, metal-organic materials

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Abstract No. : **PO-S09-0484**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Enhanced reliability in hafnium-based ferroelectric devices by controlling interfacial phase composition

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Hafnia-based ferroelectrics (FEs) are recognized as highly promising candidates for next-generation non-volatile memory due to their scalability and compatibility with complementary metal-oxide-semiconductor (CMOS) technology. However, these materials are limited by their endurance properties, necessitating high operating voltages for switching ferroelectric polarization. Conversely, hafnia-based anti-ferroelectrics (AFEs) offer advantages in terms of reduced fatigue effects, as they exhibit minimal defect movement during phase transitions. Additionally, AFEs demonstrate rapid operational speeds owing to their swift polarization switching, unlike the gradual polarization reversal observed in FEs. In this study, a multi-layer heterostructure of AFE and FE $Hf_{(1-x)}Zr_xO_2$ (HZO) was developed to leverage their respective benefits, thus enhancing reliability and non-volatility. This structure not only reduces the fatigue effect but also achieves higher remnant polarization at the nanoscale. By optimizing the composition ratio and structure of AFE and FE HZO, the leakage current, typically caused by naturally formed suboxides, was successfully decreased. Furthermore, improvements in endurance properties were observed with an increased fraction of the tetragonal HZO phase.

Keywords : Hafnium Zirconium Oxide, Ferroelectrics, Anti-ferroelectrics, Multi-layer heterostructure, Interface engineering

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Abstract No. : **PO-S06-0482**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Sub-second Synthesis of Core-shell Structured SiC-Carbon Nanotubes by Microwave Induction Heating

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We introduce a new method to synthesize a core-shell structure of SiC-carbon nanotube(CNT) composite using ultrafast microwave induction heating. The SiC-CNT nanohybrid material comprising excellent conducting CNT inside and insulating SiC layer outside can be utilized to dissipate the heat generated within electronic devices. There is significant difficulty to synthesize the core-shell structure because conventional slow high temperature reaction tends to transform into carbon fiber rather than the desired SiC-CNT structure. Therefore, it is essential to heat it high temperature over 1400°C in very short time. Microwave induction heating is a technology that employs microwave magnetic fields to induce currents inside conductive materials and generate robust resistive heat, in result to instantaneously heat CNTs to extremely high temperatures without thermal contact. The microwave power range of 200W to 1000W and microwave pulse duration range of 100ms to 500ms was applied to optimize for formation of the SiC-CNT core-shell structure with pellets composed of CNTs and SiO_2 powder mixture. It is confirmed that the SiC layer was successfully formed via analysis with SEM, FTIR, and XRD.

Keywords : Microwave Induction Heating, Core-Shell structure, SiC-CNT

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Abstract No. : **PO-S10-0481**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Self-Powered Disinfection Using Triboelectric, Conductive Wires of Metal–Organic Frameworks

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In rural and disaster-stricken areas lacking modern infrastructure, the demand for efficient water disinfection systems independent of power grids is critical. However, traditional disinfection approaches typically depend on consistent chemical supplies and stable electricity. In this work, we introduce a self-powered water disinfection system that employs a combination of hydrogen peroxide ($H2O2$) -assisted electroporation, powered by triboelectric nanogenerators (TENGs) that capture energy from water flow. This innovative system, augmented by sophisticated power management, produces a regulated voltage that activates a conductive array of metal–organic framework nanowires, optimizing $H2O2$ production and the electroporation process. The resulting $H2O2$ molecules, dispersing easily, intensify the disruption of the compromised bacterial cells, enhancing the disinfection process. Our self-powered prototype demonstrates exhaustive pathogen elimination (>99.9999% efficiency) across a broad spectrum of water flow rates, reaching up to 30,000 L/(m2 h), and operates effectively at minimal flow conditions (200 mL/min; approximately 20 rpm). This novel method offers a significant advancement in self-reliant water disinfection, presenting a viable solution for effective pathogen management in underserved areas.

Keywords : Self-powered disinfection, Triboelectric, Metal–Organic Frameworks, Rural and disaster-stricken areas

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Abstract No. : **OR-S05-0480**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Oral**

Organic-inorganic hybrid 2D MXenes with amido- and imido-terminations

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Two-dimensional (2D) transition metal carbides and nitrides (MXenes) have shown excellent performance in many applications including supercapacitors, batteries, electromagnetic interference shielding, and electrocatalysis. These materials not only possess exceptional properties such as high conductivity but also feature chemically modifiable surface terminations, providing an ideal platform for function-driven surface chemistry studies of 2D materials. Moreover, the surface terminations can be tuned to control intrinsic properties such as electronic structure, carrier mobility, and ferromagnetism. A key direction in the structural control of 2D MXenes involves integrating the outstanding characteristics of inorganic layered structures with the structural tunability of organic ligands, creating functional composite materials with adjustable mechanical and structural performance. However, traditional methods for preparing T_x-terminated MXenes (T_x = -O, -OH, and -F, primarily $Ti_3C_2T_x$) involve very strong Ti-O and Ti-F bonds, and organic functionalization is typically limited to intercalation, electrostatic adsorption, or reaction with -OH terminations, resulting in non-uniform ligand surface modifications and uncontrolled terminations.

Here, we report a novel strategy for the preparation of organic-inorganic hybrid MXenes (h-MXene) through covalent modification with amido and imido groups, achieving uniform organic surface modification with tunable terminations. Understanding the structure of h-MXenes necessitates a multidisciplinary approach that integrates principles from coordination chemistry, self-assembled monolayers, and surface science. The optical properties of h-MXene demonstrate strong coupling between the organic and inorganic components, and due to its unique bonding motifs, h-MXene exhibits excellent stability against hydrolysis, enhancing the potential of these materials for practical applications.

Keywords : 2D MXenes, Organic-inorganic hybrids, Structure-property relationship

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Abstract No. : **PO-S13-0479**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Systematic Study of the Effect of A-site Engineering on the Crystallization Kinetic of Sn-Pb Perovskite

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Perovskites with narrow band gaps exhibit high theoretical efficiency, and there is still considerable room for improvement at the current stage. Introducing a combination of Sn and Pb into metal halide perovskites is way to obtain narrow band gap perovskites. For high-quality Sn-Pb perovskite formation requires delicate controlled crystallization rate of the perovskite precursor solution. However, due to the fast crystallization kinetics of high Lewis acidic Sn^{2+} the reaction between SnI_2 and methylammonium iodide (MAI)/ formamidinium iodide (FAI) proceeds notably quicker than that involving PbI_2. Consequently, as the Sn content increases in Sn-Pb binary perovskite films, the rapid nucleation rate by Sn^{2+} crystallization kinetics leads to smaller crystal grain sizes and a higher density of defects. This uncontrollable crystallization and reaction competition of organic ammonium with Sn and Pb make it hard to fabricate of high-quality perovskite film. At present, the most high-performing Sn-Pb perovskite based solar cells consist of an A-site mixture of FA and MA. The doping of various inorganic cations on the A-site of perovskite has been reported as one of the advantageous candidates for controlling the crystallographic kinetics to improve the performance and stability of perovskite solar cells. However, in the binary B-site of Sn-Pb perovskite, there is a lack of systematic research on the effect of the A-site composition by reacting more complex. In this study, we have carried out a systematic study of the effect of inorganic cations on the fast and complex crystallization process of Sn-Pb perovskites. Finally, we have demonstrated the several composition design rule of Sn-Pb perovskites to reach a photovoltaic conversion efficiency exceeding 22%.

Keywords : Perovskite, Narrow band gap, Inorganic cation, A-site doping, Composition desgin

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Abstract No. : **OR-S10-0478**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Oral**

Ultrasound-Driven Triboelectric Nanogenerator for Emergency Wound Management

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Emergency situations involving organ or tissue damage are critical challenges within healthcare, necessitating immediate treatments to halt bleeding, avert infections, and decrease death rates. Suturing and stapling are widely used for wound closure, but may cause additional tissue damage, result in suboptimal sealing and obvious scar formation. Herein, we introduced a wet-adhesive triboelectric nanogenerator, an innovative solution designed for immediate, sutureless wound closure and accelerated healing through electrical stimulation. This device features a distinctive dual-layer construction, incorporating a foundational mix of polyacrylic acid and vinyl alcohol (PAV) that that quickly forms covalent bonds with moist tissues, ensuring robust and rapid adhesion. The TENG part is composed of dielectric and conductive layers which can generate contact-separate movements for a continuous electric field when driven by ultrasound. This electric field by TENG, reaching up to 0.86 kV m-1, has demonstrated efficacy in wound healing by facilitating cell migration and proliferation, as evidenced in both in vitro and in vivo experiments. Compared with existing commercial adhesives, this device is able to form adhesive on the wet tissue surfaces within approximately 5 s, and present exceptional interfacial toughness (~150 J m-2), thus achieving instant and sutureless wound closure and hemostasis. Additionally, the material's biocompatibility and biodegradability ensure its safety for clinical use and permit its gradual decomposition, eliminating the need for surgical removal after recovery when applied inside the body. This investigation significantly advances the creation of portable bioelectronic tools for customized healthcare, offering substantial benefits in emergency care contexts.

Keywords : Ultrasound-driven, Triboelectric nanogenerator, Wet-adhesive, Emergency wound managemen

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Abstract No. : **PO-S10-0477**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Ultrasound-Triggered Transient Triboelectric Nanogenerator for Subcutaneous Antibacterial Therapy

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Microbial activity at surgical sites can precipitate infections (SSI) post-surgery, exacerbating physical discomfort and imposing financial strains on patients. SSIs manifest across various surgical incisions, including organs, muscles, and skin, potentially leading to localized discomfort, abscesses, organ malfunction, further surgical interventions, or even mortality in severe cases. Electrical stimulation (ES) represents a non-pharmacological alternative for suppressing microbial growth. However, existing methods typically focus on delivering electrical energy superficially near the suture, inadequately addressing deeper tissue infections.

Here, we introduce a novel method employing an ultrasound (US)-driven, implantable, biodegradable triboelectric nanogenerator (IV-TENG) that delivers electric stimulation effectively *in vitro*. This IV-TENG, generating approximately 4 V and 22 µA of current underwater at a 3 mm distance from a 20 kHz, 2 W cm^2 US probe, demonstrated the elimination of up to 100% of *Staphylococcus aureus* and 99% of *Escherichia coli*. *Ex vivo* assessments also confirmed its efficacy in controlling bacteria beneath porcine tissue. Comprised of biodegradable materials, the IV-TENG naturally degrades post-use, eliminating the need for surgical extraction. The transient nature of the IV-TENG, enhanced by high ultrasonic intensity, supports its non-surgical removal, offering a potent solution to reduce both the physical and economic impacts of SSIs for surgical patients.

[1] Imani, I. M., B. Kim, and X. Xiao. "Ultrasound-Driven On-Demand Transient Triboelectric Nanogenerator for Subcutaneous Antibacterial Activity. Advanced Science, 10, e2204801." (2023).

Keywords : electrical stimulation, triboelectric nanogenerator, ultrasound, implantable, antibacterial

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Abstract No. : **PO-S09-0476**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Characterization of Al-doped ZnO Thin Films with Various Substrate Temperature

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Transparent conducting oxides (TCO) are widely used materials in various optoelectronic fields such as displays, sensors, automobiles, and solar cells because of their low sheet resistance and high transmittance in the visible light region. Among them, indium tin oxide (ITO) is the most suitable TCO material due to its high transmittance, high conductivity, low light absorption, low refractive index, and high stability. However, due to the low surface energy, chemical instability, and high price and scarcity of In, the development of transparent electrodes to replace ITO is in progress. Transparent electrodes doped with various elements in ZnO and SnO_2-based metal oxides are relatively cheaper than ITO and have large reserves, making them a viable alternative material. Especially, Al-doped ZnO (AZO) shows the potential to replace ITO due to its excellent optical and electrical properties. AZO can be grown using various deposition techniques such as magnetron sputtering, chemical vapor deposition (CVD), sol-gel, and electrodeposition. In this study, AZO thin films were prepared on soda-lime glass (SLG) using RF magnetron sputtering. The films were deposited at a range of temperatures from room temperature (RT) to 450 ℃ using an RF power of 70 W. In particular, The thin film deposited at 450 ℃ shows the lowest sheet resistance of 22.59 Ω/sq. Crystallographic and morphological properties were analyzed using X-ray diffraction (XRD), Atomic force microscopy (AFM), and scanning electron microscopy (SEM). Optical and electrical properties were confirmed through UV-Vis spectroscopy and Hall measurements.

Keywords : TCO, ITO, AZO, substrate temperature

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Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Oral**

Crystal orientation-dependent oxygen evolution activity in IrO_2 film

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Rutile iridium oxide, IrO_2, is well known for oxygen evolution reaction (OER) catalysts. OER activity on the surface of IrO_2 varies depending on the crystallographic orientation due to its structural anisotropy. Previous studies did not directly observe the surface structure, but only described the correlation between the surface structure and OER activity through DFT calculation [1]. Here, we demonstrate crystal orientation-dependent oxygen evolution activity in rutile IrO_2 thin film. Using high resolution electron microscopy, we directly visualize the surface atomic structure of IrO_2 thin films on (001), (110), and (101) orientations. eABF-STEM image makes it possible to observe oxygen on the IrO_2 surface by maximizing the light element signal. Based on the observed structure, we establish a correlation between the surface structure and oxygen evolution activity through electron density calculation. This work highlights the importance of understanding the surface atomic structure of OER catalyst and demonstrates that atomic-level imaging is powerful tool to visualize it. Understanding correlation of surface atomic structure and oxygen evolution activity could improve enhancing catalytic activity.

Keywords : Rutile iridium oxide, oxygen evolution reaction, surface structure, atomic-scale imaging

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Abstract No. : **PO-S12-0474**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Sub-second and in-situ formation of metal alloy nanoparticles in reduced graphene oxide matrix by microwave induction heating

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We have studied in situ nanoparticle formation of metal alloy in reduced graphene oxide (rGO) matrix for hydrogen storage in a short time by microwave induction heating (MIH). Metal alloy nanoparticles can store a larger amount of hydrogen than microparticles due to their larger surface area, however a low cost and mass production process of the nanoparticles are required. MIH is a novel method of non-contact and volumetric heating conductive nanomaterials by generating resistive heat through magnetically induced currents in giga-hertz microwave band. Pristine metal alloy microparticles mixed with the rGO powder were vaporized with temperature of over 2000°C in sub-second by the MIH method, and in subsequent cooldown, the metal alloy immediately re-nucleate and form nanoparticles on the rGO matrix. Well-dispersed metal alloy nanoparticles in rGO matrix have been obtained via optimization of applied microwave power level control (200W~1000W) and duration of the microwave short pulse (100ms~1000ms). Phase separation of the metal alloys was observed in conditions of relatively low temperature heating with low-power microwave and longer duration of the microwave power pulse.

Keywords : Hydrogen storage, Metal alloy nanoparticles, Microwave induction heating, sub-sencond

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Abstract No. : **PO-S08-0473**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Domain Orientated Nanoparticle Exsolution in Defect Engineered Stannate Perovskite

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[1] *POSTECH*

The exsolution, a new catalyst design method that has recently attracted attention, is to make metal nanoparticles through a single reduction heat treatment without any special process [1- 3]. This phenomenon is the specific metal component is seperated from oxide support (mainly perovskite-structured oxides such as ABO3) to the surface of the support. The exsolution from the 'defect-free' perovskites has the limited number of the exsolved nanoparticles on the oxide surface [4]. Recently, the exsolutions from the 'defect-structured' perovskites have received growing attention as an effective route for formation the nanoparticles [4-6]. It is well known the density of catalyst nanoparticles is high in non-stoichiometric perovskites, leading to both A-site and oxygen deficiencies that make easier ion diffusion using the reduction by hydrogen [4-6]. Herein, we propose the exsolution using the domain boundary in stannate perovskites (e.g., ASnO3). Unlike titanate perovskties (ATiO3), which has been mainly studied, stannate perovskite structure generally has a wide band gap and is a material that is manufactured as a transparent electrode due to low electron-phonon scattering [7]. It is reported that, using these advantages, we demonstrate an unprecedentedly bimetallic exsolution in SrSnO3 thin films, with domain structures. Our design of the bimetallic exsolution using the planar defects in thin film proposes the effective approach to tailor catalytic particle density in nanostructure engineering.

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Keywords : domain boundary, metal exsolution, bimetallic nanoparticles, stannate perovskite

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Abstract No. : **OR-S11-0472**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

A Programmable and Minimally Invasive Conformal Triboelectric Nanogenerator

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Implantable medical electronics (IMEs) enhance the effectiveness of diagnosis, treatment, and rehabilitation processes. However, conventional IMEs often rely on non-biodegradable batteries and require invasive procedures for implantation. Prolonged utilization of batteries may cause degradation and corrosion, potentially leading to multiple surgical interventions for device maintenance and replacement. Furthermore, extensive surgical procedures and substantial implant sizes can provoke complications and injuries, thereby complicating the clinical outcomes. Consequently, there exists a demand for IMEs that are biocompatible, biodegradable, highly reliable, and miniaturized.

Here, we introduce a bioresorbable, injectable, ultrasound-mediated triboelectric nanogenerator (TENG) designed for in vivo electrical stimulation. This TENG comprises a molybdenum electrode and a friction layer constructed from bio-based polymers that are fully degradable. Its compact design facilitates targeted insertion via a piercing needle, thus reducing risks associated with long-term implantation and minimizing tissue damage. The device operates on capacitive triboelectric principles, driven non-invasively by ultrasound, and our research has demonstrated the capacity to modulate the efficiency of the TENG through adjustments in ultrasonic intensity. The TENG produces a consistent alternating electric field that conforms to varying organ surface curvatures, ensuring safe and continuous electrical output under diverse conditions. Cellular experiments have verified that the TENG effectively promotes cell migration and proliferation, thereby indicating its potential to expedite the healing of wounds. Our results validate the potential of the TENG as a transformative energy source for IMEs, aimed at reducing the risks of infection and chronic inflammation.

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Keywords : electrical stimulation, triboelectric nanogenerator, implantable, ultrasound

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Abstract No. : **PO-S11-0471**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Biodegradable Triboelectric Nanogenerators Using a High-Performance ϰ-Carrageenan-Agar Composite Derived from Nature

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In recent studies, researchers have explored biodegradable triboelectric nanogenerators (TENGs) for powering transient biodegradable electronics. Key to this research is the development of materials that are not only biodegradable but also highly tribopositive and biocompatible. Our research focuses on a composite made from ϰ-carrageenan and agar (ϰC-Agar) which has shown excellent performance as a triboelectric material. We discovered that this composite significantly improves electron-donating capabilities, with a peak increase in surface potential of 57.5% at an optimal ϰC concentration of 80 wt%. This improvement is attributed to the composite's higher density of charge trapping sites, enriched with Ca^{2+} cations and sulfate ester groups. Additionally, the ϰC-Agar composite is inherently biocompatible, evidenced by high cell viability in MTT assays and minimal inflammation from subdermal implants, likely due to its high hydrophilicity. We also developed a fully biodegradable TENG using this optimized ϰC-Agar composite, which is both ultra-thin (0.3 mm) and flexible, producing a high root-mean-square (RMS) current of 0.45 $mA\cdot m^{-2}$ and power output of 0.15 $mW\cdot m^{-2}$ at the optimal impedance. This work lays a foundational step towards developing high-performance, biodegradable TENGs suitable for self-powered, transient electronic applications.

Keywords : Triboelectric nanogenerator, Biodegradable composite, Polysaccharides, Transient electronics, Charge trapping,Biomechanical energy

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Abstract No. : **PO-S11-0470**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Biodegradable Triboelectric Nanogenerators Using a High-Performance ϰ-Carrageenan-Agar Composite Derived from Nature

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In recent studies, researchers have explored biodegradable triboelectric nanogenerators (TENGs) for powering transient biodegradable electronics. Key to this research is the development of materials that are not only biodegradable but also highly tribopositive and biocompatible. Our research focuses on a composite made from ϰ-carrageenan and agar (ϰC-Agar) which has shown excellent performance as a triboelectric material. We discovered that this composite significantly improves electron-donating capabilities, with a peak increase in surface potential of 57.5% at an optimal ϰC concentration of 80 wt%. This improvement is attributed to the composite's higher density of charge trapping sites, enriched with Ca^{2+} cations and sulfate ester groups. Additionally, the ϰC-Agar composite is inherently biocompatible, evidenced by high cell viability in MTT assays and minimal inflammation from subdermal implants, likely due to its high hydrophilicity. We also developed a fully biodegradable TENG using this optimized ϰC-Agar composite, which is both ultra-thin (0.3 mm) and flexible, producing a high root-mean-square (RMS) current of $0.45\ mA \cdot m^{-2}$ and power output of $0.15\ mW \cdot m^{-2}$ at the optimal impedance. This work lays a foundational step towards developing high-performance, biodegradable TENGs suitable for self-powered, transient electronic applications.

Keywords : Triboelectric nanogenerator, Biodegradable composite, Polysaccharides, Transient electronics, Charge trapping,Biomechanical energy

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Abstract No. : **PO-S09-0469**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Effect of Process Temperature on The Properties of Indium Zinc Oxide Transparent Electrode

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Transparent conducting oxide (TCO), characterized by its ability to transmit light with minimal absorption, is highly sought after as an electrode material in optoelectronic devices that demand both transparency and electrical conductivity comparable to that of metals. Metal oxides of In_2O_3, SnO_2, and ZnO are widely used with various dopants, among which indium tin oxide (ITO) is primarily employed in various fields such as displays and solar cells. ITO has excellent physicochemical properties such as high transmittance, electrical conductivity, mobility, band gap, and low resistance. However, achieving the high electrical and optical properties of ITO necessitates relatively high deposition temperatures, which can compromise the base material's performance. Additionally, in the infrared spectrum, the transmittance performance significantly decreases due to free carrier absorption. Therefore, research is ongoing into materials that exhibit low resistance at low temperatures and high stability at elevated temperatures. Indium zinc oxide (IZO), a material comprising 10 wt% ZnO added to In_2O_3, can be deposited at low power and low temperatures without the addition of oxygen, and it contributes to enhanced transmittance through low absorption in the long-wavelength region. In this study, IZO was deposited on soda lime glass at various temperatures using RF magnetron sputtering. The thicknesses were kept 300 nm using an RF power of 20 W. In particular, The thin film deposited at 250 ℃ showed the lowest sheet resistance of 12.97 Ω/sq. On the contrary, the thin film deposited at 450 ℃ showed the highest sheet resistance of 24.73 Ω/sq. The various analysis of the thin films were conducted by SEM, XRD, AFM, and Hall measurements.

Keywords : TCO, ITO, IZO, RF magnetron sputtering

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Abstract No. : **PO-S11-0468**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Enhanced Microbial Inactivation through Tunneling Charges injected in Two-Dimensional Electronics

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Airborne pathogens exhibit extended infectious activity when adhered to indoor surfaces, presenting a significant risk to public health. Traditional air filtration systems lack the capability to inactivate these physically-separated microorganisms effectively, while chemical-based antimicrobial agents often suffer from limitations such as diminished stability, suboptimal efficiency, and inadequate viral neutralization. Herein, we have developed a novel microbial inactivation method utilizing a large-scale disinfection device driven by tunneling-charge mechanisms, which incorporates a monolayer of graphene distributed over insulating substrates. This configuration allows for the stable retention of free charges beneath the graphene layer via tunneling effects. The sequestered charges facilitate sustained electron depletion from adherent microorganisms, thereby expediting the disinfection process and circumventing the diffusion constraints associated with chemical disinfectants. We demonstrate that this approach achieves comprehensive (>99.99%) and broad-spectrum microbial inactivation within one minute of exposure to the device, which measures 25 cm^2. Furthermore, this disinfection efficacy is maintained reliably over a period of 72 hours under conditions of elevated temperature (60°C) and high humidity (90%). The described method holds significant potential for application to frequently contacted surfaces within indoor settings, enhancing pathogen control.

Keywords : Graphene, tunneling charge injection, bacterial and viral disinfection, indoor sanitation, electron transfer-based antimicrobial effect

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Abstract No. : **PO-S14-0467**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

A Study on Stable Vanadium Oxide Protective Layer and Defect Inactivation in Bismuth Vanadate Photoelectrode via Photoelectrochemical Transition-Metal Control

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Photoelectrochemical (PEC) cells for water splitting have garnered significant interest as a promising technology for green hydrogen energy production. Bismuth vanadate ($BiVO_4$), serving as the photoanode among semiconductors, offers various advantages including optical, physical, and band structure properties. However, the PEC performance and long-term stability of $BiVO_4$ photoanodes are hindered by surface defects and photo-corrosion.

To address these challenges, we propose a novel protective layer that mitigates these issues. Recognizing the role of V^{5+} ion dissolution in photo-corrosion, we suggest a surface oxidation approach aimed at transforming photo-corrosion into advanced photo-oxidation. This involves strategically introducing V^{5+} ions and H_2O_2 into the electrolyte. The induced surface phase transition leads to the formation of an unprecedented vanadium oxide (VO_2) PEC protection layer. This layer, being conductive and ultra-thin, exhibits atomic controllability.

Charge kinetic analyses of the $BiVO_4/VO_2$ photoanodes revealed enhanced transport of interfacial charges and efficient transfer of photogenerated carriers through the VO_2 protection layer. Notably, the $BiVO_4/VO_2/CoFeO_x$ photoanodes demonstrated a high photocurrent density of 6.2 mA/cm^2 and an onset potential of 0.25 $V_{RHE.}$ They also exhibited long-term stability over 100 hours, enabling sustained active oxygen evolution.

Keywords : Transition metal control, Sol-gel process, Bismuth vanadate, Ultra-thin film, Photoelectrochemical-oxidation

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Abstract No. : **OR-S06-0466**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Investigation of Microstructure and Electrochemical Properties of Al-Mg-Si alloys via Heat Treatments/Cu Addition

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As necessity to reduce greenhouse gas emissions and the corresponding stringent fuel economy regulations increase, there has been a continuous growth in demand for lightweight materials. The 6xxx series Al alloys, a vital lightweight material, have been widely used in the transportation industry due to high strength-to-weight ratio, good workability, and corrosion resistance in comparison to steel. Both additions of other alloy elements and changes in heat treatment conditions have been significantly tried to improve the mechanical properties of 6xxx series Al alloy. In this study, the effects of Cu additions and aging conditions on the microstructure and electrochemical behavior of the Al alloys are assessed. The result shows that an increase in corrosion rates of the Al alloys with aging time, while the Al alloys with Cu element exhibit a decrease in corrosion rates with aging time. The morphology of corroded cross-sections is observed by optical microscopy. Overall precipitation behavior is studied by employing differential scanning calorimetry. Transmission electron microscopy and small-angle neutron scattering are used to characterize precipitate types and distribution within the microstructure. From these studies, we demonstrate the precipitation effects on the electrochemical behavior in Al-Mg-Si and Al-Mg-Si-Cu alloys.

Keywords : Al alloys, Cu addition, artificial aging, electrochemical behavior, precipitation behavior

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Abstract No. : **PO-S11-0465**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Cell activity manipulation system based on piezoelectric diphenylalanine peptide nanotube-based nanocomposite

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Here we propose a material design for nanocomposites of self-assembled diphenylalanine (FF) nanotubes with bioresorbable polymer matrices to achieve a flexible and mechanically durable bio-piezoelectric nanogenerator (bio-PENG). The piezoelectric property of the nanocomposite membranes demonstrates a normal-like distribution in accordance with Young's modulus of the polymer matrices. Attributed to the high conformability between polyvinyl alcohol (PLA) and FF nanotubes, the PLA-based nanocomposite bio-PENG exhibits high electrical output performance, reaching an output voltage of 2.8 V and power density of 2.6 μW cm^{-2}. Moreover, the bio-PENG shows stable energy-generating performance for over 1000 operating cycles. Benefiting from the high piezoelectric property, the nanocomposite can manipulate cell activities including alignment and proliferation. The results of the simulation using the finite element method (FEM) confirm that the nanocomposite can generate piezoelectricity through mechanical strain caused by free migration of cells. *In vitro* demonstration shows that cell migration-induced piezoelectricity allows for the manipulation of cell alignment and proliferation. Thus, our material design of FF nanotube-based nanocomposites presents a promising option for bioresorbable energy harvesters that will be widely available in biomedical applications.

Keywords : Energy harvesting, Piezoelectric, Biomaterial, Diphenylalanine peptide, Cell activity

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Abstract No. : **OR-S11-0464**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

Bioresorbable materials for self-powered, on-demand neurostimulation system

Dong-Min Lee[1], Sang-Woo Kim[*1]

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Bioresorbable electroceuticals exploit electrical impulses to cure neuropathy with their clinical benefits of eliminating the need for surgical extraction. However, their clinical practice heavily relies on the predetermined device lifetime, limiting the adaptation of clinical plans to address the unique needs of patients. We propose an ultrasound-mediated on-demand bioresorbable triboelectric implant that allows for peripheral nerve electrotherapy. The ultrasound-mediated transient mechanism enables: i) electrical stimulation through transcutaneous ultrasound-driven triboelectricity, and ii) rapid device elimination using high-intensity ultrasound without adverse health consequences. In addition, our triboelectric implant provides a therapeutic option for both acquired peripheral nerve injury and hereditary peripheral neuropathy, as demonstrated through nerve conduction and histopathological studies. We expect that our study leads to a paradigm shift in electroceuticals to treat peripheral neuropathy.

Keywords : Energy harvesting, Triboelectric, Bioresorbable materials, Neurostimulator, Ultrasound-driven

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Abstract No. : **PO-S01-0463**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Titanium-based Metal-Organic Framework Derived Biphasic TiO_2 Embedded Carbon Nanocomposites for High Efficiency Lithium-Ion Batteries

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Lithium-ion batteries (LIBs) are widely used for storing energy due to their affordability, rechargeability, long cycle life, and high energy density. However, graphite, commonly used as an anode material, has limitations such as low theoretical capacity and safety concerns. TiO_2 is considered a promising alternative due to its abundance, cost-effectiveness, high discharge voltage plateau, and minimal volume change. But, its practical capacity is lower than theoretical values, despite improvements with nanostructured forms like bronze TiO_2, which has a high theoretical capacity. Recent strategies involve creating dual-phase nanostructures to enhance both capacity and rate capability.

Metal–Organic Frameworks (MOFs), comprising metal elements and organic linkers, offer potential in catalysts, electrodes, and energy storage devices due to their porous structure and catalytic sites. Ti-based MOFs can be converted into porous carbon materials containing TiO_2 nanoparticles. This study introduces the use of Ti-based MOFs to create a bronze-rich dual-phase TiO_2 embedded in carbon structure via a two-step pyrolysis process. In the first step, metal clusters decompose to form intermediate phases, facilitating the synthesis of bronze TiO_2 crystals. In the second step, the resulting dual-phase TiO_2 is integrated into a conductive amorphous carbon matrix.

This approach demonstrates a significant specific capacity of 638 and 194 mAh/g at current densities of 0.1 and 5A/g, respectively, attributed to interfacial storage. Moreover, the proposed bronze-rich dual-phase TiO_2 embedded in carbon structure derived from Ti-MOFs exhibits reversible stability under high-rate density conditions over 6000 cycles.

Keywords : TiO2, Metal-Organic Frameworks, Anode, Lithium-Ion Batteries

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Abstract No. : **PO-S09-0462**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Selective Deposition of Cobalt Using Atomic Layer Deposition for Next-generation Packaging Technology

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As semiconductor devices are scaled down, miniaturization and high integration of transistors have been achieved. However, economical and physical limitations are encountered as the channel length of semiconductor devices approaches 10 nm or less. Consequently, the interest in 3D packaging technology has great demand. Among various 3D packaging technologies, the research on Cu-SiO_2 hybrid bonding has being actively conducted. However, issues such as high-temperature process conditions and copper oxide control pose challenges for the electrical and mechanical reliability of the devices.

In this study, we have investigated selective deposition of metal films on Cu-SiO_2 composite substrates to prevent copper surface oxidation and reduced the temperature and pressure of process. At this time, a metal film must be deposited as a very thin layer for copper diffusion. Therefore, we utilized Atomic Layer Deposition (ALD), which allows precise control of film thickness at the atomic level. Selective deposition was achieved by adjusting the nucleation delay time during the ALD process. To effectively control the nucleation delay time, we applied a Self-Assembled Monolayer (SAM) as a growth inhibitor on the SiO_2 surface.

We established the process conditions for depositing a Co film using a $Co(EtCp)_2$ precursor and utilizing plasma-enhanced atomic layer deposition (PEALD), which allows for precise atomic level thickness control. In addition, we attempted to use a growth inhibitor by growing a self-assembled monolayer (SAM) material, octadecyltrichlorosilane (ODTS), on a SiO_2 substrate to selectively suppress the growth of Co film. We compared the growth behavior of the Co film under various PEALD process conditions and examined their selectivity based on the ODTS growth time.

Keywords : atomic layer deposition (ALD), self-assembled monolayer (SAM), selective deposition, Co(EtCp)2, octadecyltrichlorosilane (ODTS)

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Abstract No. : **PO-S13-0461**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Grain Boundary Passivation for Wide Bandgap Sub-cell of Perovskite Tandem Solar cells using Inorganic Potassium Lead Halide

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Wide bandgap (WBG) perovskite solar cells (PSCs) are a crucial component in advancing perovskite-based tandem solar cells for absorbing high-energy photons. However, increasing Br to I ratio in WBG perovskites decreases the formation energy, leading to rapid crystallization and small grain size. Consequently, the numerous grain boundaries are formed with charged defects such as vacancies, interstitials, and undercoordinated ions, leading to large open circuit voltage (V_{OC}) deficits and severe halide segregation under continuous light illumination. Therefore, passivating grain boundary defects is essential for achieving high V_{OC} and enhanced stability. Here, we introduce an effective strategy to passivate the grain boundaries with an inorganic protective layer as well as to reduce the density of grain boundaries on perovskite film, by incorporating potassium thiocyanate (KSCN) into I-Br mixed halide WBG perovskites. The incorporation of KSCN into the mixed halide forms band-shaped barriers on the film along the grain boundaries. Meanwhile, the KSCN enlarges the grains of the mixed halide film, which is attributed to the effect of SCN ions, as is well-known. The incorporation of potassium thiocyanate dramatically increases the fill factor and V_{OC} of WBG (1.82 eV) single junction PSCs owing to reduced trap density, achieving a high power conversion efficiency of 18.02%. Furthermore, both operational and shelf stability are improved with retarded light-induced halide segregation. Using the passivated WBG sub-cells, monolithic all-perovskite tandem solar cells are demonstrated.

Keywords : Perovskite, Solar cell, Grain boundary, Passivation, Tandem

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Abstract No. : **OR-S09-0460**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Oral**

Absence of Critical Thickness and Polarization Enhancement of Ferroelectric Thinfilm by Surface Adsorptions

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The spontaneous polarization that can be reversed by applying an electric field is the key feature of ferroelectric materials. Advancements in epitaxial growth techniques have also benefited the fabrication of ferroelectric thin films at ultra-low thicknesses. However, the instability of polarization in perovskite-based ferroelectric thin films due to the intrinsic size effect such as, critical thickness, becomes important when the thickness is reduced to a few nanometers. For example, prototypical ferroelectric material $BaTiO_3$ (BTO) thinfilm, the polarization reduces significantly below 30 nm scale, and critical thickness, below which the polarization disappear, is around 6 unit cells (24 Å). Therefore, overcoming these size-dependent limitations is crucial for the successful integration of ferroelectric thin films into next-generation semiconductor or energy-harvesting devices.

Here, we apply surface adsorption techniques to stabilize the ferroelectric ground state at ultra-low thicknesses. Using first-principles density functional theory, we found that BTO thin films can persist ferroelectric polarization up to a single unit cell thickness through the surface adsorption of O_2. The charge transfer from the BTO surface to the O_2 adsorbate compensate the polarization charge at the surface. The surface-adsorbate interaction activates long-range ferroelectric order and exhibit a large enhancement of polarization in BTO thin films. This suggests that the absence of a critical thickness could be achieved in perovskite-based ferroelectric thin films through surface adsorption. This study offers a novel approach to boost polarization in ultra-thin ferroelectric films, with potential applications in ferroelectric devices.

Keywords : Ferroelectric thinfilm, Critical Thickness, Polarization Enhancement

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Abstract No. : **OR-S01-0459**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Oral**

Unveiling the Latent Chemical Space of Oxygen Defect Formation Energies in Metal Oxides Using Ensemble Machine Learning

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Oxygen vacancies (V_os) in cathode materials offer a critical trade-off, enhancing battery performance through improved lithium-ion diffusion and capacity. However, excessive V_os can lead to structural degradation and reduced longevity. Our research explores the broader realm of metal oxides, delving into the intrinsic properties crucial for the efficiency and capacity of energy storage technologies, specifically the formation energy of oxygen vacancies (V_o) in cathode materials made from metal oxides. Traditional methods for determining V_o formation energy, often labor-intensive and limited in scope, have hindered the comprehensive exploration of the vast chemical space of metal oxides. Our research employs a machine learning ensemble model to rapidly and accurately predict V_o formation energy across a diverse range of metal oxide cathode materials. This approach not only correlates closely with density functional theory calculations but also reveals a significant portion of the unexplored chemical space. Notably, it suggests that cathode materials rich in lanthanide metals exhibit higher V_o formation energies, indicating promising directions for material innovation. This methodology speeds up the discovery of novel cathode materials for energy storage, providing new insights through a data-driven statistical perspective and pushing the boundaries of energy technology.

Keywords : Oxygen vacancy, Density functional theory, Energy, Metal oxides

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Abstract No. : **PO-S13-0458**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Base Doping Process to Improve Hole Transport Layer Characteristics of Lead-Tin Based Perovskite Solar Cells

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Poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) is a composite of the conductive polymer Poly(3,4-ethylenedioxythiophene) (PEDOT) and the acidic doping polymer poly(styrenesulfonate) (PSS). It is widely used as the hole transport layer in photovoltaic devices due to its low-temperature solution processability and high visible light transparency. Additionally, because it possesses a similar work function to that of narrow bandgap perovskites, it is employed as the hole transport material in lead-tin based perovskite solar cells. However, the strong acidity of PSS promotes the oxidation of tin ions (II), and degradation of narrow bandgap perovskite which lowers the efficiency and stability of solar cells. In this study, a new doping process was developed by introducing 'A-site alkaline' materials to address this issue. 'A-site alkaline' doping reduces the acidity of the hole transport layer surface, enhancing the thermal stability of the devices, while minimizing interfacial defects to improve the efficiency of solar cells.

Keywords : Perovskite, Solar cells, Narrow bandgap

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Abstract No. : **OR-S07-0457**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

The Role of Au/MO_x Interface in CO Oxidation : A DFT Study of Reaction Mechanism and Catalytic Activity.

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Elucidating the catalytic reaction mechanism and understanding the reactive species under the reaction conditions are the first step for catalysts study. Historically, the size-dependent activity and interfacial effect between the metal and support is tremendously reported. Following these studies, the reaction center is interface of metal NPs and oxide support. Oxide supported Au-based heterogeneous catalysts have received great attention due to their effectiveness in CO oxidation at low temperatures. The activation of O_2 on Au nanocatalyst remains challenging because only small Au nanoparticles can activate O_2. Here we used density functional theory(DFT) calculations to study the mechanism of CO oxidation catalyzed CeO_2, TiO_2, Al_2O_3-supported Au nanoparticle under reaction conditions. We found that the diverse reaction mechanism exhibited for kinds of oxide supports. The CeO_2-supported Au_9 NPs catalyze CO through the MvK mechanism without additional activation of O_2 regardless of facet of CeO_2 (111) and (100), respectively. In contrast, the activation of O_2 occur on TiO_2 and Al_2O_3. In case of Au NPs on TiO_2, the reaction mechanism of CO oxidation is followed by utilizing pre-activated O_2 as well as the lattice oxygen of TiO_2. the Al_2O_3, regarded as inert oxide, the lattice oxygen cannot participate in oxidation, but the pre-activated O_2 on Lewis acid site (Al^{3+}) can catalyze CO. Our study delivers comprehensive understating about the detail of interfacial effect as following the oxide supports, enabling rational design of heterogeneous catalysts.

Keywords : Density Functional Theory, CO oxidation, Catalysts

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Abstract No. : **PO-S07-0456**
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Abstract Preference : **Poster**

A DFT study of CO_2 Hydrogenation over Pd-based Catalysts: The Role of C-O Bond Activation

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CO_2 is a greenhouse gas that is found abundantly in the earth’s atmosphere due to emissions from industrial emissions and the combustion of fossil fuels to generate energy sources. Hence, carbon capture and storage (CCS) has attracted attention as a method for reducing CO_2 in the atmosphere and is used to bury underground or deep in the oceans. However, buried CO_2 brings about serious pollution to the soil and marine environment after a long period of time. Therefore, hydrogenation of carbon dioxide is a promising reaction that is widely researched due to its ability to effectively reduce CO_2 by converting clean fuels and hydrocarbons such as methane, formic acid, and C_{2+} products. However, the hydrogenation reaction still has a problem of improving product selectivity, and a clear active site has not been revealed. In this study, we used density functional theory (DFT) calculations to unravel the mechanism of CO_2 hydrogenation catalyzed MgO, CaO-supported Pd_{22} nanoparticle under the reaction conditions as thermal catalysts. We found that the H_2 and CO_2 showed activation behavior at different positions of metal NP and the interface between oxide support and metal NP, respectively. Interestingly the final products are different between oxide supports. We confirm that such productions appear because the activation of the *C-O bond varies according to the binding energy of CO_2 on oxide supports. Our results provide a new insight into the hydrogenation reaction of CO_2, clarifying the pivotal role played by the activation of *C-O bonding.

Keywords : CO2 hydrogenation, Density functional theory, Activation of *C-O bonding

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Abstract No. : **PO-S02-0455**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Enhanced Electrical Performance and Stability of Top-Gate ZBTO Thin-Film Transistors with Aluminum Metal Capping

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The oxide semiconductors based thin film transistors (TFTs) have garnered significant attention due to their numerous advantages, including high mobility (>10 cm^2/Vs), transparency, and uniformity over large areas. However, traditional AOSs face limitations such as the use of rare metals, which increases overall process costs, and a trade-off between mobility and stability. To address these challenges, there is a critical need to develop cost-effective semiconductor materials that exhibit excellent electrical properties and stability. Recently, $(Zn_{1-x}Ba_x)SnO_3$ (ZBTO) has emerged as a highly stable oxide semiconductor material with high electron mobility, attributed to its small effective mass and less defective structure. Leveraging these properties, enhancing the carrier concentration of ZBTO could enable cost-effective and high-performance TFTs.

Recently, much research has been explored to achieve high mobility, including modifying metal cation compositions, plasma treatments, and employing metal capping layers. Metal capping layers, in particular, have been shown to enhance TFT performance through mechanisms such as eliminating scattering/trapping centers, promoting low-temperature crystallization, facilitating electron injection, and inducing conductive regions. However, previous studies on metal-capped TFTs have predominantly focused on the bottom-gate structure, with limited exploration of the top-gate (TG) configuration.

In this study, we present a novel approach employing a top-gate (TG) structure for metal-capped ZBTO TFTs. The robust oxidizing capability of aluminum metal (Gibbs free energy of Al_2O_3: -1582.3 kJ/mol) induces a conductive region in the active layer, particularly near the aluminum-ZBTO interface during the aluminum oxidation process. This induction generates free electrons, serving as effective carriers with minimal scattering owing to the low defect density of the ZBTO active layer. As a result, TG-ZBTO TFTs incorporating an aluminum (Al) metal layer exhibit significantly enhanced electrical performance. Furthermore, our results demonstrate good stability under bias and illumination stress, which are crucial for the practical implementation of AMOLED displays.

Keywords : Oxide TFTs, High mobility, Metal capping layer, Top-gate structure

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Abstract No. : **PO-S12-0454**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Effect of the Support Size on Pt Single-Atom Catalysts for CO Oxidation in Pt-CeO_x-TiO_2 System

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Herein, we elucidate the size effect of oxide materials for catalytic reaction over the Pt single-atom catalysts. Our group provided a rational design of single-atom catalysts in previous research. We found high stability and superior activity of Pt single-atom catalysts anchored at the CeO_x-TiO_2(CT) interfaces. Based on the previous study, we deposited CeO_x nanoclusters on a TiO_2 support to form a CeO_x-TiO_2(CT) hybrid support system and Pt to CT using the set impregnation method. The loading amount of Ce was set to 1 to 6wt%, and 0.05wt% of Pt was added to CT support. TEM (Transmission Electron Microscope) and XPS (X-ray Photoelectron Spectroscopy) confirmed the size difference and structure of CeO_2 on TiO_2. We performed CO oxidation reaction to figure out the effect of activity depending on nCeOx nanocluster (n=1~6wt%) size. Our results show that the size of ceria clusters adjacent to a single Pt atom plays a crucial role in low-temperature CO oxidation. A combination study of experiment and DFT (Density Functional Theory) calculation revealed that the catalytic performance significantly degrades as the content of Ce increases. The light-off curve indicates that the temperature reaching 100% conversion was the highest. To understand the behavior of Pt single-atom catalyst, we performed a DFT calculation.

In DFT calculation, we constructed the nCeOx-TiO_2 models, which are CeO_2-, Ce_2O_3-, and $Ce_{14}O_{28}$-TiO_2, CeO_2 (100), respectively. Compared with other CT models, large particles of CeO_x, which corresponds to CeO_2 (100), show a somewhat high oxygen vacancy formation energy, indicating that the CO oxidation reaction is not facilitated on a high-loading Ce sample. Based on the combined results of the experiment and theory, We found the inversely proportional correlation between the size of the CeO_x nanocluster and catalytic activity, which is derived from the reactivity of oxygen in nCeO_x. Thus, we suggest that the reactivity of oxygen in oxide support, which catalyzes CO via the MvK mechanism, is pivotal to estimating the catalytic activity.

Keywords : single atom, CO oxidation, support size

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Abstract No. : **PO-S05-0453**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

High-Performance Multi-Functional Electronics through Scalable Printing of Two-Dimensional Materials

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Two-dimensional (2D) materials hold significant promise for the next generation of electronic devices due to their unique electronic properties. However, their application in scalable electronic systems is often hindered by a trade-off between material quality and the ability to produce these materials at scale. To overcome the limitations, I will introduce a simple printing approach of two subsequent materials, including deposition of solution-processed 2D semiconductor and ion-embedded alumina as channel and gate dielectric, respectively, to implement scalable and high-performance electronics. The synergy between the channel and the gate dielectric through this approach results in devices that exhibit high charge carrier mobilities up to 80.0 cm^2/Vs, enabling band-like transport in the thin-film networks, a critical feature for high-performance electronics. Based on the characteristics, I will introduce its practical applications by integrating various logic gates, including NOT, NOR, NAND, and circuits for static random-access memory. These implementations demonstrate the feasibility of using this approach in future electronic systems. Moreover, the potential of these materials extends into the neuromorphic devices, where we leverage the unique properties of the channel/electrolyte interface. This interface permits controlled ion injection in response to the applied gate bias, facilitating conductance modulation with high linearity and symmetry - key characteristics necessary for the creation of artificial synapses. From the results, future directions and outlook for multi-functional 2D-based electronics will be further discussed.

Keywords : Transition Metal Dichalcogenide, 2-Dimensional material, Ion dielectric, Logic gates, Neuromorphic device

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Abstract No. : **PO-S03-0452**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Copper(I) Iodide Nanoparticles Embedded Highly Stretchable Thermoelectric Fiber Based Wearable Multimodal Sensor

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Thermoelectric(TE) fiber sensors, possessing the potential for multimodal sensing of both mechanical and thermal stimuli, represent a promising avenue in advanced wearable electronics tailored for personalized healthcare systems. However, existing TE fibers based on carbon or organic TE materials exhibit low performance in detecting thermal variations, while rigid inorganic TE materials lack stretchability, limiting their ability to detect mechanical deformations. In this study, we introduce a novel approach to address these limitations by developing the first stretchable TE fiber-type multimodal sensor utilizing Copper (I) iodide (CuI), an inorganic TE material. By embedding dense networks of CuI nanoparticles within the fiber structure, we achieve exceptional stretchability (up to ~835% maximum tensile strain) alongside superior TE performance (with a Seebeck coefficient of approximately ~203.6 μVK^{-1}). Our sensor demonstrates outstanding capabilities in strain sensing (with a gauge factor of ~3.89 within a tensile strain range of ~200%) and pressure sensing (achieving a pressure resolution of ~250 Pa over a pressure range of ~84 kPa). Furthermore, it enables independent and simultaneous sensing of temperature changes, tensile strain, and pressure by monitoring distinct parameters. Integration of this sensor into a smart glove showcases its practical utility in wearable technology applications.

Keywords : copper(I) iodide, inorganic thermoelectric materials, thermoelectric fibers, multimodal sensors, stretchable electronics, wearable electronics

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Abstract No. : **OR-S06-0451**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Hot deformation behavior of Mg-6Gd-3Y-1.5Zn-0.6Zr (wt%) alloy with LPSO phases

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The different treatment before hot deformation were applied to control the morphology of long period stacking ordered phase (LSPO) phase in Mg-6Gd-3Y-1.5Zn-0.6Zr(wt.%) alloy. The blocky 18R-LPSO phases were remained in the alloy after heat treatment of 460 ℃ ×2h (water cooling), and the lamellar 14H-LPSO phase formed in the alloy after heat treatment of 500℃×12h+420℃×3h (water cooling). The hot deformation behaviors of the alloys with blocky and lamellar LPSO phases were investigated, and effects of LSPO phase morphology were discussed. The block LPSO phase promotes dynamic recrystallization (DRX) through particle stimulated nucleation (PSN) mechanism. The promotion of DRX from blocky LPSO phases is efficient. The lamellar LPSO phase mainly promotes the DRX process, and some lamellar LPSO phases promote DRX through the kinking band at the deformation of 400℃/ 0.01s^{-1}. The lamellar LPSO phase hindered lattice rotation and inhibited twin formation. At low temperature and high strain rate, the alloy with lamellar LPSO phases exhibits higher hot deformation capability due to lamellar LPSO phase kink.

Keywords : Mg alloy; LPSO phase; hot deformation behavior; kink; dynamic recrystallization

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Abstract No. : **IN-S05-0450**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

Functionalization and Manipulation of Optoelectronic Properties and Their Applications in CVD-Grown 2D Semiconductors

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Two-dimensional (2D) van der Waals materials are substances with ultra-thin layers that have atomic layer thickness. They include a variety of material groups such as metals, semiconductors, dielectrics, magnetics, ferroelectrics, etc. These can be easily exfoliated from the layered structure of bulk materials or synthesized using chemical vapor deposition (CVD). These ultra-thin 2D characteristics can modulate various quantum phenomena by adjusting thickness, stress, electric field, and interlayer bonding. Therefore, they not only lead to new physical phenomena but also have far-reaching applications in electronics, optoelectronics, spintronics, sensors, and other wide-ranging areas. As an alternative to exfoliation, the CVD method enables large-area synthesis, but controlling defects during growth remains a critical challenge. In this work, the author explores specific optoelectronic and surface properties manipulated by defects, interfaces, doping, and plasmonic hybridizations in CVD-grown 2D semiconductors. Furthermore, the author discusses the application of these characteristics in optical communications and electronic devices.

Keywords : chemical vapor deposition, two-dimensional, MoS2, defect

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Abstract No. : **IN-S06-0449**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Effect of heat treatment on the microstructure evolution and properties of rare earth magnesium alloys cast with electromagnetic stirring

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The Mg-6Gd-3Y-xZn-0.6Zr (X=1, 1.5, 2, 3) alloy, melted using electromagnetic stirring (EMS) solidification, was subjected to solid solution treatment and aging. This process was followed by an analysis focusing on the microstructural evolution and property changes. The chosen solid solution treatment involved water quenching the alloy after maintaining it at 520°C for 8 hours. After the solid solution treatment, the second phases dissolved back, making an increase in plasticity. After the aging treatment, the age-hardening curve flattens out with increasing Zn content. The more residual LPSO phases, the less β' phase precipitated by aging. Solid solution aging significantly enhanced the mechanical characteristics of the alloys compared to their initial as-cast state. The 1.5Zn alloy, aged for 48 hours, exhibited the best performance, achieving strength and elongation values of 213.5 MPa and 9.7%, respectively.

Keywords : Rare earth magnesium alloy; LPSO phase; Heat treatment; Electromagnetic stirring

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Abstract No. : **PO-S13-0448**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Exploring hybrid SnSe/SnS bilayer absorbers for solar cells: A comprehensive analysis of numerical and experimental results

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Binary tin chalcogenides, such as SnS and SnSe, are potential candidates for absorbers in photovoltaic applications owing to their promising optical and electrical properties. In this study, we simulated (using the SCAPS-1D program) and fabricated a thin-film solar cell (TFSC) based on a bilayer absorber. Firstly, we modeled the bilayer absorber device theoretically using SCAPS-1D and analyzed the output results. The maximum performance of the device with a bilayer absorber shows an open circuit voltage (V_{OC}) of 0.828 V, a short-circuit current density (J_{SC}) of 31.71 mA cm^{-2}, a fill factor (FF) of 85.1%, and a power conversion efficiency (PCE) of 22.35%. Conversely, single SnS and SnSe absorber-based devices showed PCEs of 14.79%, and 13.69%, respectively. We used the theoretical model to fabricate bilayer absorber based TFSCs using vapor transport deposition (VTD). The fabricated cells reveal a PCE of 2.87%, 3.32%, and 1.40% with a V_{OC} of 0.310,V 0.312 V, and 0.206 V, a J_{SC} of 18.37 mA cm^{-2}, 25.46 mA cm^{-2}, and 25.88 mA cm^{-2}, and a FF of 50.0%, 42.0%, and 26.0% for SnS, SnSe/SnS, and SnSe absorbers, respectively. Although there was a significant difference between the output performance of the simulated and experimental studies, the simulated and fabricated devices showed a similar trend in all parameters. We have analyzed the results to identify the key parameters responsible for the lower performance in the experimental study.

Keywords : Tin selenide (SnSe), tin selenide (SnS), thin-film solar cells, bilayer, hybrid bilayer absorber, SCAPS 1D.

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Abstract No. : **PO-S05-0447**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Selective area phase-controlled edge contact $MoTe_2$ polymorphic transistors with sub-10nm scaled contact length

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Owing to the ultrathin nature of 2D materials, channel regions are susceptible to damage during metallization, particularly because of chalcogen vacancies, which hinder the formation of *p*-type transistors. In this regard, edge contact represents an optimal configuration, even capable of contact length scaling (L_c). However, scalable fabrication of edge contact field effect transistors (FETs) is challenging because of the requirement of a sophisticated lithographic process and vulnerability of etched edge regions to oxidation. In this study, we demonstrated a one-pot synthesis method to create wafer-scale edge contact $MoTe_2$ FET arrays, assisted by ternary telluride electrodes that enable selective area phase control. W heteroatoms behave as stabilizers to establish a semimetal phase (1T') regardless of growth conditions, allowing pre-patterned transition metal films to be converted to 1T'-W alloyed $MoTe_2$ (W:$MoTe_2$) and semiconducting (2H) $MoTe_2$. Structural characterization showed that W:$MoTe_2$ retains its semimetal structure even at high growth temperatures (~700 °C), and the sheet resistivities of the various compositions of W:$MoTe_2$ were comparable to those of binary electrodes. Transmission electron microscopy (TEM) demonstrated that W:$MoTe_2$ atomically connects with $MoTe_2$, forming a true edge contact. Furthermore, we compared *p*-type $MoTe_2$ FETs with different metal electrodes. Our W:$MoTe_2$ edge contact FET exhibited excellent performance compared to other electrodes. Furthermore, it is exhibited that the lowest contact resistance of 7.5 kΩ·μm at a L_c of 8 nm. The efficient hole transport of the W:$MoTe_2$ edge contacts compared to top contacts was corroborated by the small hole Schottky barrier height of ~59 meV, which was further verified by simulation results. Our one-pot synthesis method eliminates air exposure and misalignment issues during device fabrication, not only enabling the formation of high-quality lateral heterostructures, but minimizing device-to-device variation.

Keywords : TMD, Ternary ditelluride, Selective area phase control, Edge contact transistor

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Abstract No. : **PO-S13-0446**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Research on Improving SnS/CdS Thin Film Solar Cell Performance Through HNO_3 Treatment

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The surface modification of vapor transport deposition (VTD) grown tin monosulfide SnS-absorber layers and their impact on SnS/CdS heterojunction thin-film solar cells (TFSCs) has been investigated. The Orthorhombic SnS having promising properties for a thin film solar cells absorber including optical band gap (~1.35 eV), high absorption coefficient (> 104) also, comprises of relatively earth abundant constituents and non-toxicity. The theoretical efficiency limit of SnS is ~32% but cell efficiency has mostly remained below 4% which is fairly low as compared to theoretical, because of low heterojunction quality with CdS buffer layer as well as due to short circuit loss.

In this study the highest efficiency of 2.75% with V_{oc} o 0.298 V, J_{sc} 19.01 mA-cm^{-2}, and FF 48% was found to observe for VTD-SnS absorber/CdS heterojunction solar cells for a 3 min treatment of SnS absorber surface with 20 mol % of HNO_3 solution. While without treatment of SnS surface the device shows a performance of 2.35% with V_{oc} o 0.308 V, J_{sc} 15.85 mA-cm^{-2}, and FF 48%. These improved characteristics are primarily attributed to the reduction in interface defects of the SnS/CdS heterojunction, which can occur either due to direct CdS deposition on SnS or annealing of SnS/CdS heterojunction at 300 °C or during the deposition of transparent conducting oxide (i-ZnO). The detailed analysis of the device performance has been presented for different concentration and time of HNO_3 treatment.

Keywords : Tin sulfide, Thin film solar cells, Absorber layer, Interface

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Abstract No. : **PO-S14-0445**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Investigating the influence of graphene morphology on photoelectrochemical performance in graphene/$SrTiO_{3-X}$ photoanodes

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Graphene's versatility in catalytic support, protective layer for catalysts, and as a catalytic center itself has been extensively studied, particularly in the realm of photoelectrochemical (PEC) water splitting. While previous studies have primarily focused on synthesizing and characterizing various graphene-based catalysts, the precise role of graphene remains incompletely understood. This study delves into the multifaceted impact of graphene on the PEC water splitting process by tailoring the shape of graphene layers, including edge-rich configurations, and creating heterojunction with $SrTiO_{3-X}$. Single-layer graphene (SLG) enhances charge transport within the depletion region of $SrTiO_{3-X}$, thereby elevating photovoltage, while ad-layer graphene (ALG) facilitates charge transfer at the photoanode surface. As a result, the SLG/ALG/$SrTiO_{3-X}$ structure demonstrates superior photocurrent density under water oxidation conditions, highlighting a remarkable 262 % improvement at 1.23 V_{RHE} compared to bare $SrTiO_{3-X}$. These enhancements in PEC efficiency arise from effective photoinduced charge separation, driven by a unique alignment of band structures, coupled with the catalytic activity of the graphene layer. Additionally, the engineered graphene/$SrTiO_{3-X}$ structures ensure enhanced light absorption within the photoanodes, achieved through optical confinement of incident light via multiple reflections and aurgmented light scattering effects from graphene layers. Understanding these mechanisms is crucial for catalyst development, enabling the optimization of electronic structures for tailored applications.

Keywords : graphene, SrTiO3, photoelectrochemical, catalyst

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Abstract No. : **PO-S13-0444**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

A Study on Encapsulating Performance of Metal Oxide Thin Films by Low-Temperature Atomic Layer Deposition

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In recent years, solar cells based on organic-inorganic mixed perovskite have emerged as a next-generation prospect, and several studies have been conducted to commercialize them. Perovskite solar cells (PSCs) show high photoelectric conversion efficiency of over 24% along with excellent electrical and optical properties, but they are generally vulnerable to heat and moisture; therefore, researchers are trying to improve their stability by using various protecting strategies. Encapsulation by metal oxide layer has been studied to passivate the perovskite material and improve its stability. Atomic layer deposition (ALD) is a widely used method to deposit encapsulation layers in the field of microelectronics due to its fine control over the thickness and the ability to passivate various structures and complex surfaces uniformly. In the ALD process, the deposition of metal oxide thin films is usually carried out using deionized water, ozone, or O_2 plasma as oxidants, and the process is generally carried out in the temperature range of 150 to 300 °C. However, new process conditions must be proposed since such process conditions can cause unintentional oxidation or damage in the PSCs.

Al_2O_3 is one of the widely used materials as an encapsulation layer for electronic devices. However, most deposition process for Al_2O_3 have been carried out at temperatures above 100 °C. Furthermore, in the case of low-temperature plasma process, it may cause damage to the surface. In this study, we propose a low-temperature Al_2O_3 by thermal ALD process, and compared its performance with SnO_2 that is mainly used for ETL. The growth behavior of the metal oxide thin film at a low temperature of 90 °C or less was studied, and the passivation characteristics were confirmed.

Keywords : Perovskite, Encapsulation Layer, Metal Oxide, Low-Temperature Atomic Layer Deposition (ALD)

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Abstract No. : **PO-S02-0443**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Surface passivated high responsivity and fast ultraviolate wide bandgap Li-ZnO/GaN heterojunction photodetector fabrication.

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The adsorbed O2 molecules are major contributor for surface defect state generation. The oxygen vacancy acts as defect states and lower the shottcky barrier height thus tunneling huge dark current and prolonging recovery time. Here, We have deposited highly crystaline and 0002 oriented Li-ZnO thin film on GaN (0002) wafer by utilizing RF sputtering system. The surface adsorbed defects were suppresed via depositing ultrawide bandgap Ga2O3 thin film surface passivation layer. Here, Ga2O3 layer was deposited by varying deposition time as 2.5 min, 5 min, and 7.5 min. to understand effect of thickness. The UV-Vis spectroscopy revealed Li-ZnO bandgap around 3.26 eV. Ga2O3 bandgap was seen decreasing with increasing deposition time from 5 eV to 4.92 eV for 2.5 min. to 7.5 min deposition time. Ga2O3 layer showed average transmittance above 97% in visible region. Ga2O3 surface passivated Li-ZnO device showed fast response time in ms compared to seconds for bare device. The operation mechanism is understood by XPS analysis and illustrated in detail.

Keywords : photodetector, surface passivation, fast, response time

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이중 완충층 소재 변화에 따른 Sb_2S_3 박막 태양전지 성능 향상

Sang Won LEE[1], Pravin S. PAWAR[1], Jaeyeong Heo*[1]

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개요: 황화안티몬(Sb_2S_3) 박막 태양전지(TFSC)에서 전자 수송층(ETL)은 ETL/전극 인터페이스의 인터페이스 결함을 최소화하여 더 나은 전하 캐리어 추출을 제공하는 중요한 매개변수입니다. 그러나 이중 버퍼 층의 사용은 더 나은 캐리어 추출 및 적절한 밴드 정렬의 형성으로 인해 Sb_2S_3 또는 $Sb_2(S/Se)_3$ TFSC에 대한 적절한 이종 접합 및 장치 성능 향상을 달성하기 위한 실용적인 단계입니다. 최근에는 이중 버퍼층의 적용이 Sb_2S_3 TFSC 의 전력 변환 효율(PCE) 향상을 위한 유익한 접근 방식임이 입증되었습니다 [1, 2]. 여기서는 원자층 증착(ALD) SnO_2 및 TiO_2 ETL을 Sb_2S_3 TFSC 용 CdS와 함께 이중 버퍼층으로 적용했습니다 . Sb_2S_3 흡수체는 손쉬운 열수 방법을 사용하여 증착되었습니다. TFSC 장치는 HTL이 없는 FTO/SnO_2/CdS/Sb_2S_3/Au 또는 FTO/TiO_2/CdS/Sb_2S_3/Au 구조를 기반으로 제작되었습니다. SnO_2/CdS 및 TiO_2/CdS 이중 버퍼층 기반 셀에 대해 3.98% 및 4.23%의 가장 높은 PCE가 얻어졌으며 , 기준 CdS 버퍼층과 비교하여 1% PCE를 초과하는 개선이 이루어졌습니다. 또한 SnO_2/CdS(*VOC* = 0.676V) 및 TiO_2/CdS(VOC = 0.696V) 이중 버퍼층에 대해 개방 회로 전압(VOC) 이 ~ *25mV* 및 ~45mV 개선된 것으로 관찰되었습니다 . 기준 CdS 버퍼층(*VOC* = 0.648V)과 비교하여 각각 기반 장치입니다. 향상된 장치 특성은 주로 흡수체 및 ETL 인터페이스에서 향상된 전하 캐리어 수집 및 적절한 밴드 오프셋 형성에 기인합니다.

Keywords : Thin film solar cell, Buffer layer

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Optimization of CBD-CdS Buffer Layer Via Thickness Control in SnS/CdS Thin Film Solar Cells

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The substrate-type thin film solar cell (TFSC) consists of various layers, such as back contact, absorber layer, buffer layer, window layer, and top contact. Therefore, optimization of the process conditions for each layer is essential to produce a TFSC with a high and consistent power conversion efficiency. Especially, the n-type buffer layer forms a direct junction with the p-type absorber layer. The quality of this junction directly affects the characteristics of V_{OC} and short-circuit current (J_{SC}) of TFSCs; thus, it is necessary to establish the process conditions for the buffer layer.

In this work, we investigated the effect of thickness of the CdS buffer layer on the performance of SnS/CdS TFSCs. SnS films were deposited by vapor transport deposition using SnS powder in a horizontal furnace and CdS buffer layer was deposited by chemical bath deposition method. The thickness of the CBD-CdS buffer layer was varied by changing the deposition time from 15 to 25 min, which resulted in a thickness variation within the range of 30–80 nm. Finally, we fabricated the complete devices and compared the performances of the SnS/CdS TFSCs. The maximum PCE of 3.05% with V_{OC} = 0.297 V, J_{SC} = 19.4 mA cm^{-2}, and fill factor (FF) = 52.8% was achieved for ~42 nm thick CdS buffer layer (18 min of CdS deposition time). More details on device properties will be discussed in this presentation.

Keywords : Thin Film Solar Cell, Buffer Layer, Chemical Bath Deposition (CBD), Thickness

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Abstract Preference : **Oral**

Fabrication and Analysis of Electrode from Rapid Alkaline Depolymerization of PET into Na_2TP with High Performance MXene ($Ti_3C_2T_X$) on Nickel Foam Substrate for Hydrogen Evolution Reaction.

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A civilization's technological advancement relies heavily on its ability to effectively utilize its energy resources. Consequently, there is an increasing urgency in the contemporary era to enhance the search for high-performance non-noble metal hydrogen production methods, alongside a critical need to address the mounting issue of polyethylene terephthalate (PET) waste.

In recent times, MXenes, denoted by the naming convention Mn+1XnTx, have garnered significant attention as efficient electrocatalysts for electrochemical reactions. They exhibit promising potential in the hydrogen evolution reaction (HER) due to their structural robustness, expansive surface area, and impressive electrical conductivity. Concurrently, the utilization of small organic molecules has opened significant avenues in the energy sector owing to their environmentally friendly nature, sustainability, and cost-effectiveness, sourced from a variety of outlets. The functionalization of these compounds with MXene material has shown improved performance in HER evolution.

In this study, we propose a novel approach by employing a MXene material, specifically $Ti_3C_2T_X$, deposited on a nickel foam substrate, in conjunction with disodium terephthalate (Na_2TP) derived from the swift microwave alkaline hydrolysis of PET waste. PET depolymerization methodologies have undergone extensive scrutiny, and among them, alkaline hydrolysis stands out for yielding a product amenable to electrochemical applications. As anticipated, the $Ti_3C_2T_X/Na_2$TP composite on nickel foam (NF) demonstrates superior electrocatalytic performance for HER compared to bare nickel foam and $Ti_3C_2T_x$ on nickel foam configurations.

The resultant electrode architecture, characterized by a sandwich-like structure, proves advantageous for fostering an augmented contact interface and enhanced pathways for electron migration during electrolysis. Additionally, it exhibits low overpotential, high stability, and minimal resistance, thus laying a foundation for the advancement of MXene-derived electrocatalysts for HER while expanding their potential applications. In essence, this study underscores a dual-purpose approach: repurposing waste PET through alkaline hydrolysis into a valuable precursor and integrating it with MXene on nickel foam for hydrogen energy generation.

Keywords : Electrocatalyst, Electrode, Hydrogen Evolution Reaction, PET Alkaline hydrolysis, MXene

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Abstract No. : **PO-S14-0438**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Passivation of Planar Silica Photocathode by Nitride Materials for Photoelectrochemical Water Reduction

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Burning of fossil flues and emission of greenhouse gases caused global warming, widespread rapid changes in atmosphere that impacts losses and damages on nature and people. That triggered the need of clean renewable and sustainable energy sources. H_2 is a carbon-free source with a high energy storage density, and its generation through photoelectrochemical (PEC) water splitting using solar harvesting is the most attractive strategy to address these environmental, energy demand, and supply issues.[1,2] Recently, Transition metal Nitride (TMNs) has an enormous interest in various applications due to its unique physical properties such as: high conductivity, corrosion resistance and extreme hardness. Here in, we report deposition of polycrystaline thin film of TiN by DC Magnetron sputtering on Si photocathode as a passivation layer with the influence of cocatalyst in improving the photocurrent density efficiency. The nitride (TiN) film combined with TMN cocatalyst in acidic electrolyte demonstrated prevention of Si degradation with improvement in long-term stability under simulated AM 1.5G illumination.

Keywords : PEC, Transition metal Nitride, TiN

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Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Modification of ZnO Electrocatalyst by N Doping Towards Electrochemical CO_2 Reduction

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The discovery of efficient, selective, and stable electrocatalysts can be a key point in producing large-scale chemical fuels via electrochemical CO_2 reduction (ECR). In this study, an earth-abundant and nontoxic ZnO-based electrocatalyst was developed for use in gas-diffusion electrodes, and the effect of nitrogen (N) doping on the ECR activity of ZnO electrocatalysts was investigated. Initially, a ZnO nanosheet was prepared via the hydrothermal method, and nitridation was performed at different times to control the N-doping content. With an increase in the N-doping content, the morphological properties of the nanosheet changed significantly, namely, the 2D nanosheets transformed into irregularly shaped nanoparticles. Furthermore, the ECR performance of ZnO electrocatalysts with different N-doping content was assessed in 1.0 M $KHCO_3$ electrolyte using a gas-diffusion electrode-based ECR cell. While the ECR activity increased after a small amount of N doping, it decreased for higher N doping content. Among them, the N:ZnO-1h electrocatalysts showed the best CO selectivity, with a Faradaic Efficiency (FE_{CO}) of 92.7% at -0.73 V vs. reversible hydrogen electrode (RHE), which was greater than that of an undoped ZnO electrocatalyst (FE_{CO} of 63.4% at -0.78 V_{RHE}). Also, the N:ZnO-1h electrocatalyst exhibited outstanding durability for 16 h, with a partial current density of -92.1 $mA\cdot cm^{-2}$. This improvement of N:ZnO-1h electrocatalyst can be explained by the theoretical DFT study, demonstrating that this improvement of N:ZnO-1h electrocatalyst comes from the optimized active sites, i) lowering the free energy barrier for the rate-determining step (RDS), ii) the modification of electronic structure, and iii) enhancing the electron transfer rate by N doping.

Keywords : ZnO, N-doped ZnO, CO selectivity, Gas-Diffusion-Cell, CO2RR

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Abstract No. : **PO-S04-0436**
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Abstract Preference : **Poster**

Silver Selenide Nanoparticles Embedded Nanomesh-based RRAM

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Resistive random access memory (RRAM) stands out as a leading next-generation non-volatile memory, offering simplicity in operation and fabrication, thus making it suitable for wearable and skin-attachable devices. However, the insulating layer used in conventional RRAM, typically composed of inorganic materials, possesses high mechanical strength due to strong chemical bonding and crystalline structure, making it challenging to integrate into flexible components. Organic semiconductors like Musin and Pentacene have been proposed as alternatives, but their memory characteristics (endurance, chemical stability, durability, etc.) are inferior to those based on inorganic materials. Additionally, applying non-porous structures to wearable and skin-attachable devices often leads to discomfort and skin irritation due to poor breathability. Therefore, developing flexible and porous structure components based on inorganic materials is essential for applying RRAM components to wearable and skin-attachable devices. Herein, we present sliver selenide (Ag_2Se) embedded nanomesh-based RRAM devices, which possess flexibility and breathability. Silver (Ag) nanoparticles are patterned on flexible and breathable nanomesh. Furthermore, we seek to form silver selenide (Ag_2Se) inorganic semiconductor material by reacting with selenium precursor solution, followed by depositing aluminum (Al) to achieve a flexible and breathable Metal-Insulator-Metal (MIM) structure. The Ag_2Se nanoparticles embedded nanomesh-based RRAM presents outstanding switching characteristics ($I_{on}/I_{off} > 10^6$, and retention time $>10^6$ s). This study suggests the possibility of further application for memory devices of wearable and skin-attachable devices.

Keywords : Silver selenide, Nanoparticles, Nanomesh, RRAM

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Abstract No. : **PO-S13-0435**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

The Role of Center for Advanced Solar PV Technology

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Development of solar cell technology in Korea is essential to maintain the future global competitiveness of domestic industries. This includes achieving high power per installation area and low manufacturing costs to meet national greenhouse gas reduction targets and achieve carbon neutrality. Although tandem technology R&D is being vigorously pursued, numerous technical challenges such as material stability and difficulties in mass production need to be overcome to hasten commercialization. Consequently, PV experts from industries, universities, and research institutions must unite their expertise and competencies for troubleshooting, scale-up, and technological demonstrations through a flagship project.

KIER is also leading an infrastructure initiative called ‘Center for Advanced Solar PV Technology (CAST),' situated within the 'International Science-Business Belt' in Daejeon, Korea. This center is designed to serve as an open-innovation platform, evaluating pre-production based solar cell technologies developed by domestic companies like Hanwha Q Cell and Hyundai Energy Solutions, among others. The facility includes pilot lines that support the fabrication of c-Si solar cells for PERC and TOPCon structures, along with the production of new-type modules. With ample capacity for integrating complementary HJT and tandem structured solar cell fabrication technologies, the center is poised to become a hub of collaboration among companies specializing in solar cells/modules, and PV-related materials, parts, and equipment manufacturing.

Furthermore, the center is expected to contribute to the training of highly skilled personnel globally, familiar with next-generation technologies, and to enhance the R&D efficiency of domestic industries by fostering world-class performance evaluation and analysis technologies. Together, we aim to drive technological innovation by promoting international cooperation and joint research with overseas institutes, accelerating the realization of a carbon net-zero society through solar PV technology.

Keywords : CAST, PERC, TOPCon, Tandem solar cell

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Abstract Preference : **Poster**

Impact of Annealing Duration on GeSe Growth and Application in Photoelectrochemical Water Splitting

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The importance of energy, its usage, and resolving associated issues is critical in today's society. There has recently been an increasing demand for greener, cleaner, and renewable technology to address environmental concerns about traditional fossil fuels and their derivatives. Natural hydrogen generation provides a limitless and environmentally benign energy choice. The photoelectrochemical (PEC) water-splitting process, which turns sunlight into storable hydrogen energy, is well recognized as an environmentally benign means of harvesting solar energy. Various materials have been investigated for research. As a result of their unique features, interest in chalcogenide-based materials has grown, prompting significant study in this area. Germanium Selenide (GeSe) is an ideal photocathode material due to its adequate bandgap for light absorption, activity in the visible light spectrum, and chemical stability. Furthermore, GeSe is non-toxic, plentiful in the Earth's crust, and inexpensive to produce, making it a promising candidate for energy applications. In this instance, a radio frequency (RF) sputtering instrument was used to make the GeSe. Research has been done on the impact of Tube Rapid Thermal Annelaing (RTA) time on GeSe growth. X-ray diffraction (XRD) and scanning electron microscopy (SEM) performed structural and morphological investigations that shed light on the crystalline structure and surface morphology of the produced GeSe films. In addition, the photoelectrochemical (PEC) performance of the synthesized GeSe was evaluated to determine its appropriateness for solar power conversion uses.

Keywords : Germanium Selenide, Tube RTA, Photocathode, Photoelectrochemical Water Splitting

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Abstract Preference : **Poster**

Change in CZTSSe solar cell characteristics according to absorber layer annealing time

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Kesterite-based ($Cu_2ZnSn(S,Se)_4$) (CZTSSe) have been spotlighted as the next-generation solar cell to replace existing CIGS and CdTe thin film solar cells (TFSCs). However, despite these advantages, the CZTSSe TFSCs exhibit inferior power conversion efficiencies (PCE) below 15%. Therefore, various optimizations are necessary to improve efficiency. In this study, we fabricated the device with different annealing time which could further improve the quality of the absorber layer. In this study, the thermal treatment conditions were fixed to 530°C with 500 mtorr pressure to fabricate CZTSSe absorber layer, and the annealing time was finely adjusted to 1 minute. The structure of the device was ultimately made of Mo/CZTSSe/CdS/i-ZnO/AZO/Al structure. Afterwards, XRD and RAMAN analysis were performed for crystallographic analysis of the device. Surface analysis was observed using SEM, and each completed solar cell was analyzed under solar conditions.

Keywords : CZTSSe, Solar cell, Annealing time, absorber layer

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Abstract No. : **PO-S14-0432**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Improvement of optical properties of CZTSSe-based solar cells and photocathode devices due to cadmium doping

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CZTSSe material is a material that replaces cigs, which is currently being studied, and is attracting attention as an eco-friendly and economical material because it does not use indium or gallium. However, various studies are being conducted due to low solar cell efficiency and low hydrogen conversion efficiency in PEC water splitting. Among them, cation doping is known to significantly contribute to improving device performance by improving the optoelectric properties of CZTSSe thin films. Cations doped into CZTSSe include various elements such as Ge, Cd, and Ag, and among these, Cd can be easily doped using the Chemical Bath Deposition method. Cd is doped into cztsse and plays a role in suppressing the formation of secondary phases and voids, and when applied to a device, it improves photocurrent and improves light-hydrogen conversion efficiency. In this study, cztsse was doped with Cd at different times (9.5, 10.5, 11.5) using the CBD method to analyze its single thin film properties, and solar cells and PEC photocathodes were manufactured under the same conditions to measure device characteristics. As a result, in the sample doped with cadmium for 11.5 minutes, the solar cell efficiency was measured up to 9.24%, and as a PEC photocathode, the photocurrent was measured up to 20 mA/cm2. In addition, the CZTSSe single thin film analysis results showed that the thin film doped with cadmium for 11 minutes and 30 seconds had excellent light absorption and electrical properties.

Keywords : kesterite, PEC, photocathode, hydrogen, Cd doping

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Abstract Preference : **Oral**

Solution-Based Processed van der Waals Thin Films for High-Performance and Wafer-Scale Electronics

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The integration of two-dimensional (2D) materials into practical electronics has been hindered by the lack of scalable fabrication methods. To overcome the limitation, I will introduce a general approach for wafer-scale electronics based on 2D nanomaterial inks, which is fabricated by molecular intercalation-assisted exfoliation method, enabling highly uniform, ultrathin, phase-pure, and large lateral size 2D nanoflakes. This approach enables the printing of large-area thin films characterized by effective van der Waals (vdW) sheet-to-sheet contacts, which promote a clean interface and minimal charge trapping states. We demonstrate the versatility of the printed thin films by integrating them with various electrical functionalities—dielectric, semiconducting, and metallic—resulting in vdW thin-film devices that exhibit exceptional performance over large scales. These devices not only enhance current electronics but also expand potential applications to include photodetectors, diode, and logic gates, demonstrating their broad utility in advanced electronic systems.

Keywords : vdW thin film, solution-processing

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Abstract Preference : **Oral**

Surface passivation of 2D Piezoelectric Materials via Atomic Layer Deposition of Al_2O_3 Thin Films

Sangwoo Lee[1], Joonbong Lee[1], A young Cho[1], Dae haa Ryu[1], Hyunbin Chung[1], Taekjib Choi[*1]

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In the semiconductor applications, a passivation layer is a thin film that protects the material from environmental influences that can affect its properties. Our research focus is on passivation layers in semiconductor products to protect 2D piezoelectric materials from environmental influences. These layers must have high chemical resistance and low surface recombination rates in order to effectively protect the semiconductor surface. Aluminum oxide has proven to be a suitable material for these layers due to its excellent chemical resistance, etch selectivity, and density. We study the properties of alumina through parameter control of atomic layer deposition (ALD) and post-treatment methods such as rapid thermal annealing (RTA) and UV treatment.

Keywords : ALD, Aluminum oxide, Passivation, 2D piezoelectric material

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Abstract Preference : **Oral**

All Inkjet-Printed Electronics from Electrochemically Exfoliated Two-Dimensional Nanomaterials

Okin Song[1], Joohoon Kang[*1]

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Inkjet printing offers a cost-effective and scalable method to assemble colloidal materials into desired patterns in a vacuum- and lithography-free manner. Two-dimensional (2D) nanosheets are a promising nanomaterial for printed electronics because of their compatibility with solution processing for stable ink formulations as well as a wide range of electronic types from metal, semiconductor to insulator. Furthermore, their dangling bond-free surface enables atomically thin, electronically-active thin films with van der Waals contacts which significantly reduce the junction resistance. In this study, we demonstrate all inkjet-printed thin-film electronics consisting of electrochemically exfoliated graphene, MoS_2, and HfO_2 as metallic electrodes, a semiconducting channel, and a high-k dielectric layer, respectively. In particular, the HfO_2 dielectric layer is prepared via two-step; electrochemical exfoliation of semiconducting HfS_2 followed by a thermal oxidation process to overcome the incompatibility of electrochemical exfoliation with insulating crystals. Consequently, all inkjet-printed 2D nanosheets with various electronic types enable high-performance, thinfilm transistors which demonstrate field-effect mobilities and current on/off ratios at low operating voltage.

Keywords : Solution-process, Inkjet-printing, 2D Materials

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Abstract Preference : **Poster**

Enhanced hybrid thermoelectric-piezoelectric generator via suppressed thermal saturation using cantilever vibration

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We present a novel hybrid energy harvester that combines piezoelectricity and thermoelectricity. The efficiency of the thermoelectric generator (TEG) is proportional to the temperature difference between cold and hot sides, which can be increased by the vibrational characteristics of the cantilever. The heat dissipation effect, a crucial factor in power generation in thermoelectric, is determined by the cantilever oscillation-induced cooling. Additionally, a cantilever is equipped with piezoelectric Macro Fiber Composites (MFCs) to capture piezoelectric energy from its oscillation. The study investigates heat dissipation effects with respect to three cantilever designs. Experimental results indicate that the narrow cantilever design exhibits the highest displacement and heat dissipation. Additionally, COMSOL multiphysics simulations are conducted to validate the experimental findings, aligned with the measured heat dissipation trends. The hybrid energy harvesting method achieves a power of 7.62 mW output in a presence of 0.5g vibrational source, a 52% (at 29.0Hz) increase compared to a static condition. This improved performance validates a potential of the hybrid approach for diverse applications where vibrational energy sources are present.

Keywords : Thermoelectricity, Piezoelectricity, Hybrid energy harvesting, Cantilever cooling, Heat dissipation

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Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

A Study on the Removal of Impurities in MoO3 Powder depending on Leaching Solutions

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Molybdenum is a key resource used in semiconductors, displays, carbide, and plants, which are the forward industries, based on its excellent heat resistance, electrical resistivity, and thermal conductivity. In order to be used as a raw material for a semiconductor target, it must have a high purity of 3N5 or more, but due to the current absence of refining technology, all molybdenum materials are dependent on foreign imports. Therefore, domestic commercialization is necessary for the smooth supply of molybdenum, a national strategic element, and the development of high-purity purification technology is urgently needed for this purpose.

In this study, we investigated the leaching behavior of metallic impurities using several leaching solutions to purify MoO3 powder. The purity of the raw MoO3 material was 81% as a result of ICP-OES analysis, Fe and Cu were the main impurities. NaOH, NH4OH, HCl, and HCl+NH4Cl were used as leaching solutions under constant leaching temperature and time conditions, and the leaching behavior of impurities was investigated by adjusting the concentration of the solutions.

As a result, NaOH solutions effectively removed impurities, but since Na acts as impurity, additional processes was needed to remove them. The NH4OH solution leached molybdenum up to 80%, and co-leached Cu. In the HCl solution, more than 90% of major impurities (Fe, Cu) were leached, but molybdenum was also co-leached. The HCl+NH4Cl solution leached more than 80% of the major impurities, and the leaching rate of molybdenum was about 7%. Therefore, we determined that the HCl+NH4Cl solution had the highest impurity removal efficiency.

Finally, we conducted five leaching experiments using HCl+NH4Cl solution to increase the removal rate of major impurities, and then NH4OH leaching and heat treatment processes were conducted to remove residual impurities. The molybdenum compound recovered after the heat treatment process was MoO3 and the purity was 99.8%.

Keywords : Molybdenum, MoO3, leaching, purification

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Abstract No. : **PO-S02-0426**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Understanding the role of photon recycling effect in perovskite light-emitting diodes to improve performance

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Perovskites have emerged as promising candidates for next-generation optoelectronic devices, particularly in the fields of solar cells and light-emitting diodes (LEDs), owing to their high performance and favorable optical properties. Perovskite LEDs have been extensively optimized, achieving an external quantum efficiency exceeding 20%. In contrast to conventional organic light emitter, perovskites exhibit relatively high refractive indices ($n > 2$), leading to the low ray-optics limit of $1/2n^2$ of <12%. However, recent experimental outcomes have shown efficiencies several times higher than this limit, indicating a deviation primarily attributed to the photon recycling effect, wherein photons re-emitted after being reabsorbed in trapped optical modes, in addition to the microcavity effect.

Herein, we investigate the role of photon recycling effect in perovskite LEDs, based on the quantification of the external efficiencies. We propose an optical model that considers the reabsorption of emitters. These studies provide the design rules for highly efficient perovskite LEDs, distinguishable from those for classical organic LEDs.

Keywords : Perovskite light-emitting diode, photon recycling, light emission efficiency

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Abstract No. : **PO-S14-0425**
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Abstract Preference : **Poster**

MOF-Derived FeCo-Based Layered Double Hydroxides for Oxygen Evolution Reaction

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Exploring earth-abundant, highly effective and stable electrocatalysts for electrochemical water splitting is urgent and essential to the development of hydrogen (H2) energy technology. Iron-cobalt layered double hydroxide (FeCo-LDH) has been widely used as an electrocatalystfor OER due to its facile synthesis, tunable components, and low cost. However, LDH synthesized by the traditional hydrothermal method tends to easily agglomerate, resulting in an unstable structure that can change or dissolve in an alkaline solution. Therefore, studying the real active phase is highly significant in the design of eletrochemical electrode materials. Here, metal-organic frameworks (MOFs) are used as template precursors to derive FeCo-LDH from different iron sources. Iron salts with different anions have a significant impact on the morphology and charge transfer properties of the resulting materials. FeCo-LDH synthesized from iron sulfate solution (FeCo-LDH-SO4) exhibits a hybrid structure of nanosheets and nanowires, quite different from other electrocatalysts that were synthesized from iron chloride and iron nitrate solutions. The final FeCo-LDH-SO4 had an overpotential of 247 mV with a low Tafel-slope of 60.6 mV dec-1 at a current density of 10 mA cm-2 and delivered a long-term stability of 40 h for the OER. This work provides an innovative and feasible strategy to construct efficient electrocatalysts.

Keywords : FeCo layered double hydroxide, metal-organic frameworks, oxygen evolution reaction

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Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

FeOOH-induced electronic modulation of metal-organic framework-derived CoNi-ZLDH for overall water splitting

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Developing and designing inexpensive and efficient bifunctional electrocatalysts with high activity and long-term stability is highly essential for overall water splitting (OWS). Herein, a facile synthesis route is demonstrated to produce a hierarchical nanostructure comprising MOF-based cobalt-nickel layered double hydroxides (CoNi-ZLDH) nanosheets (NSs). These NSs are further coupled with self-supported FeOOH nanoparticles (NPs) demonstrating remarkable stability and high efficiency for water electrolysis. The resulting FeOOH/CoNi-ZLDH electrocatalyst possesses high intrinsic activity and outstanding electrical conductivity along with well-defined 3D structure having enhanced active electrochemical surface area. The FeOOH/CoNi-ZLDH functioning as a bifunctional electrocatalyst exhibits excellent performance in both oxygen evolution reaction (OER) with an overpotential of 226 mV at 50 mA cm^{-2} and hydrogen evolution reaction (HER) with an overpotential of 203 mV at 10 mA cm^{-2}. It is worth noting that the FeOOH/CoNi-ZLDH possesses outstanding durability for the OER, lasting for more than 150 hours at 50 mA cm^{-2} without any noticeable change in performance. Additionally, to drive the OWS, electrode system requires a cell voltage of only 1.645 V to reach at a current density of 10 mA cm^{-2}. Our work emphasizes the modulation of the local electronic structure of hollow hierarchical CoNi-ZLDH via strong interfacial interactions with FeOOH NPs for the rational design of efficient bifunctional electrocatalysts derived from MOF.

Keywords : Metal-organic framework; Hollow hierarchical structure; Overall water splitting; FeOOH

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Abstract No. : **PO-S14-0423**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Surface and interface modulation of n-GaAs photoanode for durable solar water oxidation

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Hydrogen (H_2) is one of the most widely used essential chemicals worldwide, and it is also employed in the production of many other chemicals, especially carbon-free energy fuels produced via photoelectrochemical (PEC) water splitting. At present, gallium arsenide (GaAs) represents the most efficient photoanode material for PEC water oxidation, but it is known to either be anodically photocorroded or photopassivated by native metal oxides in the competitive reaction, limiting efficiency and stability. Here, we report an effective approach to enhancing GaAs photoanode stability and efficiency by using chemically etched GaAs that is decorated with thin titanium dioxide (TiO_2) surface passivation layer along with cocatalyst as a surface hole-sink layer. The etched GaAs maximizes the photo-absorption. The integration of an bifunctional co-catalyst results in a highly efficient GaAs electrode with a ~100 mV cathodic shift of the onset potential. The electrode also has enhanced photostability under 110-h testing for PEC water oxidation at a steady current density $J_{ph} > 25\ mA\cdot cm^{-2}$.

Keywords : Water oxidation,PEC,TiO2

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Abstract No. : **OR-S13-0422**
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Abstract Preference : **Oral**

Vapor Transport Deposited SnS_xSe_{1-x} Thin-film Solar Cells: Achieving the Highest Efficiency via Se/S+Se Ratio Optimization

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The rising global energy demand calls for photovoltaic devices that are cost-effective, environmentally friendly, and use abundant materials. Tin chalcogenide (SnS_xSe_{1-x})-based thin-film solar cells (TFSCs) have emerged as a promising material with earth-abundant constituents, a tunable optical bandgap (~1.0-1.35 eV), and a high optical absorption coefficient (10^4 cm^{-1}) in the visible region. However, the synthesis process poses a great challenge in depositing SnS_xSe_{1-x} thin films with a controlled Se/S+Se compositional ratio, as secondary stoichiometric phases can easily form. This study investigates the deposition and optimization of SnS_xSe_{1-x} thin films with a controlled Se/S+Se ratio. The SnS_xSe_{1-x} thin films were prepared using a simple and low-cost vapor transport deposition (VTD) method, and their properties were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). The photovoltaic properties of SnS_xSe_{1-x} thin films were studied using the device architecture of glass/Mo/SnS_xSe_{1-x}/CdS/i-ZnO/AZO/Al. The results showed that the bandgap of the SnS_xSe_{1-x} absorber can be tuned by adjusting the Se/S+Se ratio, which can greatly influence the photovoltaic properties. The optimized device with a Se/S+Se compositional ratio of 0.3 has shown the highest efficiency of 3.75%. The improved efficiency was attributed to the optimal balance between the light absorption and carrier transport properties of the $SnS_{0.7}$Se0.3 absorber. This study provides a promising strategy for the development of high-performance and low-cost TFSCs.

Keywords : Tin chalcogenides, Vapor transport deposition, Thin-film solar cells, Efficiency

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Abstract No. : **PO-S14-0421**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

$MoS_2/MnMoO_4$: Stable and efficient nanocomposite structured electrocatalyst for hydrogen evolution reaction.

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Nowadays, it is very important to produce low cost, environmentally friendly and cheaper electrocatalysts for electrocatalytic hydrogen evolution reaction with superior characteristics. Considering this approach, MoS_2 based catalysts have been used widely due to their electrochemical catalytic activity, low cost, most promising and high efficiency alternative to Pt for HER but it suffers from low conductivity and limited active edges. To overcome this problem, we report $MoS_2/MnMoO_4$ nanocomposite by varying ratios of Mo:Mn using one step hydrothermal reaction which gives improved catalytic activity and good stability towards HER in acidic medium. According to the analysis, MoS_2 nanosheets combined with $MnMoO_4$ rods are more electrochemically active than either alone. Additionally, the combined effect of manganese and molybdenum ions from $MnMoO_4$ produces more redox chemistry reactions that can help expose more MoS_2 nano sheets active sites. The nanocomposite consisting of $MoS_2/MnMoO_4$ (Mo:Mn = 1:2.5) has an lower overpotential of -153 mV to drive current density of 10 $mA{\cdot}cm^{-2}$ than other ratios of Mo:Mn and also gives excellent stability upto 100 hrs , allowing commercial electrocatalysts to be designed.

Keywords : MoS2,Electrocatalyst,HER.

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Abstract No. : **OR-S04-0419**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Hydrogel-based Adhesive Film for Versatile Electrical Interfacing in Soft Electronics

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Electronic packaging, which attaches electronic elements to the substrate and connects the circuits, has developed from soldering to an anisotropic conductive film (ACF). The ACF prevents short-circuiting and can form a more concentrated electrical connection to circuits compared to the previous packaging technologies. However, the conventional ACF has a limitation in that it is inappropriate for interconnecting elastic material, which has become more problematic as soft electronics have received attention as an interface to connect electronic devices to the human body. Because the electrical connection between Si based electrical components and soft electronics is necessary to perform the advanced function. Therefore, more investigations have been demanded to develop an advanced method that is capable of electrically connecting various materials to electronics.

In this study, a hydrogel-based adhesive film (H-AF) is designed for material-independent interconnection between electronic parts. H-AF is fabricated by stacking poly (vinyl alcohol) (PVA) and tannic acid (TA) layers. Through the moisture absorption and drying process, the polymer chain entanglement of PVA enables adhesion to various substrates such as IC chips, elastomers, and hydrogels. Based on abundant hydroxyl groups, TA strengthens adhesion to the surface and improves the mechanical properties of the H-AF by crosslinking PVA. Additionally, the non-toxic nature of these two substances confers biocompatibility to H-AF.

With these features, H-AF enables rapid (>1 min) and strong bonding (<7 MPa) between various materials, which is essential for consistent connection even in harsh conditions with mechanical. Additionally, H-AF demonstrates comparable electrical performance to conventional ACF, exhibiting low connection resistance (<0.06Ω in 0.25mm2) and absence of shorts at fine pitches (<20μm). Through S-parameter (S21) measurements, it was also confirmed that AC signal transmission at frequencies below 5GHz is possible for H-AF. As a result, H-AF presents a novel method for overcoming limitations in integrating soft electronics.

Keywords : Soft electronics, Anisotropic conductive film, Hydrogel

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Abstract No. : **PO-S11-0418**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Electrocaloric effect in bulk relaxor ferroelectric ceramics for energy harvesting applications.

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Electrocaloric refrigeration, where temperature changes occur in response to electric fields, offering several advantages over traditional vapor compression cooling devices. Unlike conventional refrigeration systems that rely on vapor compression and refrigerants with high global warming potential, electrocaloric refrigeration operates without harmful greenhouse gases and ozone-depleting substances. Moreover, electrocaloric systems exhibit rapid response times, compatibility with miniaturization, which are also suitable to thermal energy harvesting applications. Within the realm of electrocaloric materials, relaxor ferroelectric bulk ceramics have emerged as promising candidates due to their unique electrocaloric properties and structural characteristics. The relaxor behavior in these ceramics, characterized by a diffuse phase transition and a broad temperature range of peak electrocaloric response, enables efficient heat exchange and temperature control over a wide operating range. In this study, Sm-doped PMN-PT ceramics are developed to improve electrocaloric effect. Fabricated ceramics exhibited the relaxor behavior and the electrocaloric effect, heat dissipation and heat absorption. This work introduces a promising candidate material for electrocaloric energy harvesting and refrigeration.

Keywords : Energy harvesting, Electrocaloric effect, Refrigeration, Relaxor ferroelectrics, Ceramics.

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Abstract No. : **PO-S11-0417**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Fabrication of Complex 3D Structured Ceramics based on Direct Ink Writing

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Piezoelectric ceramics, known for their exceptional electrical properties, have been widely used in fields such as sensing, actuation, and energy harvesting. As industries advance, there is increasing demand for lightweight and intricately structured piezoelectric ceramics. However, traditional ceramic fabrication methods like casting and mold forming encounter complex manufacturing processes and limited geometric design flexibility. This study proposes intricate structured piezoelectric ceramics fabricated via Direct Ink Writing (DIW) 3D Printing, one of the additive manufacturing techniques. The optimization of the printing process minimizes the degradation of d_{33}, thereby maintaining d_{33} of approximately 700 pC/N, even within intricate structures. Porous 3D structures like honeycombs are suitable for use as pressure sensors due to their ability to map measured pressures.

Keywords : Direct Ink Writing, Piezoelectric ceramics, Energy Harvesting

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Abstract No. : **PO-S06-0416**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Changes in Microstructure, Mechanical Properties, and Electrical Conductivity of Severely Wire-Drawn AA1070 with Annealing

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Commercial AA1070 alloy for electrical wire severely deformed from 2 mm to 0.4 mm in diameter by multi-pass drawing process was annealed for 1h at various temperatures from 200 to 400°C. Changes in the microstructure, mechanical properties and electrical properties of the Al alloy with increasing the annealing temperature were investigated in detail. The as-drawn Al wires showed a severely deformed structure in which the grains are greatly elongated in the drawing direction, however above 275°C they exhibited the complete recrystallization structure. For not only the drawn specimen but also all annealed specimens, the fiber texture of the {110}<111> and {112}<111> components was mainly developed. The hardness decreased with increasing the annealing temperature due to occurrence of recovery and/or recrystallization. The strength also decreased with an increase of the annealing temperature, very similar to the change in hardness. The electric conductivity tended to increase gradually with increasing the annealing temperature.

Acknowledgement
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Keywords : AA1070 alloy, wire drawing, microstructure, mechanical properties, electrical properties

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Abstract No. : **OR-S07-0415**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

Beyond Linear Scaling: Innovations in Catalyst Optimization

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Recent studies in electrochemical reaction simulations have revealed the construction of Volcano plots and 2D contour plots based on a strong linear scaling relation between the adsorption energies of intermediate species. This linear scaling relation provides researchers with a straightforward descriptor to predict catalyst performance and enables the visualization of large datasets of catalyst performance on simple contour plots. However, to maximize catalyst performance, it is crucial to identify outliers that do not follow the linear scaling relation. Particularly in the oxygen reduction reaction (ORR), a strong linear scaling relation between OH and OOH adsorption energies sets clear limits on catalyst activity. Overcoming these limits requires understanding how outliers arise and how researchers can control them. In this presentation, we will explore the fundamental assumptions and theories of electrochemical catalyst simulations and examine how Volcano plots and 2D contour plots are formed based on the linear scaling relation. Additionally, we will investigate the impact of ensemble, electronic, and strain effects on adsorption energies and explore various possibilities for generating outliers that deviate from the linear scaling relation.

Keywords : Linear Scaling, DFT, Catalyst, ORR, OER

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Abstract No. : **IN-S06-0414**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Grain refinement of zinc single crystals and polycrystals by SPD process

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Zinc has an hcp structure and shows crystal orientation dependence on deformation behavior. A single pass of equal channel angular pressing (ECAP) at 223 K was applied to six kinds of zinc bulk single crystals with different crystal orientations, and the deformation behavior was investigated, such as grain refinement. A zinc single crystal with several hundred cubic millimeters was found to be divided into a large number of grains by a single pass of ECAP. Twinning and recrystallization above the shear plane are key for grain refinement. ECAP deformation behavior of zinc polycrystals at 276 K was also investigated. Recrystallization occurred during ECAP and equiaxed grains were observed; the mean grain size was 12.8 micrometers after 8-pass of ECAP. On the other hand, accumulative roll-bonding (ARB) was applied to zinc polycrystalline sheets. The mean grain thickness was 6.9 micrometers after 7-cycle. Recrystallization occurred but no grain grew beyond bonding interfaces; the grain size depends on the thickness of layers. ARB is the most efficient SPD for the grain refinement of zinc.

Keywords : ECAP; ARB; shear plane; twinning; recrystallization

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Abstract No. : **PO-S06-0413**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of Zn and Mg ratio on mechanical properties and stress corrosion cracking resistance of high-strength Al-Zn-Mg aluminum alloy

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As future mobility that reduces carbon emissions and solves environmental problems, research on the development of rapidly growing mobility technologies such as self-driving cars, hydrogen electric vehicles, and UAM is increasing. In particular, as urban concentration appears in all countries, the number of large cities with a populations exceeding 10 million is increasing. This population density phenomenon has worsened the habitual automobile congestion and constrained land transportation. To address these challenges, there is a growing interest in developing UAM technology. Particularly, the development of lightweight and high-strength materials is necessary to enhance UAM efficiency through weight reduction. In this study, the mechanical properties and resistance to stress corrosion cracking (SCC) behavior of Al-Zn-Mg aluminum alloy, designed by varying the Zn and Mg contents, were measured. The SSRT (Slow Strain Rate testing) was conducted at a speed of 10^-5/s by controlling the electric potential in a 3.5% NaCl solution. The applicability of UAM materials exposed to various environments was examined by measuring the sensitivity of samples to SCC in both anodic dissolution and hydrogen embrittlement conditions, known as the primary causes of SCC.

Acknowledgement
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Keywords : Aluminum alloys, Alloy design, Stress corrosion cracking, Mechanical properties, Structural materials

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Abstract No. : **PO-S06-0412**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Aluminum alloy design and mechanical properties for next-generation mobility structural materials

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Aluminum alloys applied to next-generation mobility are required to be eco-friendly in zero-carbon era along with their reliability. At present, tens of aluminum alloys for automobiles are being applied. Therefore, during recycling, there is a problem that it is used as low-grade scrap due to the difference in alloy composition, so the next-generation aluminum alloys for mobility such as xEV, UAM is required to be improved. In this study, Al-Zn-Mg-(Cu) wrought alloy designed for structural materials of next-generation mobility that can be used universally in body-in-white. Al-Zn-Mg-(Cu) wrought alloy can realize all of the characteristics of Al-Mg, Al-Mg-Si, Al-Zn-Mg-(Cu) based aluminum alloys applied to vehicle structural materials and has a single composition designed for easy recycling.

In this study, the effects of major additive elements on microstructures and mechanical properties were analyzed through the design of Al-Zn-Mg-(Cu) based aluminum alloys for application to next-generation mobility.

Acknowledgement
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Keywords : Aluminum alloys, Alloy design, Recycling, Mechanical properties, Net zero carbon

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Abstract No. : **OR-S10-0410**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Oral**

3D Printing of Mechanically Tough and Self-healing Hydrogels with Carbon Nanotube Fillers

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Hydrogels have the potential to play a crucial role in bioelectronics, as they share many properties with human tissues. However, to effectively bridge the gap between electronics and biological systems, hydrogels must possess multiple functionalities, including toughness, stretchability, self-healing ability, 3D printability, and electrical conductivity. Fabricating such tough and self-healing materials have been reported, but it still remains a challenge to fulfill all of those features, and in particular, 3D printing of hydrogel is in the early stage of the research. In this paper, we present a 3D printable, tough, and self-healing multifunctional hydrogel in one platform made from a blend of poly(vinyl alcohol) (PVA), tannic acid (TA), and poly(acrylic acid) (PAA) hydrogel ink (PVA/TA/PAA hydrogel ink). Based on a reversible hydrogen-bond (H-bond)-based double network, the developed 3D printable hydrogel ink showed excellent printability via shear-thinning behavior, allowing high printing resolution (~100 μm) and successful fabrication of 3D printed structure by layer-by-layer printing. Moreover, the PVA/TA/PAA hydrogel ink exhibited high toughness (tensile loading of up to ~45.6 kPa), stretchability (elongation of approximately 650%), tissue-like Young’s modulus (~15 kPa), and self-healing ability within five minutes. Furthermore, carbon nanotube (CNT) fillers were successfully added to enhance the electrical conductivity of the hydrogel. We confirmed the practicality of the hydrogel inks for bioelectronics by demonstrating biocompatibility, tissue adhesiveness, and strain sensing ability through PVA/TA/PAA/CNT hydrogel ink.

Keywords : Hydrogels; 3D Printing; Toughness; Self-healing; Nanofillers; Bioelectronics

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Abstract No. : **PO-S09-0409**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Refining impurities in Si_3N_4 powder through plasma ashing and assessing its thermal conductivity for heat dissipation board applications

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The significance of environmental technologies has recently surged, prompting active development aimed at transitioning automobiles from internal combustion engines to electronics. Ceramic semiconductor substrates, particularly, are gaining prominence for their role in achieving this transition. Si_3N_4 stands out as a promising material for such substrates due to its exceptional thermal conductivity, low thermal expansion coefficient, and excellent thermal shock properties. However, these desirable properties are significantly influenced by the quality of Si_3N_4 powder.

This study delves into a manufacturing process for producing Si_3N_4 powder with enhanced thermal conductivity, crucial for electric vehicle heat dissipation substrates. To achieve optimal thermal conductivity, impurities such as Fe, Al, and O in the Si_3N_4 powder were meticulously controlled. Employing a plasma ashing process, we analyzed the purification effect using ICP and XRD before and after purification, subsequently confirming the resultant thermal conductivity through sintering.

Keywords : Si3N4, Thermal conductivity, Plasma ashing, Impurities

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Abstract No. : **PO-S06-0408**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of boron addition on electrical conductivity and mechanical properties of Al-0.2X(X=Sc, Zr)-xB alloy

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Aluminum alloy is attracting attention as a material that can replace copper due to its high conductivity and low density. In order to develop an aluminum alloy that satisfies high strength and electrical conductivity properties, appropriate strengthening mechanisms must be considered. In the case of solid solution strengthening, the addition of alloy elements improves strength, but reduces electrical conductivity. In this study, Al alloy that achieved both high strength and electrical conductivity was developed by suppressing solid solution strengthening and inducing the formation of a precipitated phase.

In order to improve mechanical properties and minimize the decrease in electrical conductivity, a small amount of Zr or Sc was selectively added into Al alloy(Zr or Sc has low solubility in the aluminum matrix). Additionally, to improve the electrical conductivity of the cast Al alloy, 0.1 to 0.3 wt.% of boron was added to both Al-Zr and Al-Sc alloys. And the electrical conductivity and mechanical properties were evaluated about the 8 mm diameter extruded material after the hot extrusion process.

It was confirmed that the electrical conductivity was improved when B was added to both Al-0.2Sc-xB and Al-0.2Zr-xB. The electrical conductivity and mechanical properties of Al-0.2Sc-xB increased as the amount of B added increased. In particular, Al-0.2Zr-0.2B achieved hardness of 35Hv and electrical conductivity of over 62%IACS.

Keywords : Al-Sc-B alloy, Al-Zr-B alloy, Electric conductivity, Mechanical properties, Solubility

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Abstract No. : **PO-S09-0407**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Implementation of Firing Type Threshold Device for Next-generation Semiconductors Using Atomic Layer Deposited Vanadium Oxide

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In the field of semiconductors, there is an increasing demand for high-performance/low-power computing hardware. To meet this demand, researchers are currently exploring devices that simulate the human brain and deviate from the traditional von Neumann method. Specifically, phase transition metal oxide materials have been found to exhibit a rapid insulator-metal transition firing-type switching phenomenon at a certain threshold voltage depending on voltage application. This phenomenon is characterized by volatile behavior that returns to the original state when the voltage is removed, as well as a very large current change and a fast switching speed of several nanoseconds.
To develop a high-performance phase transition device, it is essential to achieve precise control over the material properties of thin films. Previous research on phase transition materials has mainly relied on PVD-based processes such as sputter. However, this approach has significant limitations when it comes to implementing a phase transition oxide on a complex 3D structure due to poor step coverage. To address this challenge, we developed an ALD-based vanadium oxide (VO_2) process technology that enables the successful formation of a VO_2 thin film through subsequent heat treatment. Furthermore, the characteristics of thin films under various heat treatment conditions were analyzed using various analysis equipment, ultimately leading to the successful implementation of an ALD-based VO_2 firing type device.

Keywords : atomic layer deposition (ALD), vanadium oxide, metal-insulator transition, firing type threshold device

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Abstract No. : **PO-S03-0406**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Poster**

Fabry-Perot filter based short-wavelength infrared InGaAs photodetector

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Multispectral imaging is a useful tool in various fields in environmental monitoring, remote sensing, food quality, and biomedical diagnostics. It helps us identify objects better by collecting both spatial and spectral information simultaneously. Traditionally, multispectral imaging has been implemented in visible and near-infrared spectral ranges with heavy and bulky optical components, including rotating optical filters positioned in front of a charge coupled device image sensor or a complementary metal oxide semiconductor. In this study, the design, fabrication and characterization of a Fabry-Perot filter based photodetector operated in the short-wavelength infrared (1–3 μm, SWIR) range are demonstrated. A Fabry-Perot optical bandpass filter consists of Si/SiO_2 top and bottom mirrors and SiO_2 cavity fabricated by electron beam deposition, photoresist reflow, and cavity etching processes. The Fabry-Perot filter based InGaAs photodetector exhibits linear variable optical filtering for the spectral range of 1–3 μm. Furthermore, the Fabry-Perot SWIR InGaAs photodetector shows a responsivity of 0.34 A/W and a specific detectivity of 6.3×10^8 cm·$Hz^{1/2}$/W at 300 K.

Keywords : Multispectral imaging, Infrared, Photodetector, Fabry-Perot

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Abstract No. : **OR-S11-0405**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Acoustic Impedance Matched Triboelectric Nanogernerator with Biocompatible 2-Hydroxyethyl Methacrylate Driven by Ultrasound

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Ultrasound-driven triboelectric nanogenerators (TENGs) were recently proposed as an energy solution technology for a sustainable lifespan of implantable medical devices (IMDs). While the improvement of ultrasound transmission is crucial for achieving high energy generation, research on the material properties of ultrasound-driven TENGs is still in its initial stage. In this work, multifunctional, biocompatible 2-hydroxyethyl methacrylate (HEMA) is suggested as both an encapsulation and triboelectric layer for an implantable, modulus-tunable ultrasound-driven TENG (IMU-TENG). The Young's modulus of HEMA can be modulated with different cross-linker concentrations, allowing for the optimization of the acoustic impedance property to match that of surrounding body tissue. Furthermore, addition of an MAA ionic monomer can further enhance HEMA's triboelectric properties. The ultrasound transmission coefficient of IMU-TENG could be increased by about 10 times compared with a Ti plate when using the HEMA film. Under in vivo conditions, the IMU-TENG generates sufficient energy to charge a 100 μF capacitor 3.7 times faster than the case with a Ti plate. This strategy of using multifunctional HEMA for high-performance ultrasound-driven TENGs could be a promising energy solution for low-powered IMDs.

Keywords : Triboelectric Nanogenerator, Ultrasound, 2-Hydroxyethyl Methacrylate, Implantable Medical Devices, Acoustic Impedance

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Abstract No. : **IN-S08-0404**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Analysis and Design of Electrode Materials for Li Rechargeable Batteries

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Lithium-ion batteries (LIBs) have long been the go-to energy storage solution for portable electronics and electric vehicles. Despite their widespread use, LIBs struggle to keep up with increasing demands for higher energy density as technology progresses. Thus, there's an urgent call to develop alternative battery systems to supplant LIBs. The intricate nature of reaction mechanisms in most post-Li-ion battery systems only underscores this challenge. Therefore, gaining a thorough understanding of how these systems function during charge and discharge cycles is imperative for their advancement.

This presentation will focus specifically on investigating the reaction mechanisms of post-Li-ion batteries through operando imaging. For instance, there has been considerable interest in exploring Li anodes due to their high theoretical specific capacities. However, the complexity of the reaction mechanism adds a layer of challenge that is not yet fully understood. Utilizing operando X-ray microscopy enables the observation of the morphological evolution of post-Li-ion battery electrodes while the battery is in operation. By directly observing changes in electrode materials during battery operation, we can gain new insights into comprehending the complexities of the reaction mechanism.

Keywords : Li batteries, x-ray analysis

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Abstract No. : **PO-S12-0403**
Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Poster**

Deposition of copper oxide on alumina particles using atmospheric pressure dielectric barrier discharge (APDBD)

Yoon Kee Kim[*1], Kihyun Shin[1], Eun Seung Jeon[1], JuHee Son[1]

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Most metal oxides used as catalysts are made by precipitation from aqueous solutions by chemical reactions. However, the precipitation method has the disadvantage of long manufacturing time and the need for calcination treatment at high temperatures. In this study, alumina nanopowders were dispersed as precipitated seeds in the same solution as the precipitation method, and an atmospheric pressure dielectric barrier discharge treatment was performed to precipitate in a short time within a few minutes. It was also confirmed that copper oxide can be produced through heat treatment at temperatures below 100 degrees Celsius.

Alumina powder was dispersed in $CuCl_2$ aqueous solution using an ultrasonic cleaner. After mixing NH_4OH with this solution and treating it with Ar gas discharge. The precipitate was then recovered, washed, and dried to manufacture powder with copper oxide coated on alumina nanoparticles.

The crystalline phase of copper oxide was confirmed through X-ray diffraction analysis of the synthesized nanopowder, and the particle size was calculated using the width of the diffraction peaks. The size and morphology of the synthesized nanoparticles were measured using scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS) was used to confirm the presence of aluminum and copper and conduct relative quantitative analysis.

Keywords : copper oxide, caltalyst, coating, dielectric barrier discharge, alumina, nanoparticle

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Abstract No. : **PO-S13-0402**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Interlayer Interaction Engineering for Achieving High Quality Perovskite Crystals and Efficient Carrier Extraction of Tin Perovskite Solar Cells

Hyemi Na[1], Tae Oh Yoon[1], Gibaek Lee[1], Min Kim*[1]

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Recently, lead-free tin halide perovskites are regarded as a promising candidate for developing next-generation photovoltaic application due to their high carrier mobility, small exciton binding energy, and ideal optical bandgap. Despite these remarkable properties, the photovoltaic performance of Sn-based perovskite solar cells (Sn-PSCs) is still far behind that of Pb-based perovskite solar cells (Pb-PSCs) because of uncontrollable crystallization and easy oxidation of Sn(II). Therefore, most researchers have focused their efforts on understanding and optimizing the microstructure of perovskite films. However, since photo-generated charge carriers should inevitably traverse entire device through the charge transport layers, it is very important to select suitable charge transport materials for achieving the efficient charge transfer. Doping the transport layer has been a widely studied to enhance electrical conductivity, tune energy level, and improve film quality. In this study, we explore interfacial engineering in Sn-PSCs through a simple doping method using functional organic molecules in charge transport materials. With optimal doping concentrations, lead-free Sn-PSCs achieve a champion power conversion efficiency (PCE) of 10.1% while also exhibiting enhanced environmental and operational stabilities.

Keywords : perovskite, perovskite solar cells, Tin perovskite, Lead-free perovskite solar cells, Tin-based perovskite solar cells

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Abstract No. : **PO-S13-0401**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Passivation of Perovskite Quantum Dots Surface by Ethylene Glycol Side Chain Conjugated Polymer for High-Efficiency Perovskite Solar Cells

Tae Oh Yoon[1], Hyemi Na[1], Gibaek Lee[1], Dohun Baek[1], Su min Park[1], Min Kim*[1]

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$CsPbI_3$ perovskite quantum dots are attracting attention as solar cell absorption materials because they can easily tune the band gap and exhibit excellent photoelectric properties. However, due to the unstable solid-state ligand exchange process, the quantum dot surface becomes very sensitive to moisture, and surface defects are created. These defects reduce the overall solar cell performance and stability. To solve this problem, charge extraction and stability can be improved by introducing a conjugated polymer with various functional groups on the quantum dot surface. In general, conjugated polymer have self-aggregating properties, so the interaction between polymer and quantum dots is limited. However, by using the functional groups of asymmetrically designed polymers, self-aggregation of polymer can be suppressed, and the interaction between quantum dots and polymer can be enhanced. In addition, by forming a hydrophobic layer on the quantum dot layer, it prevents moisture penetration, maintains a stable crystal structure, and forms an appropriate energy band structure, thereby improving the power conversion efficiency to 14.4%.

Keywords : perovskite, quantum dots, solar cells, conjugated polymer

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Abstract No. : **IN-S05-0400**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Invited**

Copper Sulfide Electrodes for Electronic and Optoelectronic Applications

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2D nanostructures have garnered intense interests due to their 2D structure that enables super flexibility, optical transparency, and facile integration with disparate materials through van der Waals forces. In this presentation, I will introduce a new class of covellite 2D copper monosulfide (CuS) nanosheet film as a promising candidate for transparent, flexible conductive electrodes, which can be employed in various flexible and wearable electronic and optoelectronic devices. Especially, the presentation will cover from the synthesis of 2D CuS using facile sulfurization method to its employment in various electronics and optoelectronics devices including the source-drain electrode materials for 2D MoS_2 channel. We achieved record high electron mobility up to 100 $cm^2V^{-1}s^{-1}$ at room temperature in a back-gate device configuration. We will also cover effective doping method to tune its electrical and optical properties.

Keywords : 2D Materials, CuS, MoS2, Semiconductor Devices

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Abstract No. : **PO-S04-0399**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Controlling Intermetallic Layer Composition at the Interface of a Lead-Free Solder Joint for Stretchable Substrates and Devices

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Wearable technologies, notably in the realm of flexible devices, have experienced substantial advancements in research, development, and commercialization, particularly for applications in biometric signal monitoring. To further elevate the capabilities of wearable devices, the commercialization of stretchable devices that can seamlessly conform to human anatomy is critical. However, the widespread deployment of such devices is currently hindered by their susceptibility to mechanical failures and degradation due to repeated stretching. Addressing this challenge, the present study proposes an innovative approach to enhance the durability of chip bonding on stretchable substrates. Our research included an experimental evaluation wherein chips were bonded onto stretchable devices and subjected to 1,000 cycles of stretching at a 30% strain to compare the failure rates of solder joints. By controlling the composition of the intermetallic layer at the interface between the chip and the substrate, we optimized the performance of lead-free solder joints. This methodology aims to significantly enhance the mechanical robustness and longevity of stretchable devices, thus facilitating their practical application in dynamic environments. Additionally, this research contributes to the advancement of the field of stretchable electronics and establishes a foundation for future innovations in the development of durable, mechanically adaptive electronic components.

Keywords : Solder joint, Intermetallic layer, Stretchable device

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Abstract No. : **PO-S02-0398**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Green Emitting $Cs_3Cu_2Cl_5$ Nanocrystals for Light-Emitting DIode Applications

Gibaek Lee[1], Haedam Jin[1], Jeongbeom Cha[1], Dohun Baek[1], Hyemi Na[1], Su Min Park[1], Tae Oh Yoon[1], Min Kim[*1]

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Metal halide perovskites (MHPs) have garnered considerable attention in the field of next-generation light-emitting diodes (LEDs) due to their high photoluminescence quantum yield (PLQY), low-cost solution-processed fabrication, and tunable colors. However, the commercialization of MHPs faces significant challenges stemming from the toxicity of lead, which serves as a major obstacle. To address this issue, we synthesized 0D lead-free $Cs_3Cu_2Cl_5$ quantum dots (QDs) that exhibit green photoluminescence (PL) with a quantum yield of up to 44%, a large Stokes shift, and a long PL lifetime, attributed to self-trapped excitons. In this study, we successfully manufactured LEDs using the as-synthesized perovskite QDs.

Keywords : Perovskite, light emitting diodes, lead-free

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Abstract No. : **PO-S14-0397**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Investigating the impact of cation and anion substitution in spinel materials on the electrochemical oxygen evolution reaction and surface reconstruction monitoring by *in situ* near-ambient-pressure X-ray photoelectron spectroscopy

Yu-Hsu CHANG[*1]

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Cobaltite spinels have attracted significant interest as promising materials for the oxygen evolution reaction (OER) electrocatalysis. Their abundance, cost-effectiveness, versatile redox properties, and unique crystal structure have positioned them as highly appealing alternatives to the costly noble metal oxides. Typically, the synthesized spinel consists of both normal spinel $[(A^{2+}{}_{Tet})(B^{3+}{}_{Oh})_2X_4]$ and the inverse spinel $[(A^{2+}{}_{Oh})(B^{3+}{}_{Tet})(B^{3+}{}_{Oh})X_4]$, thereby enhancing charge transfer in electrochemical reactions. In terms of cation substitution, replacing Zn^{2+} ions with a cobalt-based spinel structure changes the electronic structure of and greatly alters the properties of $FeCo_2O_4$. Due to its stable divalent state and low electronegativity, the Zn^{2+} ion is a promising candidate for doping; it mainly occupies the tetrahedral site in a spinel structure, increasing the number of cation vacancies. In terms of anion impact, the sulfidation or phosphorus doping induce the production of an amorphous phase that provides a large number of active sites, and the synergistic effect of the crystalline phase and amorphous phase significantly improves the OER activity. In the presentation, the effects of Zn^{2+} and $PO_4{}^{2-}$ substitution in $FeCo_2O_4$ on the electrochemical OER are explored and compared. Synchrotron-radiation-driven *in situ* near-ambient-pressure XPS is employed to investigate heterogeneous reactions at a liquid–solid interface, allowing for real-time monitoring of the surface reconstruction of the spinel materials during the reaction.

Keywords : OER, XPS, Spinel, electrochemical catalysis

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Abstract No. : **PO-S11-0396**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Piezoelectric DC Generator Using Sequential Polarization Changes

Hyun Soo Kim[1], Hyun-Cheol Song*[1]

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The direct current (DC) grid in rural and remote areas holds considerable promise owing to its higher efficiency and compatibility with intended applications such as charging of electronic devices. Renewable energy sources such as photovoltaics, thermoelectric, and wind turbines are intrinsically DC source of electricity and thus there is emphasis on building DC grid infrastructure. Several clean energy production methods such as mechanical energy harvesters inherently result in the generation of alternating current (AC). Thus, they invariably require AC to DC converters and this introduces additional losses in the system. Direct DC generation from mechanical energy harvesters based upon the high efficiency piezoelectric mechanism will be transformative and result in mass adoption of this technology for applications ranging from powering electronics to driving electrochemical reactions to charging storage systems. Here for the first time, we demonstrate a DC piezoelectric generator that provides continuous output through sequential in-phase polarization variation, yielding an open-circuit voltage of 33.44 V and a short-circuit current of 3.72 mA. Using this output, successful CO_2 electrolysis is demonstrated that lays down the pathway for substantial renewable energy generation through combination of DC mechanical generator with electrochemical cells.

Keywords : Direct-current, Piezoelectric

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Abstract No. : **PO-S02-0395**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Electrical Pumping for Amplified Spontaneous Emission (ASE) in Perovskite Diodes

Jeonghwan You[1], Changsoon Cho[*1]

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Perovskites are recently gaining significant attention in the field of solid-state thin-film lasers as a micropatternable and wavelength-tunable lasing material. Various studies have reported the excellent amplified spontaneous emission (ASE) properties of optically pumped perovskite films, and the focus of research is now shifting towards the realization of electrically pumped perovskite lasers.

This presentation discusses a perovskite device structure that is designed to achieve optical ASE within the full device stack, while also maintaining stable operation at high current densities. Our optical study identifies two critical design principles: creating a large-angle waveguide mode and reducing parasitic absorption losses, which are distinguishable from those for typical perovskite films without electrodes. Such rules are crucial for achieving positive gain in diode-based stimulated emission. To realize a fully electrically pumped perovskite laser, it is essential to enhance the external quantum efficiency at high charge carrier concentrations and lower the ASE threshold. This approach underscores the potential of perovskite as an ideal material for future laser technologies.

Keywords : perovskite, ASE

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Abstract No. : **PO-S07-0394**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Phase-field simulations on morphological diversity of directionally-solidified microstructures with varying anisotropy of solid-liquid interfacial energy

Geunwoo Kim[1], Hyunseok Ko*[1]

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In this study, we investigated the growth morphologies of directionally-solidified microstructures in fcc-based binary model alloys by means of quantitative phase-field simulations. The growth morphology of metallic materials is primarily determined by the anisotropy of solid-liquid interfacial free energy. The anisotropic property is described by anisotropy parameters e_1 and e_2, which characterize <100> and <110> growth, respectively. We investigated the effect of varying anisotropy parameters (e_1, e_2) on the growth morphology during directional solidification, and classified the growth morphologies into <100> and <110> dendrite, and seaweed structures. This classification was based on quantitative criteria using tip undercooling behavior, and a comprehensive morphology map was constructed that depicts the types of growth morphology in e_1-e_2 space. Additionally, our study also extended to the effects of solidification conditions and partition coefficient on the growth morphology. The results showed that the <110> growth region within the morphology map expands as the pulling speed increases, whereas variations in temperature gradient and partition coefficient result in small changes. Furthermore, we also discussed the emergence of doublon and triplet dendrites under weak interfacial anisotropy. The presence of <110> doublon dendrites and <100> triplet dendrites was observed, particularly under high pulling speed (V_p = 1000 mm/s) for the <100> triplet dendrites. The present comprehensive study demonstrates the critical role of anisotropy parameters (e_1, e_2) and solidification conditions in morphology selection during directional solidification.

Keywords : Phase-field simulations, Solidification, Growth morphology, Dendritic growth

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Abstract No. : **OR-S06-0393**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

In-situ transmission electron microscope investigation of the deformation mechanism in nano-pillared CoCrNi-(Si) alloys.

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In recent years, single-phase high- and medium-entropy alloys (HEA and MEA) have rapidly developed due to their extraordinary mechanical properties, for example, high strength with high ductility, especially at extremely low temperatures. However, as compared to low temperatures, HEA and MEA at ambient temperature possess a relatively low strength. Some previous works indicated that a proper addition of Si could significantly increase the overall mechanical properties, including yield strength, ultimate tensile strength, and total elongation. The enhancing mechanical properties could be attributed to the decrement of stacking fault energy via adding Si. The easier formation of twin and HCP structures in Si-containing CoCrNi MEA contributed to the tensile strength.

In this work, to investigate the strengthening mechanism with and without Si addition in CoCrNi medium entropy alloys, in-situ compression tests on nanopillars in a transmission electron microscope (TEM; JEOL ARM300F) were conducted for single-phase equiatomic CoCrNi and $CoCrNiSi_{0.3}$ medium entropy alloys. In the CoCrNi sample, dislocations dominated at the early-stage compression. With the continuing compression, the first slip band suddenly occurred on the (111) plane. While the strain was increased, several planar slip bands could be seen during the compression and then formed shear steps at the surface. The $CoCrNiSi_{0.3}$ sample showed a similar trend (dislocation glide) as the CoCrNi sample at the initial deformed stage. However, as the sample compression proceeded, some stacking faults occurred but disappeared immediately, indicating the addition of Si significantly lowered the stacking fault energy, leading to a different deformation mechanism. The following deformation was accompanied by both dislocation and deformation twin. This work provided direct evidence that adding Si could efficiently decrease the stacking fault energy, thus easily forming twin as deformation behavior. As compared to equiatomic CoCrNi MEA, $CoCrNiSi_{0.3}$ displayed a significantly higher strength due to the twinning mechanism.

Keywords : In-situ compression transmission electron microscopy; CoCrNi medium entropy alloy; Silicon addition; Deformation twin; Dislocation

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Abstract No. : **OR-S12-0392**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Bio-Fabrication of Calcium Carbonate from Biomass Combretum Micrathum Extract for Water Purification Applications

Adama FALL[*1], Balla Diop NGOM[2], Malik MAAZA[1]

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One of the newest innovations on the scene, nanotechnology has special applications and enormous promise for cleaning up waste water of contaminants. A potential replacement for conventional water purification methods is waste water remediation controlled by nanoparticles. The wastewater from regular domestic tasks is discarded in large quantities, contributing to long-term environmental damage and consequently raising the need for purified water. In this work, the aim is focused to fabricated of Calcium carbonate nanoparticles. Calcium carbonate has been successfully produced via green process by utilizing natural extract of Combretum Micrathum(Kinkeliba) biomass leaves and the solvent distilled water at room temperature. This process is making very attention presently in the research of nanoparticles due to its eco-friendly, cost effective, and large scale fabrication possible. In this investigation, the CaCO3-NPs were characterized by utilizing SEM, TEM, Raman, XRD,UV-vis, PL, and FTIR **.** The effect of the CaCO3-NPs was examinate for the treatment of water and lands fertilization. Calcium carbonate was employed as an excellent agent for the environment.

Keywords : Calcium Carbonate, Kinkeliba, Water

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Abstract No. : **OR-S11-0391**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Printable solid polymer electrolyte for direct ink writing of solid-state batteries

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High-performance power sources fabricated using direct int writing (DIW) have attracted considerable interest for miniaturized and customized electronics. Among them, form-factor-free lithium-ion solid-state batteries (SSBs) can be promising candidates due to their high energy density and safety. Herein, we report a printable solid polymer electrolyte (SPE) for all DIW of solid-state batteries. The molecular weight of the main polymer and the composition of the electrolyte were carefully optimized. The rheological properties of our DIW printable electrolyte allow a high printing resolution of ~100 μm and a high ionic conductivity of 0.7 mS cm−1 at room temperature. Compared to a commercial liquid electrolyte and separator, this solid electrolyte is non-flammable and exhibits a low shrinkage or decomposition rate at high temperatures. This polymer solid electrolyte is also well-compatible with LiFePO4 (LFP) exhibiting good rate capability and cyclability at room temperature. Our printable solid polymer electrolyte can pave the way to realize all 3D printed batteries for next-generation arbitrary-shaped devices.

Keywords : DIW printing, Solid polymer electrolyte

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Abstract No. : **PO-S03-0390**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Mimicking the Flexible, Layered Structure of Human Skin for Tactile Sensing by Embedding a Laser Scribed Graphene (LIG) Flexible Hall Sensor

Bokyung Seo[1,2], Hyejin Kim[*1], Inkyu Park[*2]
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When it comes to touch sense by skin, the physical details (normal/tangential/shear force) are defined by how the deformation of the skin activates mechanoreceptors[1][2]. Human skin has an epidermis and dermis and a mechano-receptor for touch sensing, making it ideal for classifying objects with different properties (e.g., texture, hardness, or shape)[1][2]. There have been reports of touch sensors made of hall sensors with a buffer layer and magnetic skin that take their inspiration from human skin. Unlike skin with soft organic mechano-receptors, magnetometer-based skin-mimicking sensors still possess rigid parts (commercial hall sensors)[3], making them hardly flexible. Our method uses laser-scribed graphene (LIG) flexible hall sensors[4] that are structured like the layers of human skin. Magnetic skin acts as the epidermis, a buffer layer as the dermis, and a LIG flexible hall sensor as a cutaneous mechanoreceptor. We could see how the magnetic skin and buffer layer changed when people touched the flexible hall sensor by reading its magnetic flux density (B) values. This demonstrated the effectiveness of laser-scribed graphene hall sensors with a skin-like structure as a touch sensor.

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Keywords : Laser-scribed graphene, LIG, Hall sensor, Mechanoreceptor, Touch sensor

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Abstract No. : **PO-S13-0389**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Enhancing the Photovoltaic Performance of VTD-SnS Thin Film Solar Cells by Pre-baking the SnS Source with Sulfur

RAHUL KUMAR YADAV[1], Pravin Shivaji PAWAR[1], Yong Tae KIM[1], Indu SHARMA[1], Jaeyeong HEO*[1]

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Tin sulfide (SnS) has excellent photovoltaic properties; however, its power conversion efficiency (PCE) is typically below 4%. Sulfur vacancy (V_S) and surface roughness of the vapor transport deposition (VTD)-SnS absorber are the key parameters for the underperformance of solar devices. In this study, we reduced the V_S in the SnS absorber layer by pre-baking the SnS source with a small amount of sulfur powder. This increased the efficiency of the SnS solar cell from 3.39% to 4.82%. As clear from XPS analysis this improvement resulted from the reduction in V_S, and bulk defects, which enhanced the collection of generated charge carriers. We have observed that the shunt properties can be further enhanced by improving the interfacial properties and surface roughness of the film. Therefore, the findings of this study provide a novel approach to increasing the efficiency of SnS solar cells, which may have significant practical implications for the development of efficient and cost-effective solar cells.

Keywords : Thin-film solar cells, Pre-baking of SnS, Efficiency, VTD, Tin sulfide

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Abstract No. : **PO-S14-0388**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Cobalt Iron Nano Cube Encapsulated in N-Doped Carbon Shell for Efficient Hydrogen Evolution in Anion Exchange Membrane Water Electrolysis

Byeong Guk Kang[1], Ru Li Lee[1], Tae Hong Kim[1], Bong Kyun Kang[*1]

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To address the pressing concerns of fossil fuel depletion and environmental degradation, extensive research is underway on hydrogen production via water electrolysis. The formidable energy barrier inherent in electrochemical water decomposition significantly impedes efficient hydrogen generation, thus necessitating the development of highly effective electrocatalysts.

Surface modifications of transition metals offer a promising avenue for reducing the energy barrier associated with the hydrogen evolution reaction (HER), as well as the hybrid structure with carbon materials can augment electrical conductivity and structural resilience. Furthermore, surface engineering through nitrogen doping on carbon shells can furnish electrochemically active catalytic sites.

In this study, we present the synthesis of Cobalt-Iron nano cubes encapsulated within a nitrogen-doped carbon shell. The N-doped carbon shell was obtained through the calcination of a polymer layer coated on a Co-Fe Prussian blue analogue precursor. Additionally, the nano cubes were further encapsulated in a melamine layer to enhance the nitrogen dopant content, thus optimizing the electrocatalytic performance.

The optimized CoFe@highly n-doped shell exhibits a low overpotential (98.2 mV) than CoFe@n-doped shell (133.2 mV) at 10 mA cm^{-2} on alkaline HER performance, and the exhibited performances were stable after 3,000 CV cycles. To commercialize electrocatalyst for hydrogen production, the CoFe@highly n-doped shell was applicated on anion exchange membrane (AEM) device. The CoFe@highly n-doped shell as cathode catalyst in AEM water electrolyzer shows low cell voltage of 1.808 V to achieve current density of 0.5 A cm^{-2}.

Keywords : Water Electrolysis, Electrocatalyst, Surface Modification, Anion Exchange Membrane

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Abstract No. : **PO-S11-0387**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Electric field-driven tunable thermal conductivity materials for heat control device

Byoungjin Yoon[1], Jeyeon Lee[1], Wonjoon Choi[2], Hyun-Cheol Song[1], Sunghoon Hur*[1]

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The field of heat flow control has grown to more efficiently utilize the thermal energy released into the environment. Ferroelectrics induce significant polarization changes within the lattice in response to a range of electric fields, it leads to variations in dipole moment and domain wall size, thereby affecting phonon dispersion relevant to thermal conductivity. Therefore, tunable thermal conductivity materials based on ferroelectrics are suitable for heat control devices, offering advantages such as fast response time, active control capabilities, and simple driving equipment. This study proposes a method to modulate thermal conductivity while enabling high temperature gradient by using bulk-type ferroelectrics. Consequently, Advanced measurement system achieved high precision (≤ 10 mK). Experimental results, characterized by a switching ratio of 1.2, validate the potential to modulate the thermal conductivity of single crystal PMN-PZT. The materials hold promise for application in fundamental thermal circuit components, contributing to the advancement of phonon computing systems using waste heat as a driving source.

Keywords : Heat flow control, Thermal conductivity, Ferroelectrics, Phonon dispersion, Precise measurement

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Abstract No. : **PO-S05-0386**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Atomically-thin 3D structured semiconducting thin films

Jong-Hoon Kang[*1]

[1]*POSTECH*

3D architecture design and process with thin and lightweight components is promising for high-speed and low-power operation towards next generation electronics and optoelectronics. However, constructing 3D nanoscale structures from atomically thin semiconductors is challenging. Here, we present a unique approach to demonstrate three-dimensional (3D) nano-structuring of atomically thin semiconductors using transition metal dichalcogenides (TMDs). For this, the conformal growth of monolayer TMDs (MoS_2, WS_2, and WSe_2) has been optimized on surfaces with nanoscale half-spherical textures, producing wafer-scale optical films with distinct geometry at different length scales. Using this approach, we successfully reprogram their optical properties to produce atomically thin TMD films that are optically isotropic. Our films show optical flatness and uniformity at the macroscale, conformal and continuous films at the mesoscale, and atomic lattice configuration of monolayer TMDs at the microscale. The resulting films show an order-of-magnitude increase in the out-of-plane susceptibility for enhanced angular performance, compared to their flat-film counterparts. We further show that such 3D geometric programming of optical properties is applicable to different TMD materials, offering spectral generalization over the entire visible range.

Keywords : Atomically-thin, three-dimensional (3D) nano-structuring, monolayer TMDs

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Abstract No. : **OR-S03-0385**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Oral**

Nanotransfer Printing of Metal and Metal-oxide Nanopatterns on Electrospun Fibers for Wearable Healthcare Applications

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With the advancement of functional textile technology, the industrial and societal demand for textiles with enhanced functionality has increased. Nanotransfer technology has recently emerged as a promising method for fabricating functional textiles. However, traditional transfer methods face challenges such as difficulties with transfer onto curved fiber surfaces, polymer residues, and delamination of transferred nanopatterns. This study introduces an innovative nanopattern transfer technique that employs surface modification and thermoforming principles on microscale electrospun fibers. The method utilizes covalent bonding and mechanical interlocking to affix nanopatterns to fibers without the need for additional adhesives. The resulting nanopatterned electrospun fibers show great promise for nanophotonic-based wearable healthcare applications. We present two specific wearable healthcare applications that exploit optical properties: surface enhanced Raman scattering-based diagnostics. This versatile textile with a silver nanogap pattern detects glucose in sweat, indicating hypoglycemia and diabetes by the shift of Raman peaks from 1071.0 cm^{-1} to 1075.4 cm^{-1} for glucose concentrations ranging from 0 μM to 150 μM.

Keywords : Nanotransfer, electrospinning, SERS, glucose sensor

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Abstract No. : **OR-S12-0384**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Understanding the Radioactive Cesium Adsorption Mechanism of Prussian Blue Analogue with Various Transition Metals

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After Fukushima nuclear power plant accident in 2011, there are many efforts are being extensively implemented to remove radioactive cesium (^{137}Cs) from environment. ^{137}Cs produces high gamma rays and beta particles with a long half-life (30.1 years) which is essential to remove it from the environment. Various materials, including zeolite, polyoxometalates, and sulfides, are utilized for the removal of ^{137}Cs. Among these, Prussian blue analogues (PBAs) have received significant attention for their high selectivity and adsorption efficiency in ^{137}Cs removal. In this study, the PBAs were synthesized using various transition metals (Co, Cu, Fe, Mn, Ni, Zn), and their physicochemical properties such as specific surface area, ion exchange capacity, lattice parameter and defect site via water molecules were evaluated to ascertain their role in Cs^+ removal. The mechanism of Cs^+ adsorption varied significantly depending on the transition metal ions present in the PBA.Cs^+ adsorption on CoFe and FeFe primarily involves ion exchange reactions with K^+ due to their higher K^+ content compared to other PBAs. Conversely, CuFe and MnFe, characterized by elevated defect levels, undergo an ion exchange reaction between H^+ and Cs^+ as the primary adsorption mechanism. Additionally, NiFe and ZnFe demonstrate increased Cs^+ adsorption capacity when exposed to light irradiation. This enhancement is attributed to their intrinsic light-absorbing properties, which trigger a reduction reaction that aids in further Cs^+ adsorption. In conclusion, the synthesized PBAs, particularly those with varied transition metals, exhibit diverse mechanisms for Cs^+ adsorption, with promising potential to effectively remove ^{137}Cs from a variety of environments.

Keywords : Prussian blue analogue, radioactive cesium, adsorption, physicochemical characteristics

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Abstract No. : **OR-S02-0383**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Graphene/III-V quantum dot mixed-dimensional heterojunction light-emitting didoes using graphene for ultrathin hole injection layer

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Two-dimensional (2D) materials such as graphene have shown great promise for optoelectronic applications due to their unique surface nature. However, realization of high performance device using 2D materials alone still remains challenging and therefore, mixed-dimensional heterostructures such as 2D/0D materials system have emerged as an alternative to enhance material properties and device functionalities. Here we demonstrate graphene/InAs quantum dot mixed-dimensional heterojunction light-emitting diodes with graphene serving as an efficient ultrathin hole spreading layer. The novel 2D graphene/0D quantum dot hybrid devices show 800× stronger electroluminescence output power than LEDs without graphene. We also investigate the energy band alignments at the novel heterojunction interface by measuring ultraviolet photoemission spectroscopy to elucidate the electrical characteristics. This hybrid 2D graphene/0D quantum dot hybrid light-emitting diodes show promise for efficient ultrathin nanoscale light emitting optoelectronic devices.

Keywords : graphene, quantum dot, mixed-dimension, heterojunction, light-emitting diodes

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Abstract No. : **OR-S15-0382**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Effect of Laminated Core Size on Magnetic Properties under Inverter Excitation with Flux Density Waveforms Matching Condition

Junya Kameyama[1], Junya Kameyama[1], Kyyoul Yun[*1]

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It is stipulated that the evaluation of magnetic properties of electrical steel sheets used as the iron core material of motors is performed under conditions where the induced voltage is sinusoidal. However, since the actual drive environment of motors is mainly PWM control by inverters, the evaluation of magnetic properties must be conducted in the actual drive environment. In the past, many studies have examined the effects of inverter control parameters on the magnetic properties of laminated cores under inverter excitation, but there have not been many reports on the effects of core size. In addition, previous studies on the effect of core size have had problems with the method used to measure magnetic properties. The magnitude of the inductance and winding resistance of the excitation coil wound on the core depends on the size of the core. As a result, when the magnetic properties of cores of different sizes were compared, they were affected by differences in the measurement circuits, and the effect of size could not be accurately evaluated. Therefore, in this study, a variable resistance was connected to the conventional measurement circuit for magnetic properties. By changing the resistance value of it, adjusting the time constant of the measurement circuit, and matching the magnetic flux density waveform, the effect of the difference in the measurement circuit was eliminated. When the magnetic properties of three laminated cores with different magnetic path lengths were measured, the difference in iron loss was smaller than 1% with this method, compared to a maximum of 35.2% with the conventional measurement method. These results indicate that the magnetic path length of the core has no effect on the magnetic properties under inverter excitation as well as when measured under conditions where the induced voltage is sinusoidal.

Keywords : laminated core, electrical steel sheet, magnetic properties, inverter

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Abstract No. : **PO-S06-0381**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Study of changes in mechanical properties and electrical conductivity through composition control and plastic deformation process of highly heat-resistant Al alloy

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In relation to responding to green barriers, the development of eco-friendly and lightweight materials is emerging in various industrial fields. Especially in the electronics field, there is a need to develop a new Al alloy to replace Cu, which has high conductivity but has high density and high unit cost.

Accordingly, in this study, a highly heat-resistant Al alloy was developed by selectively adding Y, Sc, and Zr to Al. As a result of comparative analysis of the electrical conductivity and mechanical properties of alloys manufactured through the casting process, Zr caused grain refinement to ensure high mechanical properties, but grain boundaries and precipitated phases hindered the movement of electrons, resulting in a decrease in electrical conductivity. Accordingly, after manufacturing the casting material by adjusting the addition amount of Y and Sc, changes in properties according to the hot pressing process and post-heat treatment process were studied. It was confirmed that Y and Sc dissolved in the Al matrix formed a precipitated phase at the grain boundary during the hot extrusion process, thereby simultaneously increasing electrical conductivity and tensile strength. In addition, through additional heat treatment, a uniform precipitated phase was formed to create an alloy with an electrical conductivity of 60% IACS or more and a tensile strength of 180 MPa or more.

Keywords : High heat-resistant Al alloy, Electrical conductivity, Precipitation, Hot extrusion

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Abstract No. : **IN-S14-0380**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

Organic Semiconductor Photocatalysts for Water split under Solar Irradiation

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Self-assembled PDINH supramolecular is an effective visible-light photocatalyst for oxygen evolution. Strong π-π stacking between PDINH molecules enables effective long-range electrons delocalization and accordingly promotes photo-generated charge migration and separation, leading to its remarkable photocatalytic activity. The highly crystalline perylene imide supramolecular photocatalyst is prepared. The catalyst possesses a breakthrough photocatalytic oxygen performance (40.6 mmolg^{-1} h^{-1}), which is 1353 times higher. The SA-TCPP can powerfully spilt water to hydrogen and oxygen at 40.8 and 36.1 μmol·g^{-1}·h^{-1}. Photogenerated holes work as the most significant radical in the photocatalytic therapy process, which is abundant on the surface of photocatalyst in cytoplasm. The solid tumors was completely removed via photocatalysts injection and red-light irradiation. The donor-acceptor (D-A) TPPS/C_{60}-NH_2 photocatalyst was prepared by ionic self-assembly (ISA) method. The photocatalytic H_2 production rate of TPPS/C_{60}-NH_2 is greatly improved, which is 17.71 times than the pure TPPS.

A highly crystalline urea-perylene imide polymer photocatalyst has been successfully built, which achieves super efficient oxygen evolution production (3223.9 μmol g^{-1} h^{-1}) without cocatalysts. Its performance is 106.5 times higher than conventional PDI supramolecular photocatalyst. The g-C3N4/rGO/PDIP Z-scheme heterojunction has been successfully constructed and shows an efficient and stable photocatalytic overall water splitting performance with H2 and O2 production rate of 15.80 and 7.80 μmol h^{-1}, respectively, about 12.1 times higher than g-C3N4 NS. Meanwhile, the notable AQE of 4.94% (420 nm) and solar-to-hydrogen energy conversion efficiency of 0.30% are achieved. The tetracarboxylic perylene and HOF supramolecules with hydrogen production performance of 120 mmolg^{-1}h^{-1} and 1046 mmolg^{-1}h^{-1} were obtained. In addition, the organic semiconductor photocatalyst also has excellent hydrogen peroxide production ability, and the sunlight conversion efficiency reaches 1.8%.

Keywords : Photocatalysis , Hydrogen , Water Split

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Abstract No. : **OR-S12-0379**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Catalytic Hydrogen Combustion; Kinetic Study and Comparison of the Catalyst Materials

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Catalytic hydrogen combustion (CHC) is an efficient way to mitigate hydrogen slip from industrial processes, overcoming the potential risks of explosion and NO_x emissions. While Pt-based catalysts currently dominate this field, there exists a notable knowledge gap regarding the potential of other transition metals (TMs) and their associated reaction kinetics. In this research, well-dispersed nano-sized TM-Al_2O_3 (TM= Pt, Ru, Co, Ni, Mo) catalysts are synthesized. The catalysts are characterized with spectroscopic and electron microscopy methods. It is found that, during the CHC reaction, competitive oxidation between the catalyst and hydrogen species takes place. Kinetic studies are performed with a new data acquisition approach to collect more data points for kinetic studies. The kinetically controlled region is determined, and the activation energy and pre-exponential factor values are compared between TM-Al_2O_3 catalysts. This information is highly valued for designing supported catalysts and optimizing the CHC systems in different applications with different temperature range requirements.

Keywords : Catalytic Hydrogen Combustion, Transition metal Catalyst, Kinetic control region, Reaction kinetics, Activation energy

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Abstract No. : **OR-S05-0378**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Flexible and Waterproof Functionalized Titanium Carbide MXene for Electromagnetic Interference Shielding

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[1] *UNIST*

Two-dimensional (2D) transition metal carbides (MXenes) have been highlighted owing to their high electromagnetic interference (EMI) shielding efficiency, high electrical conductivity, solubility, and scalable processability. However, MXenes are susceptible to oxidation, particularly in moist environments or water, which limits their industrial use. In this study, we developed water- and oxidation-resistant MXenes through alkyl amine-based surface functionalization between NH_2 and the surface terminations of MXene. Functionalized MXenes exhibited high flexibility and structural stability after 1,000 bending cycles and tensile strength of 35 MPa. Changes in the structural and physical properties depending on the length of the alkyl amine chain and the minimum alkyl chain length required for dispersion in a non-polar solvent were confirmed. Pristine MXenes increased its electrical resistance by 51 ± 5% for seven weeks at relative humidity (RH) 80 and 100 °C; however, functionalized MXenes increased by only 7 ± 2%. Functionalized MXene films maintained a constant current even in water and exhibited waterproof properties, whereas the current quickly decreased in the pristine MXene films. In addition, even when a current was flowed at 1 V for 24 h by immersion in a 3.5 wt% NaCl aqueous solution, which is the same environment as seawater, the current value was well maintained. Functionalized MXene paint was adaptable to various scalable and versatile processes, such as spray coating, paint brushing, and blade coating, for coating curved and flat surfaces. Moreover, the coated functionalized MXene exhibited higher adhesion to the metal substrate than pristine MXene because of the presence of the alkyl chain covering MXene surface. Notably, functionalized MXene achieved high EMI shielding efficiencies of 50, 58, and 68 dB at thicknesses of 5, 10, and 20 μm, respectively.

Keywords : MXene, Surface functionalization, Electromagnetic interference shielding, Waterproof

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Abstract No. : **OR-S15-0377**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Determining an appropriate sampling frequency considering the rise time of the SiC inverter

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In this study, we conducted excitation using a SiC inverter and investigated what kind of difference would occur in magnetic measurement when the sampling frequency was changed. The data measured at 500 MS / s is thinned out so that the data points are the same as 50 MS / s and 5 MS / s to analyze the magnetic characteristics, and the measurement is performed by changing the sampling frequency with an oscilloscope. Was done. When the data was thinned out and analyzed, the maximum magnetic flux density and the iron loss value increased in variation as the sampling frequency became smaller at any carrier frequency. It is considered that the cause of the increase in variation is that when the carrier frequency becomes smaller, the number of data points decreases and the waveform cannot be reproduced accurately. Similar results were obtained when the data was thinned out and analyzed, and when the data was measured at different sampling frequencies with an oscilloscope. At 50 MS / s and 5 MS / s, the average iron loss value was smaller than the sampling frequency of 500 MS / s at any carrier frequency. It is considered that this is because the overshoot is hardly measured as the sampling frequency becomes smaller, and its influence is not taken into consideration. Further, the higher the carrier frequency, the larger the difference in the iron loss value when the sampling frequency was changed. It is considered that this is because the amount of data per pulse cycle decreases as the carrier frequency increases, and the deviation from the accurate waveform increases.

Keywords : SiC device , inverter excitation , magnetic properties , sampling frequency

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Abstract No. : **PO-S11-0376**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Eu and Mn Co-doped High Tc PIN PMN PT Piezoelectric Ceramics for High Power Application.

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The 0.24 $Pb(In_{1/2}Nb_{1/2})O_3$-0.44 $Pb(Mg_{1/3}Nb_{2/3})O_3$-0.32 $PbTiO_3$ (PIN-PMN-PT) has high d_{33} value and Curie temperature (T_C), and the co-doped PIN-PMN-PT was prepared by traditional ceramic process. In high power applications, temperature stability is crucial due to the heat generated by mechanical loss at high frequencies. Therefore, the operating temperature range is limited to $T_C/2$ in order to prevent performance degradation due to heating. In the case of PIN, PMN, and PT, each material exhibits high T_C values of 150ºC, 200ºC, and 490ºC, respectively, allowing them to maintain a T_C exceeding 200ºC even in a ternary system. To reduce heat generation, a high mechanical quality factor is also necessary. If suitable donor dopants with favorable piezoelectric properties can be introduced into acceptor-doped ceramics, it is possible to achieve large d_{33} and high Q_m simultaneously in ceramics doped with both donor and acceptor materials. In the perovskite structure, Eu^{3+} and Mn^{2+} are substituted into the A-site and B-site, respectively. Eu_2O_3 doping induces contraction of the a-axis and b-axis in the phase structure, resulting in local structure heterogeneity, thereby impacting the enhancement of d_{33}. Doping MnO_2 induces a domain pinning effect, which restricts domain wall motion and leads to a higher Q_m. In this study, Mn^{2+} was optimized at 2 mol% and Eu^{3+} at 1-2 mol% through solid-state sintering, resulting in $d_{33} > 400$ pC/N, $Q_m > 600$, and $T_C > 190°C$. Hence, the Eu^{3+} and Mn^{2+} Co-doped PIN-PMN-PT exhibit excellent properties suitable for the high-power applications and it is expected to be applicable to the Templated Grain Growth process to achieve even higher performance.

Keywords : High power application, TGG, Piezoelectric materials, Ceramics, Energy Harvesting

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Abstract No. : **IN-S15-0375**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Enhanced oxygen evolution reaction in alkaline water splitting using (Ni,Fe)-based oxides decorated on surface-modified carbon nanotubes

Sungwook Mhin[*1]

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Noble metal-based electrocatalysts, such as RuO_2 and IrO_2, have been employed for the oxygen evolution reaction (OER) in alkaline water splitting. However, their widespread industrial application is hindered by high costs and limited availability. In this study, we report transition metal-based oxides supported on carbon nanotubes (CNTs) as an efficient electrocatalyst for OER. Experimental results show that amorphous/crystalline oxides anchored on CNTs provide a substantial enhancement in OER performance. Optimized electrocatalysts demonstrate excellent OER activity, with an overpotential of only 286 mV at a current density of 10 mA/cm² and a Tafel slope of 32 mV/decade. This work provides clear evidence that the formation of amorphous/crystalline heterostructure on conductive supports is beneficial for further enhancing the OER performance in alkaline water splitting.

Keywords : water splitting, Carbon nanotube, oxygen evolution reaction, heterostructure

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Abstract No. : **IN-S05-0374**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Invited**

Single-gate programmable graded doping for 2D reconfigurable $MoTe_2$ devices

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Nonvolatile reconfigurable devices can operate in multiple designed functions, offering great opportunities to improve integration levels and decrease power consumption in next-generation electronics. With their ultrathin nature and strong gate control, two-dimensional (2D) semiconductors are promising materials for nonvolatile reconfigurable devices. However, it is a dilemma to realize rich reconfigurable functions with a simple device configuration. In this talk, we will report a flexible effective-gate-voltage programmed graded-doping (EGV-pGD) strategy, which utilizes the programmable synergy among gate, drain, and source terminals, to endow a single-gate 2D $MoTe_2$ device with abundant reconfigurable functions. The reconfigurability of our device, allowing functions of polarity-switchable diodes, memory, in-memory Boolean logics, homosynaptic plasticity, and heterosynaptic plasticity, has surpassed all other reconfigurable devices. Accompanying the rich reconfigurable functions, our device also exhibits extraordinary performance. In particular, as a diode, the device exhibits a rectification ratio up to ~10^4, and as an artificial heterosynapse, it shows heterosynaptic metaplasticity with an ultralow modulatory power consumption that can be reduced to 7.3 fW, only 1/2700 of the lowest value previously reported. Our work provides an effective strategy to realize reconfigurable multifunctionality of 2D devices with the lowest complexity of device configuration and boosts the understanding of gate-controlled graded doping for 2D ambipolar semiconductors.

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Keywords : 2D materials; MoTe2; ambipolar; reconfigurable device; graded doping

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Abstract No. : **PO-S09-0373**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Improving on the reliability characteristics of flash memory through hydrogen control in SiO2/SiNx/SiO2 stack film

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With the evolution of multi-level cell (MLC) NAND flash, finely tuned operation and stable charge retention have become imperative. Nevertheless, continuous charge trap layer (CTL) in 3D-NAND introduces lateral charge migration, exacerbating the reliability challenges of NAND cells. This issue is mainly attributed to shallow traps in CTL that easily lose trapped charge. Despite extensive efforts in CTL engineering to address charge instability, the trade-off between memory window and retention characteristics remains persistent. In this study, we successfully enhanced memory characteristics by creating a number of accessible deep traps within CTL through post annealing. Interestingly, during annealing, trap deformation varied significantly depending on the N/Si ratio of SiNx. Applying N2 ambient annealing on Si-rich SiNx resulted in reinforced retention characteristics, preserving 84% of the memory window over a 10-year retention period. The newly formed Si-Si bonds acted as deep traps, effectively suppressing charge loss. Conversely, annealing N-rich SiNx in forming gas ambient markedly increased the memory window from 4.68 eV to 6.57 eV. The dissociation of N-H bonds led to the passivation of interface traps and the formation of additional Si-H bonds. Consequently, post annealing alleviated the trade-off in memory characteristics for both N-rich and Si-rich SiNx. Our finding guides the direction for advanced CTL design and contribute to the generational expansion in NAND flash development.

Keywords : NAND flash, deep trap, hydrogen, post annealing, retention

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Abstract No. : **KN-S02-0372**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Keynote**

Nano-perovskite materials for high performance light-emitting diodes and photodetectors

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Halide perovskites have raised wide interest these years for photovoltaics, light-emitting diodes, and other applications due to their excellent optical and electronic properties, low cost, solution processability, and diversity as a group of materials. By ligand designs, we will discuss the influences on the phase distribution, carrier transfer and confinement of low dimensional perovskites will be improved. Using blue quasi-2D perovskites LEDs as examples, we can enhance the hole injection for better balance carrier and improve the efficiency[1], we also modulate the n-phase distribution[2,3] and optimize the carrier transfer and confinement to improve the performances of PeLEDs[4]. For perovskite nanocrystals (NCs), we will introduce new ligands to synthesized red color perovskite (CsPbI3) NCs. The ligand can significantly stabilize the CsPbI3 NCs without any crystalline deformation on the NC crystal structure. Additionally, these chemically crosslinked PMA also significantly reduces PbCs deep defects[5]. Overall, the efficiency and stability of the red perovskite LEDs can be significantly improved.

We will also demonstrate new approaches of double-side crystallization and passivation on MA-free Sn-Pb perovskites for UV-NIR photodetection applications[6-8]. The photovoltaic-mode photodetectors show a high and flat efficiency of ~80% at 760-900 nm, a high responsivity of 0.53 A/W, and a high specific detectivity of 6 exp12 Jones at 940 nm. The high-quality Sn-Pb perovskite can be fabricated on metal/Si substrates for promoting direct integration with CMOS electronics and realizing an efficient imaging array [9]. The work contributes to the evolution of perovskite for practical applications in optoelectronic devices.

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Keywords : low-dimensional perovskite, ligand design, LEDs, photodetectors, efficiency, stability, efficiency, operation mechanisms, device physics.

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Abstract No. : **OR-S03-0371**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Oral**

Liquid-Metal-Based Soft Multidirectional Pressure Sensor with Machine Learning Application for Direction and Magnitude Discrimination

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Multidirectional pressure sensors have seen significant research development owing to their wide range of potential applications. Multidirectional pressure is mostly achieved by applying shear pressure to the sensor's four-sensing structure. However, when subjected to applied radial pressure, extracting directional information from a four-sensing element-based sensors' setup remains a formidable challenge. The difficulty arises because the four-sensing element approach is primarily designed for shear force-based applications.

In this study, we present a new solution to address the limitations of existing multidirectional sensors. Our strategy involves the development of a soft sensor, a dome-shaped design that enables discrimination of directional pressures. We utilize machine learning algorithms to discern both the direction and magnitude of applied pressure. The microchannels of the soft pressure sensor were created using fused deposition modeling (FDM). A 3D-printed mold made of poly(vinyl alcohol) was embedded into the elastomer and dissolved with water to create the microchannels. The empty microchannels were filled with liquid metal, and a vacuum process was applied to create the dome structure. When pressure is applied, the microchannels within the liquid-metal-based soft pressure sensor exhibit a transient response. Specifically, each direction of the sensor indicates a distinct transient response when the pressure is applied, which helps to differentiate between different directions of pressure. The machine learning technique we have implemented is based on dual-task 1D convolutional neural networks (CNN). The developed liquid-metal-based soft pressure sensor can detect the direction with a classification accuracy of 99.1% and the magnitude with a regression error of 20% of the multidirectional pressure in real-time pressure prediction through a 1D CNN algorithm. The real-time movement of the vehicle is controlled using machine learning predictions, which encompass the direction and magnitude of the pressure detected by the sensor.

Keywords : liquid metal, 3D printing, soft sensor, machine learning, human-machine interaction

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Abstract No. : **KN-S05-0370**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Keynote**

Boosting bulk photovoltaic effect in transition metal dichalcogenide by edge semimetal contact

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The bulk photovoltaic effect (BPVE) has traditionally been observed in non-centrosymmetric oxide materials, yet its cell efficiency was too negligible for practical use. Recently, significantly larger BPVE coefficients have been noted in two-dimensional (2D) materials, albeit under specific extrinsic operational conditions such as strain engineering and the use of heterointerfaces, depolarization fields, and edge-embedded structures. However, harnessing these materials' intrinsic BPVE potential for practical applications continues to pose a significant scientific challenge. In this context, we have achieved a significant milestone in enhancing the intrinsic BPVE of 3R-MoS_2 by utilizing edge contact (EC) geometry with a bismuth semimetal electrode. Unlike the traditional top contact (TC) geometry, EC geometry enables full exploitation of the in-plane spontaneous polarization of the underlying layers, resulting in a photocurrent BPVE enhancement of more than 100 times. As a result, the performance of the EC-based BPVE device is now constrained by the depth of light penetration instead of electrode contact. Furthermore, by engineering a 3R-MoS_2/WSe_2 heterojunction, we have successfully demonstrated the synergistic integration of BPVE with the photovoltaic effect (PVE), marking a significant leap forward in the pursuit of practical applications in this domain.

Keywords : bulk photovoltaic effect; Edge contact; 2D materials

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Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Dual molecular bridges at perovskite heterointerfaces for efficient inverted solar cells with fill factor beyond 0.87

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Utilizing molecular bridges presents a promising means to enhance the performance of perovskite solar cells (PSCs) by boosting fill factor (FF). However, concurrently bridging the perovskite absorber and its adjacent interfaces is challenging. Here, we construct dual molecular bridges at perovskite heterointerfaces, enabled by a self-organizing additive of 4-fluoro-phenethylammonium formate (4-F-PEAFa) and a customized hole transporter of [2-(7H-dibenzo[c,g]carbazol-7-yl)ethyl]phosphonic acid (DBZ-2PACz). The molecular bridges spanning two interfaces lead to the formation of an "integral carrier transport pathway", mitigating both non-radiative recombination and charge-transport losses in the fabricated PSC devices. We thus achieve a remarkable power conversion efficiency (PCE) of 26.0% (25.6% certified) in inverted PSCs, accompanied by a high fill factor of 0.87 and a low ideality factor of 1.06. The unencapsulated devices retain 96% of their PCEs after aging at 85 °C for 2200 hours and 90% after maximum power point tracking at an elevated temperature of 50 °C for 973 hours.

Keywords : perovskite solar cells; molecular bridges; self-organizing additive; hole transporter; fill factor

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Abstract No. : **OR-S11-0368**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Improved Dielectric and Energy storage properties of $BaTiO_3$ ceramics by addition of Sm_2O_3

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$BaTiO_3$ (BTO) is a representative ferroelectric material for capacitors. It’s extensive applications across diverse fields stem from such strengths as outstanding piezoelectric properties, the ability to change polarization direction under an external electric field, and to modify electrical properties through doping. However, the pure BTO ceramics has their T_c of approximately 120°C, which limits their suitability for high-temperature components. Also extensive changes in dielectric properties occur at T_c, leading to diminished dielectric properties at room temperature (RT). Therefore, by doping suitable additives into BTO, these limitations can be overcome, allowing remarkable and stable dielectric properties, thereby enhancing the applicability of the material in various applications. In this work, we studied the changes in the dielectric properties and energy storage performance of BTO ceramics with the addition of Sm_2O_3. BTO ceramics were synthesized via a solid-state route varying amounts of Sm_2O_3. The increment in Sm_2O_3 content resulted in decreased tetragonality and grain growth. These engendered the results that lowered the T_c, thereby increasing the dielectric constant at RT. Moreover, with higher Sm_2O_3 content, the stability of the dielectric properties improves under an applied electric field. Comparing the hysteresis characteristics (Polarization-Electric field; P-E) across different Sm_2O_3 contents, it was observed that dielectric breakdown strength (DBS) increased and the remanent polarization (P_r) decreased from 9.3 to 6.1 μC/cm^2, with 160% increase in energy storage density compared to pure BTO displaying narrower P-E loop. Simultaneously, it showed an energy storage efficiency exceeding 90%, thus affirming the potential of Sm_2O_3-doped BTO ceramics as capacitors suitable for high-energy storage density applications.

Keywords : BaTiO3, Sm2O3, dielectric properties, energy storage, capacitors

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Abstract No. : **IN-S17-0367**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Invited**

Halide perovskite films for high-power hybrid nanogenerator and storage device applications

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Halide perovskite, renowned for multifunctional properties, holds significant potential for realizing self-charging power systems, representing a pivotal advancement in sustainable energy technology. Herein, the potential application of a lead-free methylammonium bismuth iodide ($MA_3Bi_2I_9$) perovskite for a self-charging power unit is demonstrated. This involves constructing a hybrid piezoelectric-triboelectric nanogenerator (HP-TENG) and utilizing $MA_3Bi_2I_9$ for energy storage as a cathode in a lithium-ion battery (LIB). Initially, synthesized $MA_3Bi_2I_9$ nanorods were composited with polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene (SEBS) polymer, and the dielectric and mechanical properties of composite films with perovskite loading content were investigated. The optimized HP-TENG exhibited superior performance, generating a voltage of 537 V, current density of 13.2 μA/cm² and maximum power density of 3.04 mW/cm^2 attributed to the high piezoelectric coefficient of $MA_3Bi_2I_9$ nanorods (~20.6 pm/V). Moreover, $MA_3Bi_2I_9$ thin films, serving as a cathode in LIB, demonstrated the highest specific capacity of 2378.9, mAhcm^{-3} with a capacity retention of ~87% for 150 cycles, underscoring its stable performance. Furthermore, HP-TENG was employed to charge the $MA_3Bi_2I_9$-based LIB, showcasing the realization of a self-charging power unit for small-scale electronics. This study underscores the promising potential of perovskite materials in the development of high-performance nanogenerators and LIBs.

Keywords : PENGs and TENGs, halide perovskite films, Storage

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Abstract No. : **OR-S11-0366**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

Nanoclustering of $PbZrO_3$-$PbTiO_3$ Ceramics to Form Artificial Morphotropic Phase Boundary by Aerosol Deposition

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Ferroelectrics have been utilized in various fields thanks to their high-performance electrical property when the composition of phases is achieved to the morphotropic phase boundary (MPB) region which is defined as a boundary of two distinct ferroelectric phases. Conventionally, the MPB has been formed in a limited way to adjust the composition due to the limitations in solubility. Due to this limitation, densification via sintering has been considered as the only method of choice, often accompanying grain growth or secondary phases caused by chemical reactions. As a solution to the limitations of forming MPB, nano-crystalline film fabricated through the nanoclustering using aerosol deposition (AD) can implement the MPB artificially accompanied by the nano-crystalline structure without the compositional alert or phase transitions. The artificially introduced MPB in thick films can generate strong bonding at the interfaces between different phases. This study demonstrates that the composite thick films comprising nanoclustered PZ and PT with an artificially induced MPB, present enhanced electrical properties which are similar to the MPB properties observed in single-phase PZT thick films.

Keywords : Morphotropic phase boundary, nano-clustering, Pb[Zr0.5Ti0.5]O3

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Abstract No. : **IN-S02-0365**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Invited**

Image sensors with thin-film photodiode based on novel materials

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Image sensing technology has become increasingly advanced and is widely used in our daily lives. Currently, mainstream image sensing is silicon-based and uses visible or near-infrared light, but there has been a lot of research into new material-based image sensing to use different wavelengths to capture a wider range of information or to enable image sensors with different form factors. In particular, thin film photodiodes based on new materials such as organics, quantum dots and perovskites have attracted a lot of attention due to their advantages such as easy expansion to different wavelength bands, large area processing at low cost and monolithic integration on silicon.

This presentation will introduce thin film photodiode based image sensor technologies. The basics of the thin film photodiode image sensors will be described with a focus on the quantum dot based short wavelength infrared image sensor technology. In addition, the limitations of current thin film photodiode based image sensor technology will be presented along with technologies that can overcome these limitations.

Keywords : Image sensor, Qunatum dot photodiode, Organic photodiode

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Abstract No. : **PO-S12-0364**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Magnetic levitation properties of large-grain YBCO superconductors fabricated by multi-seeding technique

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Superconductors can be used in energy storage devices that utilize the magnetic levitation force between the superconductor and the permanent magnet. The total energy saved depends on the magnetic levitation force of the superconductor against the permanent magnet. Since levitation force is a function of the size of the shielding current loop (grain size) and the critical current density (Jc), the grain size of the superconductor must be increased to increase the stored energy. In this study, a 4-6 cm-sized YBCO superconductor was fabricated by a multi-seed melt growth process. The raw powders were mixed and pressed in a steel mould into pellets. SmBCO crystals with c-normal directions were used as seeds. The melt growth heated treatment was applied to the seeded powder compacts. The prepared pellets were heated-treated in flowing oxygen for oxygen embedding. The multi-seeding method shortened the heat treatment time without significant reduction in levitation force of large-grain YBCO bulk superconductors. In addition to the large magnetic levitation force, YBCO superconductors showed attraction to permanent magnets due to the flux peening capacity. This material is expected to be utilized as a superconducting bearing in energy storage devices consisting of superconductors and permanent magnets.

Keywords : superconductor, YBCO, levitation force, attraction, multi-seeding

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Abstract No. : **PO-S05-0363**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Atomically Engineering Activation on Transition Metal Dichalcogenide for Hydrogen Evolution Reaction

Yeoseon Sim[1], Aram Yoon[1], Heeseong Kang[3], Jinsung Kwak[4], Min Hee Lee[1], Jae Sung Lee[1], Chul-Ho Lee[2], Zonghoon Lee[1], Soon-yong Kown*[1]

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Atomic-scale deformation of two-dimensional transition metal dichalcogenides (2D TMDs) via structural engineering including phase tuning, defect engineering, and construction of porous/holey architectures, is critical to improving the hydrogen evolution reaction (HER) activity of an electrocatalyst. However, the electrochemical instability of structural deformation under an operating environment has been a significant barrier to realizing their application, as it results in decreased HER activity and the limited lifespan of these catalysts. Here, we reported an intriguing approach to generating atomic-scale deformation of 2D layered catalysts through 2D heterojunction with symmetry discrepancies using a heteroepitaxial conversion process and demonstrated considerable potential in electrocatalysis for TMD catalysts with distorted lattices. We used single-crystalline WTe_2 nanobelts as a starting template for their coherent conversion to WS_2. During the conversion process, the hybrid WTe_2/WS_2 heterostructure containing both lateral and vertical junctions was obtained by coherent heteroepitaxial stacking despite differences in symmetry. The lattice coherency drives spontaneous out-of-plane deformations at a nanoscale that relaxed the lattice misfit-induced stress. More importantly, such out-of-plane deformation of layers leads to an improved HER activity. Our electrochemical analyses revealed that structurally deformed lattice in WS_2 allows the activation of basal plane. The optimized, structurally-deformed WS_2 displayed a substantial reduction in the overpotential at 10 mA cm^{-2} (~95 mV) and a small charge transfer resistance (~5.1 Ω). Together with an apparent increase in intrinsic activity, these thermodynamically favorable atomic-scale engineering techniques enabled the stable operation of the fabricated catalysts with high HER performance (~237 mV at 10 mA cm^{-2}) over 54,000 cycles. Our results can provide a promising design for efficient and sustainable distorted TMD-based electrocatalysts for use in clean energy conversion processes through structural engineering techniques.

Keywords : transition metal dichalcogenides, hydrogen evolution reaction, structural engineering

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Abstract No. : **IN-S10-0362**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Invited**

Bioactive Polymeric Hydrogels for In-Situ Tissue Regeneration

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Polymeric hydrogels have attracted substantial attention as promising materials for tissue engineering and regenerative medicine due to their tunable properties and structural similarity to the natural extracellular matrices. An emerging paradigm in designing advanced hydrogels is to create bioactive matrices promoting endogenous tissue regeneration *via* host tissue stimulation by physicochemical cues of the hydrogel materials. This presentation discusses how the hydrogels are designed to create bioactive matrices that can recapitulate or stimulate native tissues to facilitate endogenous tissue regeneration. Specifically, we focus on introducing bioactive hydrogels releasing molecular oxygen or therapeutic ions for enhanced wound healing and tissue regeneration.

Keywords : Polymeric hydrogels, in situ tissue regeneration, engineered extracellular matrices, tissue engineering and regenerative medicine

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Abstract No. : **IN-S04-0361**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

SMART Metallization for Commercialization of Thin-Film-Based Electronic Skins

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Since 2011, thin-film-based electronic skins have been immensely developed for overcoming the limitations of chip-based wearable electronics. These electronic skins can form seamless contact with the skin, minimizing mechanical mismatching and providing users with imperceptible wear and accurate monitoring data. Unfortunately, critical issues hindering the commercialization of electronic skins remain unresolved. In this talk, I will describe my group’s efforts to advance electronic skins to the commercialization stage by addressing the issues such as (1) conformability degradation, (2) high material costs, and (3) performance-maturity dilemma. First, I will present sweat-pore-inspired perforation engineering, which enables electronic skins to maintain long-term conformal sensing for over a week, even under profuse sweating in daily life. Second, I will suggest copper-based metallization processes to form cost-effective, deformable interconnects with stretchability and stability comparable to gold. Additionally, we have developed stretchable and transparent electronic skins based on commercial-level conductive oxide films, avoiding the use of immature materials such as metal nanofibers. All these results demonstrate my group’s core technology and a research goal: SMART metallization and the realization of free-form complaint edges, respectively.

Keywords : Electronic skins, Commercialization, Structural engineering, Metallization

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Abstract No. : **IN-S10-0360**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Invited**

Biomimetic hydrogels for bioelectronics

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As a new class of materials, implantable flexible electrical conductors have recently been developed and applied to bioelectronics. An ideal electrical conductor requires high conductivity, tissue-like mechanical properties, low toxicity, reliable adhesion to biological tissues, and the ability to maintain its shape in wet physiological environments. Herein, a facile method for manufacturing a new conductive hydrogel through the simultaneous exfoliation of graphite and polymerization of zwitterionic monomers triggered by microwave irradiation is introduced. The mechanical properties of the obtained conductive hydrogel are similar to those of living tissue, which is ideal as a bionic adhesive for minimizing contact damage due to mechanical mismatches between hard electronics and soft tissues. Furthermore, it exhibits excellent adhesion performance, electrical conductivity, non- swelling, and high conformability in water. This hydrogel has demonstrated tissue-like extraneuronal electrodes, which improve the tissue-electronic interfaces, promising next-generation bioelectronics applications.

Keywords : bioelectronics, hydrogels, adhesives, viscoelasticity

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Abstract No. : **PO-S05-0359**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

Broad-Range Modulation in a Single MoS_2 Transistor Utilizing Hybrid-Gating-Empowered Controllable Phase Transition

Jaeeun Kwon[*1], Hanbin Cho[1], Kyungmin Ko[1], Hoon Kim[1], Seonguk Yang[1], Han-Hee Cho[1], Joonki Suh[1]

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Two-dimensional (2D) materials such as graphene or transition metal dichalcogenides (TMDs) have a unique layered structure; Both high surface-to-volume ratio and the existence of the van der Waals gap allow them to strongly interact with guest materials. This property enables the use of two strategies in device design: **Gating** and **Intercalation**, which are difficult to utilize in three-dimensional structures. Conventional transistors utilizing the guest-species interactions (= ionic gating) can effectively control the charge in the channel due to their high capacitance(>1uF/cm^2), showing highly synergistic with very thin two-dimensional TMD materials. However, to date, ion-gated devices have only been operated in a very conservative voltage range due to device stability and high leakage current issues at high voltage. Through the implementation of a novel hybrid dual gating approach, integrating both solid dielectric (bottom gate) and ionic liquid electrolyte (top gate), precise control over electrostatic and electrochemical aspects is achieved even at high voltages. This device structure works through a mechanism that couples physical as well as chemical doping effects and can control the voltage at which the phase transition occurs facilitating the diversification of the conductivity of the channel in a single device. We have also shown that even at high voltages, stable operation with very low leakage current(<10^{-11}A) is possible by blocking redox reactions at the gate through gate electrode passivation. This innovative strategy not only enhances device performance but also significantly improves the stability of the system. The controllable phase transition within the MoS_2 channel presents an intriguing avenue for diverse applications, ranging from the development of electrochemical transistors to the realization of rapid-switching devices. The inherent versatility of this approach not only promises innovation but also heralds adaptability in semiconductor device technology, marking a significant advancement in the field of electronics.

Keywords : 2D Transistor, Phase Transition, Hybrid-gating, Broad-range interaction

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Abstract No. : **PO-S13-0358**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Ge-doped Sn-Pb assisted by MACl triple metal cation perovskite solar cells with high open-circuit voltage

Seri Lee[1], Gyu Min Kim[3], Tsutomu Miyasaka[2], Se Young Oh[*1]

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The potential to achieve the best photovoltaic properties by incorporating Ge into Sn-Pb-based perovskites (PVKs) is theoretically plausible. However, practical implementation is hindered by critical obstacles associated with Ge-containing precursors, such as poor solubility and extremely low stability. Furthermore, the application of Ge in PVKs is limited, particularly when combined with Sn-Pb-based PVK, owing to the instability of Sn and Ge within the same precursor. Herein, we report a groundbreaking method for inserting Ge into Sn-Pb PVK using volatile additives, resulting in high-performance Sn-Pb-Ge triple metal cation PVK solar cells (PSCs). Adding methylammonium chloride (MACl) facilitates the dissolution of germanium iodide (GeI_2) through anion exchange in the precursor, which evaporates during high-temperature annealing after the formation of the PVK films. The resulting low-bandgap PVK (1.228 eV), containing 3% Ge, exhibits increased grain sizes and a significantly improved open-circuit voltage of 0.834 V, which can be attributed to a reduced energetic offset. The Sn-Pb-Ge triple metal cation PSC exhibits a power conversion efficiency of 20.7% and enhanced stability.

Keywords : Perovskite solar cells, Triple metal cation perovskite, Low-bandgap perovskite, Germanium iodide, Methylammonium chloride

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Abstract No. : **PO-S05-0357**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Two dimensional high entropy transition metal chalcogenide for acidic oxygen evolution reaction

Seunghwan Jo[1], Yogendra Rosyara[1], Liting Zhang[1], Keon Beom Lee[1], Ruhao Cui[1], Jung Inn Sohn*[1]

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Oxygen evolution reaction (OER) in highly acidic environments in proton exchange membrane water electrolyzers (PEMWEs) has only been studied in iridium and/or ruthenium-based noble metal oxides due to significant mismatch between a potential region of thermodynamically stable solid state and OER potential region. In this work, high-entropy non-noble transition metal chalcogenide composed of Co, Fe, Ni, Mo, W, and Te is proposed as an acidic OER electrocatalyst candidate for PEMWE application. The CoFeNiMoWTe exhibits porous arrayed two-dimensional nanosheet morphology with a glassy structure and improved catalytic performance and stability by virtue of optimal charge valence states of active metal sites (Co, Fe, and Ni) and higher configurational entropy. The PEMWE assembled with platinum-carbon cathode, Nafion proton exchange membrane, and CoFeNiMoWTe anode shows a low cell voltage of 1.81 V at a practically high current density of 1 A cm^{-2} and the cell performance maintains for 100 h at the same current density with a small potential increase of 30 mV.

Keywords : two dimensional materials, high entropy materials, transition metal chalcogenides, electrocatalysis, oxygen evolution reaction,

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Abstract No. : **IN-S07-0356**
Symposia : **Computational Materials Science**
Abstract Preference : **Invited**

Machine learning-aided design of biodegradable polymers

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In pursuing sustainable materials, biodegradable polymers have emerged as promising alternatives to traditional plastics, finding applications across diverse industries. Particularly, the degradation products of conventional plastic are of specific concern, and fully biodegradable and non-toxic plastic alternatives offer promising solutions to this ongoing challenge. However, a rational design approach to engineer biopolymers for degradation after their intended use remains elusive. This is largely due to our inability to understand and model performance metrics (such as weight loss over time) capturing the degradation behavior of these materials as a function of chemical, geometric, and environmental factors. As an exciting development in this direction, we have established predictive machine learning models that utilize physics-informed deep neural networks (NN) on previously established, manually curated experimental data that characterizes the weight loss behavior of fully biodegradable polyester copolymer samples in both water and soil natural environments. The models were applied in a series of experiments to predict the mass loss of approximately 10,000 structural and compositional variations of the 230 homo- and copolymers originally included in the original training set. The predicted mass loss for these candidate biodegradable polymers over 365 days allowed us to identify novel copolymers with the potential to replace existing chemistries while matching property values to the desired performance metric ranges. This talk will discuss our findings and future directions, including the integration of critical properties, such as thermal and mechanical characteristics, into the screening and design workflow, bringing us one step closer to realizing the grand vision of a sustainable circular plastic economy.

Keywords : Polymer, Machine learning, biodegradable

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Abstract No. : **OR-S11-0354**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Piezoelectric energy harvesters derived from epitaxial Pb(Zr,Ti)O_3 thin films on Si substrate for MEMS application

SANGHYO KWEON[1], Isaku Kanno[*1]

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To produce high-performance piezoelectric energy harvesters (PEH), piezoelectric thin films with a large figure of merit (FOM) are required. The FOM in PEH is defined as $(e_{31,f})^2/\varepsilon_0\varepsilon_{r,33}$ where $e_{31,f}$ and ε_r indicate direct piezoelectric coefficient and relative dielectric constant, respectively. Furthermore, it is strongly recommended to use Si as a substrate material for MEMS applications. In this study, PEHs were fabricated based on epitaxial Pb(Zr,Ti)O_3 (PZT) thin film which is a well-known material with a large $e_{31,f}$ and a small ε_r. The epitaxial PZT thin films were deposited on Si substrates (PZT/Si) by an RF magnetron sputtering. The Zr/Ti ratio of the thin films was controlled by using sputtering targets with various compositions and by combining them. Meanwhile, the direct $e_{31,f}$ values were evaluated by an unimorph cantilever method which is also applicable to the assessment of PEHs' performances. The PZT/Si cantilever with Zr/Ti = 58/42 exhibited a direct $e_{31,f}$ of 10.4 C/m^2 along with a ε_r of 285, resulting in the FOM of 43 GPa. Moreover, this cantilever presented a high output power of 158.0 μW at a resonant frequency of 421 Hz under an acceleration of 11 m/s^2, which is very promising for the high-performance PEH applications.

Keywords : epitaxial growth, piezoelectric energy harvesters, PZT composition, Si substrates, transverse piezoelectricity

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Abstract No. : **PO-S15-0353**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Synthesis and thermoelectric performance of a layered oxychalcogenide compound $LaCuS_{0.25}Se_{0.75}O$

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Layered oxychalcogenide *RETMCh*O (*RE*:rare-earth, *TM*:transition metal, *Ch*:chalcogen) is known as a compound that exhibits various electronic properties such as transparent *p*-type conductivity and high thermoelectric efficiency. The crystallographic structure of *RETMCh*O can be composed by variety of elements, which are replacd by several *RE* and *TM* as cations and *Ch* as anions. Furthermore, the carrier transport is seemed as two-dimensional because the carrier-conducting *TMCh* layer and the carrier-blocking *RE*O layer are sandwiched in an unit cell. In the unit cell, a square lattice is formed by *TM* of the constituent elements. LaCu*Ch*O is a a representative *RETMCh*O. In 2000-2010, several reserchers had tryed to generate *p*-type carrier in LaCu*Ch*O using aliovalent ion doping in the insulating *TMCh* layer. Hiramatsu *et al.* (2010) and Goto *et al.* (2014) reports that Cu deficient is a dominant factor to generate *p*-type carriers in LaCu*Ch*O.

In this study, polycrystalline $LaCuS_{0.25}Se_{0.75}O$ samples were synthesized via solid state reaction. Purity of the obtained bulk samples was examined by X-ray diffraction (XRD) using CuKalpha radiation (Rigaku Rint 2500). Total diffuse reflectance spectra were measured using a spectrometer equipped with integrating sphere (Hitachi High-Tech, U-4100). Electrical resistivity (rho) was measured by the four-probe method. Thermal conductivity (kappa) and seebeck coefficient (S) were measured by the steady state method to evaluate dimensionless figure of merit (ZT) of the samples. The samples exhibit optical band gap ~ 2.83 eV. Broad optical absorption around 2.3 eV was also observed indicateing in-gap states due to Cu deficiency. rho = 55 Ωcm, kappa = 5.2 $Wm^{-1}K^{-1}$, S = 339 $microVK^{-1}$, giving ZT ~ $2\cdot10^{-5}$ at 673 K.

Keywords : Layered oxychalcogenide, LaCuS0.25Se0.75O, X-ray diffraction pattern, Dimensionless figure of merit, ZT

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Abstract No. : **PO-S09-0352**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

High-performance oxide semiconductor TFT with IGZO/In-rich IGZO heterostructure using the co-sputtering process

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Over the past decade, research on Indium Gallium Zinc Oxide (IGZO) has been active due to its superior characteristics, such as high electron mobility, transparency, and flexibility, which make it highly suitable for various electronic applications, including thin-film transistors (TFTs) for displays and sensors. Previous studies on IGZO have explored various methods, including plasma treatment, functional layer treatment, and surface treatment, to enhance the performance of IGZO. These processes have typically been conducted ex-situ, however, the development of simplified in-situ processes is required to be applied directly in practical display manufacturing. In this work, we present a novel approach to enhance the performance of display active layers through the utilization of a heterostructure TFT comprising IGZO and In-rich IGZO. This approach involves the co-sputtering technique, which allows for precise control over the composition of the active layer. By controlling the oxygen injection concentration during the co-sputtering process, we were able to increase the Indium concentration while maintaining control over oxygen vacancies. Additionally, the co-sputtering process enabled us to enhance the mobility and on/off ratio of the In-rich IGZO layer. Furthermore, by utilizing the heterostructure of IGZO and In-rich IGZO, we could also improve the sub-threshold swing of the TFT. Our results not only demonstrate significant improvements in TFT performance metrics, showcasing the potential of this heterostructure design for high-performance display applications, but also suggest new prospects in the field of future TFT processes.

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Keywords : Thin film transistor (TFT), Heterostructure, Oxide semiconductor, Indium Gallium Zinc Oxide (IGZO), Co-sputtering

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Abstract No. : **OR-S10-0351**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Oral**

pH-Responsive Hydrogel with Sustained Antibiotic Release for Osteomyelitis Therapy

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Osteomyelitis (OM) is still the most encountered problem during surgical treatments, often leading to surgical failure. A combination of surgical debridement of the infection site and systemic administration of antibiotics is considered to be a treatment for osteomyelitis. However, this treatment approach not only prolongs the curing time of the patient but also induces bacterial resistance-associated side effects. Herein, we have developed a local drug delivery system (DDS) that can be applied as the precaution, in which the DDS can sustain the release of antibiotics at the potential infection site. Antibiotic drugs have been successfully loaded within a hydrogel-based DDS developed through the cross-linking of chitosan-boronic acid (CS-BA) with protocatechuic aldehyde (PA). The hydrogel, cross-linked through boronate ester and Schiff base linkages, can be disassembled in response to acidic conditions due to its pH responsiveness. Thus, considering the acidic condition at the inflammation site, the drug loaded in the DDS is predominantly released at the targeted site. Moreover, we have demonstrated that the DDS showed outstanding antimicrobial activity, antioxidation, and biocompatibility performances, with shear-thinning properties allowing facile injection. We believe that our developed DDS will bring revolutionary changes for the prevention of osteomyelitis.

Keywords : Osteomyelitis 、 Local drug delivery system 、 Hydrogel 、 pH responsiveness 、 Antimicrobial activity

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Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Investigation of surface engineering for $CsPbBr_3$ perovskite quantum dots in photovoltaic and QLEDs applications.

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Lead halide perovskite quantum dots have been considered as the most promising materials for next-generation optoelectronics because of their high light absorption, narrow emission, and excellent photophysical and optoelectronic properties. Organic ligands with long hydrocarbon chains used as ligands in quantum dot synthesis should be exchanged to short organic/inorganic ligands for improving the charge transporting in optoelectronic device applications. However, previous research related to surface ligand exchange for solar cell application have been largely focused on iodide-based $CsPbI_3$ perovskite quantum dots so far. For various solar cell applications such as tandem solar cell and Building-integrated photovoltaics (BIPVs), ligand exchange studies on bromide- and chloride-based perovskite quantum dots should be performed. Herein, we demonstrate that surface ligand exchange studies of green-emitting $CsPbBr_3$ perovskite quantum dots, utilizing several materials such as NaOAc. Improved charge transporting property within $CsPbBr_3$ perovskite quantum dot thin films contribute to the electroluminescent solar cell applications with high open-circuit voltage of 1.6 V and power conversion efficiency of 3.9 %. Also, quantum dot light-emitting diodes with $CsPbBr_3$ perovskite quantum dots was fabricated via interfacial engineering, showing 6.5% of EQE and 22.5 cd/A of current efficiency.

Keywords : Quantum dot, perovskite, QLED, Photovoltaic

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Abstract No. : **PO-S04-0349**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

Ag Core – Ag_2Se Shell based Stretchable Thermoelectric Fiber with Nanoparticle Networks for Wearable Electronics

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Amidst the swift progression in wearable technology, electronic fibers have become an indispensable element in the arena of functional textiles, demonstrating a broad spectrum of capabilities including connectivity, sensory detection, and energy generation. This breakthrough is catalyzing the development of innovative fiber-based wearable electronics, ranging from electronic skins and health sensors to sophisticated human-machine interfaces. The complexity of joining single-function fibers and the critical need for their compact integration within wearable platforms necessitate the creation of advanced multi-functional electronic fibers. Herein, we have fabricated a novel Ag core – Ag_2Se Shell based stretchable thermoelectric (TE) fiber, engineered through selective chemical reduction, poised to redefine the integration within wearable electronics. Ag and Ag_2Se nanoparticles (NPs) were embedded into a polyurethane fiber matrix, yielding a composite with extraordinary elasticity to mechanical deformation coupled with consistent electrical durability. The fiber maintains electrical even after enduring 10,000 cycles of 20% tensile strain and preserves a Seebeck coefficient of -92 μV/K up to a 100% tensile strain, with the variation in output voltage remaining under 1.752%. The successful application of selective chemical reduction facilitates the formation of efficient n-p pairs, crucial for augmenting the thermoelectric efficiency of the fiber. This technique simplifies the manufacturing process while expanding the functional potential of wearable fibers. Consequently, the Ag core – Ag_2Se shell-based fiber emerges as a versatile and robust component, ideal for the demands of cutting-edge wearable devices, and marks a significant stride toward seamless integration of high-performance and multi-functional wearable systems.

Keywords : silver selenide (Ag2Se); stretchable thermoelectric fiber; strain sensor; temperature sensor; energy harvesting; wearable electronics

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Abstract No. : **IN-S02-0348**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Invited**

Surface Engineering for Efficienct and Stable Perovskite Nanocrystal-Based LIght-Emitting Didoes

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Metal halide perovskites have gained attention as high-performance light-emitting diode (LED) materials owing to their excellent optical properties, such as facile bandgap tuning, defect tolerance, and high color purity. Furthermore, perovskite nanocrystals (PNCs) have attracted attention as high-performance LED applications due to their high exciton binding energy, high photoluminescence quantum yield (PLQY), and quantum confinement effect-driven bandgap tuning capability. However, due to the high surface-to-volume ratio, controlling sensitive surface characteristics is essential for achieving high-quality PNCs. In that sense, the importance of surface engineering has been highlighted, as the surface characteristics significantly affect the performance of PNCs, such as optical properties, electrical properties, and stability. In this talk, I will delve into the importance of surface engineering with several ligand materials and strategies to achieve high-quality PNCs for the LED application.

Keywords : Metal Halide Perovskite, Nanocrystals, Light-Emitting Diodes

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Abstract No. : **PO-S09-0347**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Microstructure and Mechanical properties of Sn-Sb-Cu-Ag lead-free solder for power devices

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Wide band gap (WBG) power semiconductors operate in higher voltage and higher frequency switching environments than Silicon (Si)-based power semiconductors. Therefore, it is expected to operate at a temperature higher than operating temperature of Si semiconductor (i.e., about 150 °C), and the thermal stress applied to the joint is significant. In order to withstand harsh thermal cycling and high temperature environments, the reliability of solder joints must be improved. For this reason, the research and development of high temperature solder is attracting attention. Sn-Sb based solder has a high melting point, making it more suitable for high-temperature applications than the conventional SAC305 solder. In this study, we systematically investigated the mechanical properties, microstructure, and intermetallic properties of joints using high-temperature Sn-Sb based solders added with Cu and Ag. Additionally, the growth of intermetallic compounds in solder interface was investigated in a high-temperature environment to determine microstructural behavior.

Keywords : Power device, lead-free solder, Interfacial microstructure

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Abstract No. : **PO-S01-0346**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

A laser patterning strategy of c-coated Al current collector for high-areal-capacity NMP-free $LiFePO_4$ thick cathodes

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Lithium iron phosphate (LFP) lithium-ion batteries (LIBs) have been widely studied for electric vehicle (EV) applications due to high safety, long cycle life and low-cost. However, conventional thick electrode is limited due to weak adhesion and high ionic/electrical resistance. Additionally, many researchers have focused on current collectors (CCs) as essential components of LIBs to enhance electrochemical performance and mechanical strength. However, conventional aluminum (Al) CCs have limited contact area and adhesion ability to active materials. Furthermore, bare Al CCs result in increased contact resistance due to their excessively smooth surface. To overcome these disadvantages, numerous studies have applied modification methods to CC surfaces such as chemical etching and solid-phase sintering. Nevertheless, these fabrication methods limit the practical application of LFP thick electrodes due to their high cost and poor precision, long manufacturing time.

Herein, we report high-areal-capacity 1-Methyl-2-Pyrrolidone(NMP)-free LFP batteries using PTFE binder applying patterned c-coated Al foils via an facile laser scribing process. The LFP electrode with the laser-patterned Al substrate (L-LFP) exhibited higher peel strength compared to the bare LFP cathode. In particular, the L-LFP half-cell showed a 5.1 mAh cm^{-2} of high areal capacity at 0.05 C and stable cycling performance with high-capacity retention (>90.3%) over 150 cycles at 0.2 C. In conclusion, an efficient laser-patterned Al current collector could endow a larger specific surface area by providing more deposition sites for lithium ions and improve rate performance of LFP thick electrode. We believe that the laser-patterning strategy is a promising technique for practical LIBs and various energy storage systems.

Acknowledgments

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Keywords : current collector, laser patterning, NMP-free cathode, thick electrode

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Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Phase-field Simulation of Thin Film Deposition and Crystallization

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Recently commercialized semiconductor devices predominantly consist of thin films deposited on nonplanar substrates. For instance, HfO2, a high-k material employed in FinFETs and MBC-FET, alongside channels and ONO layers in V-NAND, and capacitors in DRAM. Achieving sufficient on-current necessitates engineering the deposition profile and microstructure, encompassing grain structure and surface morphology. A conformal film within a hole is imperative. Prior process modeling is essential for assessing how the deposition profile and microstructure impact device performance, typically through TCAD or FEM.

In this study, we have developed a phase-field model (PFM) code for simulating thin film growth. The model comprises three phases: a substrate, a film to be deposited, and a gas. The film is segregated into amorphous and crystalline phases, with the crystalline phase capable of containing diverse grains. Additionally, parameters such as gas flux, surface reaction, and surface diffusion are utilized for the deposition process. By controlling these process parameters, various deposition outcomes can be achieved, enabling verification of result conformality. This facilitates more precise prediction of film formation and microstructure during thin film deposition.

In this presentation, we will introduce our PFM code expanded for large-scale simulations through MPI parallelization. We will also elucidate the integrated model of deposition modeling and crystallization, alongside showcasing some process optimization examples. Furthermore, we will discuss the direction of the model and future research topics, comparing various examples like the conformality and nucleation rate of thin films deposited on substrates.

Keywords : phase-field method, deposition, thin film

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Abstract No. : **PO-S01-0344**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Pre-halogenation with Hydrohalic Acid to Restore the Native Surface of Lithium-Metal Electrodes

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The initial development of a uniform and consistent solid-electrolyte interphase (SEI) is crucial for ensuring prolonged and stable cycling performance in lithium metal batteries (LMBs). Typically, lithium metal anodes (LMAs) are initially covered with inherently non-uniform native oxide layers, which lead to uneven Li+ ion flows and irregular growth of Li dendrites, resulting in unpredictable SEI formation and reduced cycling stability. Although SEIs that are halogenated provide superior mechanical strength, electrical insulation, and thermodynamic stability, determining the optimal lithium halides for the halogenation process of the LMA surface is still subject to ongoing discussions. This research introduces a straightforward chemical method for the pre-halogenation of an LMA surface using hydrohalic acids (HXs, where X = F, Cl, Br, and I) in aprotic solvents. With various halide anions (X^-), it is possible to selectively concentrate and even out LiX compounds across the LMA surface. This study experimentally demonstrates that among the pre-halogenated LMAs (HX-Li), those enriched with LiCl (HCl-Li) improve lithium electroplating dynamics, promote even Li nucleation, and achieve dendrite-free dense Li plating. HCl-Li effectively reduces the volume expansion of the reacted Li/SEI layer, thereby extending the cycle life of the LMBs.

Keywords : Hydrohalic acid treatment, Lithium metal anode, Lithium metal batteries, Native oxide layer, Pre-halogenation

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Abstract No. : **OR-S02-0343**
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Abstract Preference : **Oral**

Performance improvement of InGaN/GaN micro LED via electrochemical etching with different electrolyte

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Since the discovery of Porous Si, research on nano-porous gallium nitride (GaN) has drawn much attention. The nano-porous GaN structure is a promising method to reduce the residual stress of Multiple Quantum Wells (MQWs). Additionally, light scattering and reflection of the nano-porous GaN layer can enhance Photoluminescence (PL). Nano-porous GaN structure is fabricated through electrochemical etching using acids (Nitric acid, oxalic acid) or a base (KOH). This process originates from surface pits in GaN, where the Space Charge Region (SCR) tends to concentrate the moving charge onto the surface pit, resulting in a higher electric field than the applied bias and leading to the formation of nano-pores. We optimized the etching condition to selectively etch the high doping concentration n-GaN layer in InGaN/GaN micro LED. Through this, we fabricate nano-porous GaN embedded InGaN/GaN micro LEDs. We analyzed the structural and optical properties enhancement by comparing with planar InGaN/GaN micro LEDs.

We fabricate 50μm × 50μm InGaN/GaN micro LEDs embedded with specific nano-pore structures via one-step electrochemical etching with different electrolytes. Depending on the electrolyte, nano-pore structures such as pipe-shaped, sponge-shaped, and triangular-shaped pores were observed. To confirm the influence of porosity and pore diameter variations in the selectively etched n-GaN layer, we used X-ray Diffraction (XRD), Raman, and Photoluminescence (PL) analyses. Through XRD and Raman peak shift analyses, we confirmed the residual stress decrease of the Multiple Quantum Wells (MQWs) and observed a significant enhancement in PL intensity compared to planar InGaN/GaN LEDs. This indicates the potential to improve the characteristics of InGaN/GaN micro LEDs without damaging the p-GaN and MQW layers.

Acknowledgement
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Keywords : InGaN/GaN LEDs, Electrochemcial etching, Nano-porous GaN, Electrolyte

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Abstract No. : **PO-S02-0341**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Enhancing Stability through Passivating the Surface of $CsPbBr_3$ with ZnS via ZnS Single Molecule Precursor (SMPs)

Justice Agbeshie Teku[1], Namji Lee[1], Derrick Allan Taylor[1], Jong-Soo Lee[*1]

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To address the issue of instability and to prevent degradation of $CsPbBr_3$ perovskite, we synthesized an inorganic ZnS shell onto the surface of $CsPbBr_3$ using ZnS from the ZnS single molecule precursors (SMPs). These SMPs react at lower temperatures, releasing Zn and S ions in a one-pot synthesis process to form the ZnS shell. This study utilizes three distinct SMPs with similar reaction mechanisms to liberate ZnS.

The resulting core-shell ($CsPbBr_3$/ZnS) quantum dots (PQDs) exhibit enhanced optical properties compared to the core ($CsPbBr_3$) alone which includes narrower full width at half maximum (FWHM), higher photoluminescence quantum yield (PLQY), and a double average lifetime. X-ray photoelectron spectroscopy (XPS) confirms the presence of the ZnS shell on the $CsPbBr_3$ surface. Our findings indicate that the perovskite with the ZnS shell significantly enhances resistance to various environmental conditions. The core-shell perovskite withstands exposure to water for at least 96 hours maintaining approximately 70% of its initial PL intensity under UV irradiation with a 365nm wavelength. Furthermore, the core-shell structure exhibits resistance to halide exchange, which typically occurs within seconds or minutes of the core. We successfully dispersed both our core and core-shell PQDs in polar solvents through a ligand displacement process. Moreover, our core and core-shell PQDs were employed in direct patterning via a thiol-ene reaction, achieving high-resolution patterns. These results, along with the core-shell approach utilizing SMPs, offer a promising avenue for enhancing the stability of $CsPbBr_3$PQDs and hold potential for optoelectronic device applications.

Keywords : Single Molecular Precursor, Perovskite Core-shell, ZnS, Low temperature synthesis

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Abstract No. : **OR-S01-0340**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Oral**

High-Speed Manufacturing(<1 min) of Ultra-Thin Lithium Metal Anode for Safe and High-Energy Battery

Jueun Kim[1], Minjoon Park*[1]

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Lithium metal anode (LMA) is an ideal anode for next-generation electric storage technology due to its low density, ultrahigh theoretical specific capacity, and lowest electrochemical potential. However, the practical application of lithium metal batteries is severely restricted by several issues, such as the uncontrolled growth of lithium dendrite and poor cycle stability. Uniform lithium deposition is the core to solve these problems, but it is difficult to achieve on bare Cu foil.

In this work, As a simple strategy of controlling only temperature and pressure, it was induced to enable at uniformly deposition of lithium metal on Cu foil at ultra-high speed(~400 mA cm^{-2}). Also, to improve the stability of the electrode during the cycling process, a thin Si_3N_4 layer was coated on the surface of Cu foil. In the plating process of Li on Si_3N_4-coated current collectors, a lithiation process initially occurred by the formation of an ultra-thin Li layer. As this Si_3N_4 layer is lithiophilic, lithium nucleation was uniformly grown, showing a low nucleation overpotential, and also in the following plating process(~4 mAh cm^{-2}).

Even though it is an electrode manufactured at high speed(60 mA cm^{-2}), the modified Li||Li symmetric cells can be stably cycled for more than 600 h at the current density of 1 mA cm^{-2} for 1 mAh cm^{-2} without internal short-circuiting and exhibit small voltage polarization. Also, LFP||Li/Si_3N_4 full cells showed stability of more than 200 cycles.

This work proposes a new and facile strategy for inducing the uniform deposition of Li, indicating the scalability of this method to fabricate stable Li metal batteries.

Keywords : High speed, Ultra-thin, Lithium metal anode, Lithium metal battery, Nucleation overpotential

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Abstract No. : **PO-S10-0339**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Pomegranate Polyphenol-loaded Injectable Hydrogels for Neuronal Regeneration

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The complexity of drug delivery for treating neurological disorders has been a long-standing challenge, primarily due to the difficulty in targeting specific sites of damaged neural tissues and ensuring sustained drug release. A potential solution is the use of syringe-injectable polymeric hydrogels, which have mechanical properties similar to brain tissues, allowing for minimally invasive intracranial injections that deliver drugs to specific regions. In this study, an injectable therapeutic hydrogel with antioxidant pomegranate polyphenols, punicalagin, was developed for effective neuronal repair. The polymeric matrix of the hydrogel is made of tyramine-functionalized hyaluronic acid and collagen crosslinked through enzymatic and thermoresponsive reactions. After crosslinking, these hydrogels exhibit excellent injectability and shape fidelity after injection, and can effectively encapsulate the polyphenol antioxidant. Moreover, the punicalagin, released continuously from the hydrogels over several days, could promote the growth and differentiation of neurons. Therefore, our findings suggest that these polyphenol-encapsulated injectable hydrogels show promise for drug delivery in neuronal regeneration, potentially paving the way for the design of a new type of antioxidative biomaterials for brain disorder therapy.

Keywords : Neuronal Regeneration, Pomegranate, Therapeutics, Injectable Hydrogel, Hyaluronic Acid

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Symposia : **ICYRAM Young Researcher Symposium**

Abstract Preference : **Oral**

Enhanced tribovoltaic nanogenerator performance in high-humidity environments using hygroscopic materials

SangHyun Sohn[1], GeonJu Choi[1], ChaeJu Moon[1], SeJin Kim[1], IlKyu Park*[1]

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In an advanced smart society, energy harvesting technology is to enable self-sufficiency without external energy sources. Energy harvesting technology has already sufficiently reduced energy loss by converting unusable forms of energy into usable forms, but it can go to a higher level by reducing losses in the process of generating and transmitting energy. Already commercialized devices and Internet of Things (IoTs) devices to be developed have been developed based on semiconductor materials. This is expected to show the highest energy transfer efficiency if the power generation device also uses semiconductor materials and has a similar level of matching resistance. From this perspective, tribovoltaic nanogenerators (TVNGs) are expected to have a matching resistance like that of electronic devices, unlike existing triboelectric nanogenerators (TENGs). In fact, TVNGs show higher voltage-to-current performance compared to TENGs and are also capable of generating direct current (DC) through the tribovoltaic effect. However, both TVNGs still have low performance to be applied in an actual use environment.

This study induced synergy coupling with moisture-enabled electricity (ME) to increase the performance of TVNGs. In actual use environments, moisture acts as an ambient element that cannot be excluded. Moisture has a negative effect and reduces performance in TENGs, but in the case of TVNGs combined with ME, the surrounding moisture environment can also be utilized for power generation. ME is a technology in which a potential gradient is formed due to ion distribution and contact electrification due to the concentration gradient of water molecules that occurs in the process of water absorption, which causes current to flow in the external circuit. In this work, ME using hygroscopic materials was combined with the tribovoltaic to not only reduce the negative effects of water molecules but also achieve higher power generation efficiency through water molecules.

Keywords : Triboelectric generator, Tribovoltaic effect, Direct current, Moisture-enabled electricity, hygroscopic materials

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Abstract No. : **PO-S06-0337**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of grain size of Zn anode plate on battery performance in aqueous Zinc battery

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Lithium-ion batteries are the most widely used rechargeable batteries. However, they still have several drawbacks such as high cost, low capacity of the anode (372mAh/g), and low stability. Aqueous zinc batteries are gaining attention as next-generation batteries because they can complement these drawbacks. Aqueous zinc batteries use pure Zn as the anode, exhibiting relatively high anode capacity and low redox potential, along with high stability due to the use of a water-based electrolyte. However, when using pure Zn anode, critical drawbacks arise, such as dendrite growth and other unfavorable side reactions, leading to reduced energy density and lifetime hindering practical application of Zn batteries. In this study, we fabricated pure Zn anode plates with various grain sizes and investigated the effects of these grain sizes on battery performance. Pure Zn plates were fabricated via gravity casting. The casting process was conducted under various mold materials (Steel, Cu, Ceramic) and initial mold temperature (150°C, 300°C) conditions, and different cooling rates were employed to obtain pure Zn anode plates with diverse grain sizes. Battery performance tests using the as-cast pure Zn anode plates revealed that larger grain sizes resulted in relatively lower overvoltage. From these results, it can be inferred that the larger grain size of the anode plate, lead to fewer detrimental side reactions, thus improving battery performance.

Keywords : Aqueous Zinc battery, gravity casting, microstructure, grain size

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Abstract No. : **IN-S01-0336**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Invited**

Interface Matter: Uniformly Regulating Interfacial Evolution across Lithium Metal Batteries

Hongkyung Lee[*1]

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Inhibiting dendritic lithium (Li) plating has long been highly desired for building safe and reliable Li-metal batteries (LMBs). However, suppressing Li dendrite growth has long been challenging through conventional materials and cell platforms and their design principles that could not satisfy the demands of fast, uniform ionic transport and interphase reinforcement. Notably, the dendrite-triggered, chaotic evolution of Li-electrolyte interfaces is uncontrollable upon prolonged cycling of practical LMBs. This presentation will present novel approaches to ensure the spatial and temporal uniformity of the Li-electrolyte interfaces across LMBs through the new electrolyte designs and tailoring of the original surfaces of starting Li-metal anodes. Before moving on to the main parts, this talk will study the Li dendrite-triggered failure scenario and the dynamic structural and chemical evolution of Li-electrolyte interfaces in the cycling of LMBs under stringent conditions and update the status and worldwide efforts in LMB technology. To regulate the Li+ transport across the electrolytes, I will discuss the Li+ flux redistributing strategy with nanospinbar-assisted dynamic Li+ transfer over the Li-metal surface. After addressing the inherently uneven nature of the native layer of commercial Li, I will propose some strategies to reconstruct the Li-metal surface for reducing the surface reactivity and improving the surface homogeneity by revisiting the electrodeposition of large-area, ultrathin Li-metal. Moving apart from the traditional interfacial roles in the current Li-ion battery platform, our preliminaries presented in this talk highlight the urgent need for intelligent battery interface design to adapt to the dynamic changes of Li-electrolyte interfaces across large-area, high-energy LMBs.

Keywords : Lithium Metal Batteries, Electrodeposited Lithium Anode, Nanospinbar, Interfacial Evolution, Battery Uniformity

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Abstract No. : **PO-S02-0335**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

One-Pot Heating-Up Synthesis Towards Bright and Defect-Free $AgInGaS_2$ Quantum Dots

Derrick Allan Taylor[1], Jong-Soo Lee[*1]

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Colloidal quantum dots (CQD) are useful for optoelectronic technologies, including light-emitting diodes (LEDs), solar cells, etc., due to their intriguing size-dependent properties. While these applications are expected to advance in the coming years, new technology perspectives, such as electrically driven LEDs, lasers, and single-photon sources for optical quantum information platforms and related quantum technologies, are on the rise. These applications necessitate a narrow photoluminescence (PL) line width to ensure accurate color and single-photon purity. Until now, Cd and Pb-based (CQDs) have attained such optical efficiencies of high luminescence yield and narrowest PL width, yet they are restricted to minuscule quantities for commercial display due to their toxicity. In this work, we synthesized silver indium gallium sulfide (AgInGaS2) particles via a one-pot process with tunable emission wavelengths by adjusting the In/Ga ratio. Photoluminescence spectroscopy of core-only AgInGaS2 QDs showed a reproducible record narrowest FWHM (38 nm) and a luminescence yield of 45% at the 615 nm emission wavelength with an eliminated defect tail. The best was achieved for 620nm AgInGaS2 QDs with InS or AgGaS shell showing 34 nm FWHM and a bright emission efficiency of 68%. TEM analysis revealed a transformed QD morphology from non-uniform shapes to monodispersed spherical QDs and a corresponding XRD peak change from orthorhombic to a tetragonal crystal unit. This change could relate to the QD solution's improved phase purification. Further characterizations by XPS showed a strong chlorine (Cl-) anion peak, indicating enhanced passivation with short inorganic ligands. Additional experimental optimizations are ongoing to improve the luminescence yield by making epitaxial type I core/shell QDs for optoelectronic device applications. We believe a well-considered design focusing on fine-tuning the electronic band and direct band gap could offer a promising route to enhance the efficiency of I−III−VI quantum dots and their derivatives.

Keywords : Colloidal Synthesis, Quantum Dots, Quaternary Quantum Dots

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Abstract No. : **PO-S02-0334**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

0D–2D Hybrid Photodetectors using MoS_2 and Lead Halide Perovskite Quantum Dots

Seock-Jin Jeong[1], Jong-Soo Lee[*1]

[1]*DGIST*

We report high-performance 0D–2D hybrid photodetectors integrated with tunable band gap perovskite ($CsPbI_3$, $Cs_XFA_{X-1}PbI_3$, and $FAPbI_3$) quantum dots and MOCVD-grown bilayer MoS_2. In our hybrid structure, the lead halide PQDs can be utilized as an absorbing layer of the light of specific wavelengths and transfer the photogenerated carriers to the MoS_2 transport layer. With tunable wavelength lead halide PQDs, the 0D–2D hybrid photodetector shows a high responsivity up to 10^7 AW^{-1} and high specific detectivity exceeding 10^{13} Jones due to the difference in the built-in potential between PQDs and multilayer MoS_2 layers. This work proposes the possibility of fabricating high-performance photodetectors by hybridizing PQDs of various band gaps with 2D materials.

Keywords : QD, 2D, Hybrid, Sensor

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Abstract No. : **OR-S10-0333**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Oral**

Injectable hydrogels encapsulating high-density dental stem cells for craniofacial tissue engineering and regenerative medicine

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In the field of dentistry, hydrogels have shown great potential for applications such as drug screening, cancer therapy, and regenerative medicine. However, the development of a convenient and effective stem cell delivery system for in situ therapy remains a challenge. Thermosensitive injectable hydrogels and ultraviolet crosslinkable hydrogels have been designed but are not suitable for immediate transplantation without incision in the animal body.

In this talk, we present a novel approach using carboxymethyl chitosan (CMCTS) and oxidized hyaluronic acid (oHA)-based injectable hydrogels for the immediate transplantation of dental stem cells without the need for incisions. The hyaluronic acid was modified through sodium periodate oxidation to generate oxidized hyaluronic acid. High-density dental stem cells were then conjugated with CMCTS and oHA macromer solutions without the use of a crosslinker, resulting in the formation of solid hydrogels.

The oxidation process introduced aldehyde groups onto the hyaluronic acid, which, when blended with CMCTS, allowed for the formation of an aqueous hydrogel matrix. Physicochemical characterization demonstrated that the CMCTS/oHA hydrogel matrix exhibited robust mechanical properties and stability. The injectable hydrogel system enabled easy modulation of cell encapsulation and exhibited improved mechanical properties with enhanced stability. In vitro assessments showed that cells incorporated into the injectable hydrogel exhibited no cytotoxicity and displayed excellent osteogenic activity. These findings were further confirmed through both in vitro and in vivo assessments. The results demonstrated that the CMCTS/oHA injectable hydrogels promoted de novo tissue regeneration compared to control injectable hydrogels.

In summary, our results indicate that the developed injectable hydrogel system holds promise for delivering dental stem cells. This material could serve as an excellent tissue scaffold for the treatment of bone defects. This preliminary study paves the way for future investigations in this field.

Keywords : Injectable hydrogel, tissue assembly, in situ therapy, de novo tissue formation, implantation

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Abstract No. : **PO-S02-0332**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Micro patterning of Quantum Dots with reliable luminous properties based on Direct Optical Lithography

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By utilizing solution-processing for patterning process with crosslinker, it becomes feasible to pattern of nanomaterials Expecting environmentally friendly and cost-saving effects. It enables direct optical patterning of quantum dots (QD) comprised of inorganic ligands, facilitating distinct pattern with uniform thickness in a short time. Through thiol-ene “click” reactions, the patterning process allows rapid curing of crosslinkers and QDs via ligand-to-ligand interactions that occur upon exposure to UV light. By exposure to the I-line regions (365 nm), The formed radicals accomplish high-resolution patterns of up to 2μm through covalent bonding between oleic acids of QDs and thiol ligands of crosslinkers. The crosslinker applied to the patterning process exhibits enhanced photoluminescence (PL, 120%) compared to quantum dots of crude throughout the entire curing process. Moreover, it shows significant increase in terms of time-resolved photoluminescence compared to QDs without the crosslinker. After mixing crosslinker, the average life time of the QDs increased from 6 to 9 ns. By adopting negative patterning techniques, which has strong chemical resistance, it was possible to maintain high-resolution optical characteristics throughout other deposition processes even post-development. Furthermore, this approach prevents pattern swelling with minimal exposure times (50s, 900 mJ/cm2), contributing to the attainment of 450 to 4,500 pixels per inch (PPI) pixel density in multilayer patterns. The patterns obtained by this method can be applied to high-performance optical applications such as quantum light-emitting diodes (QLEDs) and photodetectors.

Keywords : Quantum dots, patterning, Ligand Exchange

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Abstract No. : **PO-S02-0331**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

High-resolution Direct Photo-crosslinking patterning of QDs using non-heterocyclic aromatic thiol molecules.

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Using quantum dots in a solution state has the benefit of easy large-area thin-film fabrication at low cost; nevertheless, continuous processing may be difficult due to their susceptibility to following solution processes. Sturdy QD films with subsequent patterning are required to enable intricate and integrated device architectures. Here, we report a ligand cross-linking strategy using a non-heterocyclic aromatic thiol molecule based on thiol-ene click chemistry. The thiol-ene reaction is a type of click chemistry that has strong chemo- and regioselectivity, quick and quantitative kinetics, and insensitivity to oxygen and water. The ligand cross-linking strategy reported currently utilizes an alkyl thiol molecule in the thiol-ene reaction. However, alkyl thiol presents drawbacks such as low reactivity under i-line (365 nm) exposure. So, when using a similar weight ratio of reagents in catalyst-free conditions, a UV dose of ~60000mJ/cm^{-1} was required for ligand crosslinking. Moreover, even with a catalyst, it needs a UV dose of ~7200 mJ/cm^{-1} at i-line. To improve this problem, we applied a non-heterocyclic aromatic thiol molecule that has higher initiator effectiveness than alkyl thiol molecule in i-line. As a result, a high-resolution QDs pattern corresponding to at least 2mm was realized using a similar wt% reagent as previously reported without using a catalyst, and the UV dose was able to be reduced to 2700mJ, which is half of the existing amount.

Keywords : QD's patterning, Thiol-ene click chemistry

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Abstract No. : **PO-S02-0330**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Colloidal Indium Antimonide Quantum Dots for IR Photodetector

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Infrared technologies indeed play a vital role in our modern society, with applications ranging from night vision and thermal imaging to telecommunications and biomedical sensing. The demand for advanced infrared optoelectronic materials that are easy to fabricate, solution-processable, and tunable has prompted the development of infrared colloidal quantum dots. Infrared colloidal quantum dots have unique properties such as tunable absorption, and ease of processing. For IR photodetectors, narrow bandgap semiconductor materials are used as photoactive materials due to their IR photosensitivity. In particular, the narrow bandgap (~0.17 eV) InSb quantum dots are promising in the field of IR photodetector due to their size-tunable optical bandgap in the IR region, high absorption coefficient, and unique optoelectronic characteristics. Herein, the colloidal InSb quantum dots have been synthesized by a heat-up method by using commercially available precursors. Structural and optical studies showed that the synthesized QDs possess a zinc-blende crystal structure with a tailorable absorption wavelength from ~1300 to 1800 nm by varying the composition and growth temperature. The InSb QDs showed good colloidal stability on stored in the air atmosphere for more than a month. The InSb QDs with an absorption wavelength of 1500 nm were ligand exchanged with short-chained ligands through a solid-state ligand exchange process to render the QD films electrically conductive. Furthermore, the solution-processed SWIR photodetector was fabricated by employing the InSb QDs as a photoactive material and the device performance was studied.

Keywords : InSb, IR photodetector, Quantum dots, Colloidal chemistry

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Abstract No. : **IN-S07-0329**
Symposia : **Computational Materials Science**

Abstract Preference : **Invited**

Enhancing Oxygen Evolution Reaction Efficiency: Insights from Quantum Mechanics Calculations

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Electrochemical water splitting, powered by solar-generated electrical energy to produce hydrogen and oxygen molecules, serves as a cornerstone for advancing sustainable and clean energy. However, the efficiency and electro-kinetics of hydrogen production face challenges due to the complex four-electron-proton coupling required for the oxygen evolution reaction (OER). Despite extensive efforts to improve the catalytic performance of OER electrocatalysts, the overpotential required remains too high for cost-effective hydrogen production. Through quantum mechanics calculations, we investigate the OER mechanism on nickel oxyhydroxide-based catalysts, identifying the stabilization of the radical character on the oxygen of the metal-oxyl bond as a key factor for enhancing OER. Subsequent tests on a variety of metal-doped nickel oxyhydroxide electrocatalysts confirm our theoretical findings, establishing a significant correlation between OER activity and the electronic configuration of the doped transition metal ions, as well as the in situ conductivity of the electrocatalysts. This research provides a solid foundation for designing more efficient OER catalysts, offering valuable insights into their development.

Keywords : Electrochemical water splitting, oxygen evolution reaction, electrocatalyst, nickel oxyhydroxide, quantum mechanics calculation

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Abstract No. : **OR-S14-0328**
Symposia : **Water splitting, CO2 reduction**
Abstract Preference : **Oral**

Enhanced Photoelectrochemical Glycerol Oxidation Efficiency via Layered Double Hydroxide Catalysts for Bias-free Solar Hydrogen Production System

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The utilization of photoelectrochemical water splitting for hydrogen production offers a promising and environmental-friendly method to harness solar energy and store it in chemical bonds, effectively addressing the global energy crisis and environmental concerns. However, the photoanode side continues to be the bottleneck of the overall redox process of water splitting, where the sluggish four-electron water oxidation half-reaction occurs. These challenges present a significant obstacle to the advancement of organic semiconductor based bias-free solar hydrogen production technology.

To overcome these challenges, glycerol, a byproduct of biodiesel production, was selected as the reactant due to its higher activity to oxidation compared to water, coupled with the development of a tailored catalyst for glycerol reactions. Moreover, glycerol has the potential to be converted into high-value-added chemicals by the selective oxidation of specific hydroxyl groups, emphasizing the importance of photoelectrochemical glycerol oxidation as an economically and environmentally sustainable approach. Metal-layered double hydroxide (M-LDH) has attracted attention as a state-of-the-art bifunctional catalyst owing to its special 2D structure with large surface areas, tunable compositions for glycerol oxidation. To synthesize M-LDH catalysts suitable for glycerol oxidation, an optimal Ag doped NiFe-LDH catalyst was developed by metal cation exploration and Ag doping to increase catalyst efficiency. Subsequently, the integration of the synthesized M-LDH into organic photovoltaic (OPV) system via the encapsulation method, presents prolonged stable operation and enhanced reaction rate.

This study, demonstrates its potential as a promising catalyst for photoelectrochemical biomass valorization and represents a significant advance in bias-free solar hydrogen production systems.

Keywords : Glycerol oxidation, Bias-free solar hydrogen production system, Layered double hydroxide

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Abstract No. : **PO-S05-0327**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Multimodal bipolar junction photodiode and phototransistor based on Two-dimensional materials by tunable energy barrier

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Despite the widespread use of two-dimensional transition metal dichalcogenides (TMD) materials in high-speed circuits, analog circuits, and optoelectronic applications, their potential for signal amplification through a p-n junction structure has been relatively underexplored. In this study, we developed a novel bipolar junction transistor (BJT) by integrating multi-junction n-MoS2/p-WSe2/n-MoS2 layers with an h-BN dielectric layer on a Si substrate. This BJT design enables precise control of carrier concentration in each TMD layer through selective electrostatic doping, offering versatility in operation as both a transistor and a diode. Through analysis of the hybrid graphene/Boron Nitride Tunneling Photodetector (HGBT) figures of merit, we investigated the driving mechanisms of the photodiode and phototransistor functionalities. We found that the responsivity of the phototransistor decreases with increasing optical power due to the photogating effect, whereas the photodiode responsivity remains consistent regardless of optical power, attributed to the photovoltaic effect. In BJT operation, we observed current gains of 4 and 20 in the diode and transistor regions, respectively. This research underscores the potential of TMD-based structures for advancing optoelectronics and offers insights into optimizing device performance.

Keywords : 2D material, photodetector, enenrgy barrier

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Abstract No. : **PO-S02-0326**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Direct Optical Lithography (DOL) of Quantum Dots for High-Resolution Multilayer R/G/B Patterns

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The resolution and luminescence properties of R/G/B pixels are necessary for producing high-quality images in optoelectronic applications. Compared with other lithography processes, direct optical lithography (DOL) enables high-resolution uniform patterns without using photoresists, which has associated effects of swelling and the creation of local capillary effects during solution processes. we applied core/shell QDs inks for DOL. The photolysis process of the i-line (365 nm) photoacid generator (PAG) initiated differences in solubility between the exposed and unexposed parts of the QD film. Through a negative patterning approach, the exposure areas remain after DOL using a photomask. Further development of QD film produced a high-resolution feature size of each sub-pixel 20 to 2 μm, and the edge of the patterns was clear. Multilayer patterns of R/G/B QDs were successfully demonstrated by conducting three repeated cycles of the DOL process using the PAG. The multilayer patterns have 450 to 4,500 pixels per inch (PPI) pixel density. Also, large-area patterns of R/G/B QDs (15 mm x 15 mm) were obtained by confocal microscopy during a single scan. The multilayer patterning of stacked regions was observed with the following colors: the yellow color by stacking red and green-emitting QDs, the cyan color by stacking green and blue-emitting QDs, and the magenta color by stacking red and blue-emitting QDs. This patterning technology can be expected to be implemented in various optoelectronic devices such as AR/VR displays and photodetectors.

Keywords : Quantum dots, Direct Optical Lithography, Patterning, Ligand Exchange

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Abstract No. : **PO-S06-0325**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Microstructure and Mechanical Properties of AA1050/AA6061 Sheets Fabricated by a Cold Roll-Bonding Process

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Microstructure and mechanical properties of the as roll-bonded and subsequent annealed AA1050/AA6061 layered sheets were investigated in detail. Commercial AA6061 and AA1050 sheets with a thickness of 1mm were used for the starting materials. The starting material of AA1050 was annealed state, but it of AA6061 was deformed state. The layered AA1050/AA6061 sheet was roll-bonded by cold rolling, and then annealed for 1h at various temperatures from 200 to 400 ℃. Both AA6061 and AA1050 regions still showed the deformation structure after annealing at 300 ℃, but after 350 ℃ the recrystallized microstructure was observed. The as-rolled material exhibited relatively high tensile strength of 350MPa and low elongation of 6%. However, the tensile strength decreased and the elongation increased gradually with increasing the annealing temperature. The changes in mechanical properties with increasing the annealing temperature were compared with those of other layered Al sheets fabricated in previous studies.

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Keywords : aluminum alloys, cold roll-bonding, annealing, mechanical properties, microstructure

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Abstract No. : **OR-S06-0324**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Tuning the Active Moiety in Phosphorus-Doped Fe-NC Catalyst: For Highly Efficient Oxygen Reduction Reaction in Aluminum-Flexible Air Battery

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The rational construction of transition metal-doped nitrogen-carbon (TM-N-C) electrocatalysts has much significant attention as a promising non-noble catalyst for the oxygen reduction reaction (ORR) in metal-air batteries and fuel cells. While platinum-based catalysts currently demonstrate state-of-the-art performance towards ORR, their high cost, limited availability, and relatively poor durability pose challenges for real-time applications of metal-air battery technologies. In this work, we discovered a strategy for growing metal-supported nitrogen-phosphorous in MOF (MIL-101 (Fe)) catalysts (Fe-NPC) through a higher-degree carbonization process to address the sluggish kinetics in ORR. Traditional Fe-NC catalysts face limitations due to strong oxygen binding energy, making it challenging to desorb the *OH, a key factor in ORR kinetics. By tuning the active moiety by incorporating phosphorus, we create microkinetic pathways for regulating traffic issues in the rate determination step.

Moreover, the Fe-NPC catalyst reveals onset and half-wave potentials of 0.980 and 0.887 V (vs. RHE), respectively, with remarkable durability over a 10-hour duration. A flexible Al-air battery is assembled using thin Al foil, lab-made polyacrylamide hydrogel, and Fe-NPC as the anode, electrolyte, and cathode. Testing the flexible primary Al-air battery illustrates a peak power density of 33.6 mW/cm^2 with a specific capacity of 1598 mAh/g$_{Al}$. Additionally, the battery can sustain a current density of 1 mA/cm^2 for 9 hours during discharge performance. This research provides an ideal pathway for synthesizing highly efficient ORR catalysts and benchmarking MOF properties.

Keywords : Transition metal nitrogen carbon (TM-NC); Phosphorous doping nitrogen carbon (Fe-NPC); Oxygen reduction reaction (ORR); Flexible Al-air battery.

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Abstract No. : **PO-S09-0323**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Expounding the Performance and Stability Enhancement of $CsPbBr_3/WSe_2$ Hybrid Photodetectors through Surface Treatment with Quaternary Ammonium Ligands

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The 2-Dimensional (2D) and 0-dimensional (0D) hybrid photodetector, with its high sensitivity and wavelength tunability, is reported as a promising candidate nanostructure for optoelectronic devices. The utilization of hybrid lead halide perovskite quantum dots (PQDs) in optoelectronic devices has grown due to their remarkable absorption characteristics and elevated photoluminescence quantum yield in research. Nevertheless, the stability of PQDs continues to pose a significant constraint on the overall performance of these devices. Here, it is reported that the properties and stability of the hybrid photodetectors are enhanced by surface passivation with ligand exchange using the quaternary ammonium ligand (didodecyldimethylammonium bromide, DDAB). The average lifetime of carriers in $CsPbBr_3$ PQDs is extended when treated with DDAB, showing an increase of 6.68–14.88 ns compared to untreated $CsPbBr_3$ PQDs. Furthermore, it is verified that the resistance to damage of water is only reduced by 25.8% at PL intensity, and this stability is maintained for over 16 hours. Here, we demonstrate a WSe_2/DDAB-capped PQD hybrid photodetector with enhanced responsivity of 1.4×10^3 A W^{-1} and detectivity of 3.1×10^{13} Jones under 40.0 μW cm^{-2} of a 405 nm laser. In addition, the WSe_2/DDAB-capped PQD hybrid device exhibited a stable time-dependent responsivity, indicating a 4.5% decrease (225.7–215.4 A W^{-1}) for the hybrid WSe_2/ DDAB-capped PQDs device, while the hybrid WSe_2/ pristine PQDs device showed a 36% decrease (48.3–30.9 AW^{-1}). The results of this work highlight the importance of the surface passivation dependence of the optical properties and stability of PQDs with 2D-0D hybrid optoelectronic devices. Our work demonstrates an effective approach to improve the photodetector performance of 2D–0D hybrid photodetector based on PQDs, which can be extended to various PQDs and TMDC semiconductors.

Keywords : CsPbBr3, Hybrid photodetectors ,Stability, Surface treatment

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Abstract No. : **OR-S08-0322**
Symposia : **Advanced Materials Imaging Technique**
Abstract Preference : **Oral**

Investigating the Influence of Confinement Width on Wet Etching Using Silicon Nano-Lines

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The push to fulfill consumer expectations and enhance the performance of electronic devices has generated a demand for three-dimensional structures within integrated circuits (ICs). However, the use of directional etching methods like reactive ion etching (RIE) for creating these structures has limitations, necessitating the use of suitable non-directional etching methods. Wet etching stands out as a popular non-directional etching method due to its simplicity, but challenges persist, particularly at the nanoscale level, due to experimental complexities. Specifically, while the confinement width directly impacts etch rate and quality, the detailed mechanism remains unreported.

In this study, we produce silicon nano-lines confined within a silicon nitride passivation layer to explore the correlation between confinement width and etching properties. Through measurements of etching rate and the variability in etched distance, we identify two primary mechanisms limiting etching: diffusion limit and reaction limit. The diffusion limit arises when the narrow gap impedes the easy access of fresh etchant to the etching surface, causing a decrease in etching rate with decreasing width. On the other hand, the reaction limit occurs when certain surface etching rates are slower than those limited by sluggish etchant diffusion. Therefore, diffusion limit becomes stronger when confined gap becomes narrower, and it means there is a critical width where diffusion limit predominates over reaction limit. Notably, different crystal planes exhibit distinct critical widths due to variations in inherent surface etch rates. Consequently, when the confinement width is narrower than a specific value, certain crystal planes with larger critical widths than the specified value display similar etch rates, as they are limited by diffusion rather than reaction. This observation is supported by changes in the variability of etched distance depending on confinement width. Ultimately, the dominant etch-limiting mechanism is determined by the confinement width.

Keywords : Wet etching, semiconductor processes, liquid phase TEM

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Abstract No. : **IN-S06-0321**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Optimization of simulation models for continuous casting processes of aluminum alloys

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The traditional direct-chill casting process has been widely used for manufacturing aluminum slabs or billets. Additionally, the twin-roll casting process has gained significant attention as a method for producing aluminum sheets. Recently, with the expanded application of aluminum alloys in transportation vehicles, there is a growing demand for the production of high-strength aluminum ingots. Most of these high-strength aluminum alloys have a wide solidification temperature range, requiring sophisticated process control technologies to control casting defects during the continuous casting. Trial-and-error methods in the mass production line have limitations in terms of cost and productivity. Therefore, to minimize costs and enhance the quality of ingots, the application of process simulation technology is essential. In this study, simulation models for the direct-chill casting and twin-roll casting processes are developed, and methods for optimizing them for practical application are introduced. By applying temperature distribution measurements using thermocouples in actual continuous casting processes to the simulation model, optimization was carried out. The results showed that the simulation model effectively predicted the temperature distribution and solidification behavior of actual continuous processes.

Keywords : direct-chill casting, twin-roll casting, aluminum alloy, simulation

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Abstract No. : **PO-S10-0320**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Self-assembling tooth germ model based on high-density dental stem cells-laden fully-degradable 3D microgels for regenerative medicine in Dentistry

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Fabricated microgels encapsulating dental stem cells have been widely investigated for drug screening, tissue regeneration, and transplantation. However, the self-assembling process is hindered by slow degradability of microgel substances. In addition, the unclear relationship between tissue organizations raises considerable concern about the spontaneous 3D tissue assembling process.

In this study, we designed oxidized alginate (OA) microgels by encapsulating high density dental stem cells from the apical papilla (SCAP). First, OA was prepared through sodium periodate treatment. Subsequently, a high concentration of SCAP was directly encapsulated in OA and crosslinked with calcium chloride for fabricating OA microgels. In an *in vitro* culture, single or double-microgels were cultured to form 3D tissue without residual OA. For demonstration of self-assembly, a tooth germ 3D microgel model was created using dental epithelial cells and mesenchymal cells obtained mice at the ED14.5 stage.

As a result, the successful oxidation and rapid degradation of OA were confirmed. And, the OA microgel laden with SCAP cells condensed from day 1 post-culture. Fusion of SCAP aggregates and resembling of 3D spheroids occurred from day 2 and were completed by day 5. These findings also suggested the tooth germ model was successfully made, as indicated by the fusion of epithelial and mesenchymal aggregates that were observed by day 4, with appearance of *de novo* tissue.

In summary, the OA microgel uniformly encapsulated SCAPs and embryonic dental cells, resulting in the formation of aggregated spheroids and subsequent fusion. These processes provide insights into the crosstalk between dental stem cell interactions and tooth germ development, thereby advancing dental tissue engineering and regenerative medicine.

Keywords : tooth-germ, tissue integration, dental stem cell, regenerative medicine, oxidized alginate microgels

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Abstract No. : **PO-S01-0319**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Multi-Functional Aspartic Acid Additive for both Electrode of Membrane-Free Zn-Mn Redox Flow Battery

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Redox flow battery(RFB) has been an attractive option for energy storage system(ESS) involving renewable energy with intermittent nature as its power and capacity could be designed independently. Various redox couples could be applied for RFB, but the combination of Zn and Mn exhibited high voltage, energy density and low cost than other redox couple combinations. However, they still have low applicability for its low reversibility of Mn redox couple and Zn dendrites induced by inhomogeneous Zn2+ ion flux during Zn plating/stripping process. Metal ion or organic additives and catalysts were applicated by researchers. These strategies could be good solutions for individual redox couples for RFB, but it could not be solutions for both.

Herein, we applied aspartic acid(Asp) as chelating additive for both Zn anode and Mn cathode. Asp suppressed the generation of by-product that has inferior reversibility on neutral electrolyte. Water that was essential for MnO2 generation was excluded from the solvation sheath of Mn2+. In addition, aspartic acid regulated the kinetics of Zn plating process in Zn redox couple by complexing with Zn that increased the average distance from electrode and decrease the tunneling effect. Consequently, Asp alleviated the generation of dead Zn and Zn dendrite. In addition, we eliminated ion exchange membrane which separates carbon felt electrodes and designed membrane-free redox flow battery(MFFB). MFFB was realized by the unique nature of Zn and Mn redox couple that Zn and Mn redox couple are solid so there is no contact each other. The anolyte and catholyte was combined by MFFB design resulting in the doubled energy density.

As a result, the newly designed Zn-Mn MFFB exhibited high energy density, cycle performance and low cost, indicating that Asp was the appropriate electrolyte additive for neutral Zn-Mn flow battery.

Keywords : Redox flow battery, Zinc, Manganese, Aqueous, Additive

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Abstract No. : **PO-S10-0318**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Fibronectin-Imprinted Polymer Films Integrated with Lithographically Patterned Arrays for Enhanced Cell Migration

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Molecular imprinting has emerged as a powerful technique for creating synthetic receptors with tailored molecular recognition properties within polymer matrices. These molecularly imprinted polymers (MIPs) hold promise for various cellular-level applications in both basic research and biomedical fields. Here, we present the development of fibronectin-imprinted MIP films designed to induce cell adhesion via selective cell recognition, thus establishing a novel cell culture platform.

The fabrication of striped MIP films on quartz crystal microbalance (QCM) sensors was achieved through soft lithography using a striped-patterned PDMS mask-assisted UV-initiated polymerization process. Characterization of the patterned surfaces was conducted using atomic force microscopy (AFM), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FT-IR). The binding affinity and template specificity were assessed via QCM-based gravimetric analysis, revealing distinct quantitative differences between the MIP and non-imprinted polymer (NIP) films, attributed to the molecular recognition sites present within the MIP stripes.

In vitro experiments involved the adsorption of fibronectins onto substrates coated with MIP and NIP films, followed by the application of cultured mouse fibroblasts (L929). Our findings demonstrate a clear preference for cell migration towards the MIP film, resulting in successful adhesion within the patterned arrays. The developed cell-specific molecular imprinting platform holds significant potential for creating tailored microenvironments conducive to efficient cell growth. This work represents a crucial step towards the integration of cell-based MIPs into versatile cell culture platforms and tissue regeneration scaffolds.

Keywords : Molecularly Imprinted Polymers, Quartz Crystal Microbalance, Cell Migration

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Abstract No. : **IN-S08-0317**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Investigating Structural and Chemical Characteristics of Lithium-Ion Battery Materials Using Electron Microscopy Techniques

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Over past years, the lithium-ion battery (LIB) market has undergone significant growth, prompting the need for advancements in the materials used in battery components. Among these components, the development of cathode and anode materials is crucial for enhancing the energy density and durability of battery cells. Additionally, there is growing interest in the development of solid electrolytes for the realization of all-solid-state batteries. These batteries offer enhanced safety by preventing thermal runaway and increased energy density by eliminating unnecessary components used in liquid electrolytes.

Electron microscopy (EM) is a powerful tool for analyzing the microstructure and chemical composition of materials, ranging from the microscale to the nanoscale. This technique provides comprehensive insights into materials used in LIB applications. It plays a crucial role for obtaining in-depth understanding of cathode, anode, and solid electrolyte materials.

In this presentation, we discuss the current trends in the development of cathode, anode, and solid electrolyte materials. Additionally, we highlight the importance of EM imaging studies in characterizing the structural and chemical properties of these materials. This emphasizes the significant role of EM techniques in assessing the impact of material properties on advanced LIB technology.

Keywords : electron microscopy, lithium-ion battery, cathode, anode, solid electrolyte

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Abstract No. : **PO-S08-0316**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

In-situ observation of potassiation reaction on Bi2O2Se/mica interface under TEM beam irradiation

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TEM (Transmission Electron Microscopy) beam irradiation, in which a sample is exposed to a high-intensity electron beam, can cause a variety of effects, including structural changes, radiation damage, and chemical reactions. The effects of TEM beam irradiation depend on a number of factors, including the energy and dose of the beam, the composition and structure of the sample, and the environmental conditions during irradiation. Understanding the mechanisms and consequences of TEM beam irradiation is essential for the accurate interpretation of TEM images and the development of new materials for a wide range of applications. We have studied the effects of high-energy electron irradiation on the Bi2O2Se/mica heterointerface using in-situ TEM. We determined structural changes at the Bi_2O_2Se region induced by TEM beam irradiation, which were analyzed step by step using High-Resolution TEM images. Furthermore, we determined the chemical composition and elemental analysis using energy-dispersive X-ray spectroscopy (EDS). Initially, Bi_2O_2Se undergoes a conversion reaction with potassium ions present at the Bi_2O_2Se/mica interface and reacts with bismuth. After the conversion reaction, the potassium ions in the mica diffuse into the Bi_2O_2Se and bismuth region, and a bismuth-potassium alloying reaction occurs by exposure to the TEM beam. By elucidating such mechanisms, it is anticipated that it will greatly assist in elucidating the principles of operation of potassium-ion batteries.

Keywords : In situ TEM, beam irradiation, conversion reaction, Bi2O2Se

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Abstract No. : **OR-S14-0315**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

High-efficiency ammonia synthesis via electrochemical nitrate reduction over Fe_2O_3 nanorod arrays by Zr doping

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Electrochemically reducing nitrate (NO_3^-), a common water pollutant, to valuable ammonia (NH_3) offers a green, sustainable, and decentralized route for ammonia synthesis. However, due to the multi-step reactions in the nitrate reduction pathway, there are still challenges in developing efficient catalysts that can selectively guide the reaction route towards NH_3. Therefore, how to develop an electrocatalyst that can simultaneously activate NO_3^- and promote water dissociation to release H^+ becomes critical to realizing efficient electrochemical NO_3^- reduction reaction (NO_3^-RR) for synthesizing NH_3. Herein, Zr doping is proposed as an effective strategy to enhance nitrate conversion to NH_3 on the Fe_2O_3 nanorod arrays, which not only improves the electrical conductivity of Fe_2O_3, but also lowers energy barrier of the potential determining step. SEM image indicates highly ordered Fe_2O_3 nanorod, also XPS analyses confirms successful formation of oxygen vacancy in Zr-doped Fe_2O_3, which could be influence the charge transfer kinetics. The Zr-doped Fe_2O_3 delivers a high faradaic efficiency of 80% and a significant NH_3 yield rate of 250.8μmol cm^{-2} h^{-1}. Systematic analyses further elucidate that the introduction of Zr doping enhances the adsorption characteristic of Fe_2O_3 for NO_3^-, consequently facilitating the reduction kinetics. These findings hold significant implications for sustainable electrocatalytic processes with potential environmental benefits.

Keywords : electrochemical NO3− reduction reaction, Fe2O3, Zr doping

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Abstract No. : **IN-S15-0314**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Development of an Effective Hemoglobin-based Oxygen Carrier using ELP Block Copolymer for artificial blood

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The global blood supply shortage poses a significant challenge, leading to research on various types of hemoglobin-based artificial blood to address this issue. However, hemoglobin alone in the bloodstream may easily dissociate, leading to adverse effects including ROS generation, cytotoxic heme production, renal failure, and vasoconstriction. To address this, hemoglobin was encapsulated within elastin-like polypeptide (ELP) nanoparticles in this study to enhance its stability in circulation. ELP block copolymers, specifically E50A40E50, were engineered using an E. coli expression system and purified through invert transition cycling (ITC). ELPs, known for their distinctive phase transition properties and biocompatibility, provide a feasible platform for nanoparticle formation. Particularly, the amphiphilic triblock copolymer E50A40E50 demonstrated the ability to form vesicular nanoparticles, creating an optimal environment for hemoglobin encapsulation. Characterization and investigation of hemoglobin-encapsulated ELP nanoparticles (Hb-ELP NPs) were conducted to assess their oxygen binding and releasing functionality. This study highlights the potential of ELP encapsulation as a promising approach for stabilizing hemoglobin and developing hemoglobin-based artificial blood.

Keywords : ELP-derived nanoparticles, Hemoglobin-based oxygen carrier, Artificial blood

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Abstract No. : **OR-S08-0312**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Oral**

Boosting an energy density of copper sulfide based sodium ion battery full cell utilizing presodiation strategy

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Metal sulfides have a large theoretical capacity and are reasonably priced, making them attractive options for sodium-ion battery anodes. However, because of its poor electrochemical reactivity in the early cycle and low initial coulombic efficiency, this material cannot be applied to the full cell. Here, the issue is resolved by pre-sodiation of copper sulfide. By breaking down the particles into nanograins and creating a stable solid electrolyte interlayer, pre-sodiation dramatically increases the initial Coulombic efficiency and electrochemical reaction, resulting in the formation of an bridging phase of NaCu5S3. The full cell's energy density is greatly increased as a result. We think that the practical uses of metal sulfide-based sodium-ion battery full cells will be much enhanced by our discoveries.

Keywords : CuS, Presodiation, Transmission electron microscopy

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Abstract No. : **IN-S10-0311**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Invited**

Aurozyme : A Revolutionary Nanozyme in Colitis, Switching Peroxidase-like to Catalase-like Activity

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Inflammatory bowel disease (IBD) is a refractory disease instigated by several factors such as disrupted intestinal barrier functions, elevated levels of reactive oxygen/nitrogen species (ROS/RNS), and high-mobility group box 1 (HMGB1) because these hazard signals dysregulate mucosal immune responses, which triggers the severity of colitis. Aurozyme, a novel nanomedicine composed of gold nanoparticles (AuNPs) and glycyrrhizin (GL) with a glycol chitosan coating layer, represents a promising therapeutic approach for colitis of multiple etiologies. It effectively scavenges reactive oxygen/reactive nitrogen species (ROS/RNS) and damage-associated molecular patterns (DAMPs), neutralizing hazardous signals involved in colitis. Aurozyme's unique ability to switch the harmful peroxidase-like activity of AuNPs to beneficial catalase-like activity enables it to promote sustained anti-inflammatory effects, restore intestinal function, and increase the abundance and diversity of beneficial probiotics essential for gut microbial homeostasis. To our knowledge, this is the first biocompatible instance to switch peroxidase-like activities to catalase-like activities using AuNPs. Collectively, our findings suggested that mucoadhesive gold nanoparticles could be used as a potential therapeutic for IBD treatment.

Keywords : Nanozyme; Colitis; ROS; inflammatory bowel disease

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Abstract No. : **OR-S17-0310**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Oral**

Wearable and flexible multifunctional sensor for monitoring motion signals and intelligent material perception

nhận thức vật chất
thông minh

VIET ANH CAO[1], Minje Kim[1], Van Quan Phan[1], Junghyo Nah[*1]

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The flexible multifunctional sensors for precisely monitoring human motion indicators are an emerging requirement of next-generation electronics. However, the integration of multifunctional sensors into a common substrate for the simultaneous detection of such signals without interfering with each other is the most challenging work. Here, we propose the multisensor integrated 3 platforms including pressure, bending, and triboelectric. We develop the hierarchical gradient hybrid dielectric structures for the pressure sensor using hydrogel gelatin. With a hybrid structure, the flexible pressure sensor achieves an enhanced sensitivity of 0.053 kPa^{-1}, a wide pressure range (up to 300 kPa), and excellent durability (> 2000 cycles). In the case of bending stimulus, the thin film PVDF/Ti_3C_2 composite materials were prepared. With 40 wt% Ti_3C_2, the PVDF/Ti_3C_2 sensor displayed directional sensitivity (gauge factor of 6 under compressive bending), negligible hysteresis, good linearity (>0.99), and excellent bending durability (over 10,000 cycles). Moreover, the sense of touch not only reflects the tactile response to external physical stimuli (e.g., bending or pressure) but also the analysis of information such as recognition of texture through tactile sensation. Therefore, we designed a sensor array composed of several typical materials in different positions in the triboelectric series (PU, PMMA, and PVDF) that was integrated into a multifunctional sensor, which could identify the type of materials based on triboelectric sensing. The triboelectric tactile perception has the advantages of simple fabrication, a fast response, high accuracy, wide applicability, and sensing without damaging samples (pressure sensor). The proposed approach paves a promising route to future wearables for human monitoring applications.

Keywords : Multifuntctional sensor, capacitive sensor, piezoresistive sensor, triboelectric effect

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Abstract No. : **PO-S15-0309**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Synthesis of mixed anion layered compound, polycrystalline LaNiPO samples

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Fe-based Mixed anion layered compounds (MALC), *Ln*Fe*Pn*O (*Ln*: lanthanides. *Pn*: P, As.), exhibit a superconducting phase at low temperatures. [Y. Kamihara, *et al.*, Phys. Rev. B. **77**, 214515 (2008).] The highest transition temperature (T_c) among iron-based superconductors is 58.1 K for SmFeAsO1-xFx. [M. Fujioka *et al.*, Supercond. Sci. Technol. **26**, 085023 (2013).]

On the other hand, $Nd_{0.8}Sr_{0.2}NiO_2$, a Ni-oxide superconductor with an infinite layer structure exhibits T_c of 9-15 K. [M. Azuma *et al.*, Rev. High Press. Sci. Technol. **15**, 292 (2005).] $La_3Ni_2O_7$ (Ni237) also exhibited T_c ~ 80 K under high pressure. [H. Sun *et al.*, Nature **621**, 493(2023).] Direct observation of superconducting critical cureent will be required for the novel candidate.

LaNiPO, Ni-based MALC, shows superconductivity at temperatures under 3 K [T. Watanabe, *et al.*, Inorg. Chem. **46**, 7719 (2007).]. The LaNiPO and related materials may be a candidate which exhibits Tc as high as those of Fe-based and Cu-based superconductors.

La_2O_3 powder is dehydrated at 800 ºC for 10 h in the air. La, P, and Ni were heated at 700 ºC for 10 h, and LaP-NiP-Ni_2P (133 powder) was obtained. Synthesis of LaNiPO was performed by heat-treating 133 powder and La_2O_3 at 900 ºC/950 ºC for 40 h. The crystal phases of samples were determined by powder X-ray diffraction (XRD) spectroscopy (Rigaku RINT 2500, CuKα) and the magnetizations were measured by the Magnetic Property Measurement System (MPMS, Quantum Design).

The obtained samples did not show superconductivity at temperatures above 3 K and exhibited a molar diamagnetic susceptibility ~ -5×10^{-5} emu.

Keywords : Ni-based superconductor, Mixed anion layered compound, Solid reaction

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Abstract No. : **PO-S11-0308**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

High performance of triboelectric nanogenerator using the degradable cellulose acetate and gelatin nanofiber

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[1]*Chungnam National University*

Triboelectric nanogenerators (TENGs) have brought attention to new energy fields due to their excellent conversion of mechanical energy into electrical energy. However, most traditional device-based TENGs raise concerns about their environmental impact upon disposal. Thus, the exploration of alternative paths for TENG fabrication using environmentally friendly materials has gained attention. Besides, due to limited choices and nanostructures, the challenge of degradable materials used for TENGs exhibited lower power outputs than those with non-degradable triboelectric materials. So, our study will focus on optimizing the key factors influencing TENG efficiency. In this work, we systematically investigated nanofiber structures, introduced chemical surface modifications, and tailored triboelectric properties by integrating ferroelectric molecules and composite structures. Thanks to the degradable triboelectric nanogenerator based on cellulose acetate (CA) nanofiber layer as the tribo-positive layer and performing facile chemical modification using branched polyethyleneimine (PEI(b)) and gelatin-based nanofibers composited with ferroelectric molecules ($ImClO_4$) and MXene (Ti_3C_2) nanoflake fillers as the tribo-negative, we have elevated the output performance of TENGs to a level comparable to those based on non-degradable polymers. Specifically, our degradable TENGs demonstrated an open-circuit voltage of up to 300 V, a short-circuit current of 10 μA cm^{-2}, and an impressive maximum power density exceeding 500 mW cm^{-2}.

Keywords : Biodegradable triboelectric nanogenerator, surface-modification, cellulose acetate (CA), gelatin, molecular ferroelectric imidazolium perchlorate (ImClO4), MXene (Ti3C2)

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Abstract No. : **OR-S01-0307**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Oral**

Lithiophilic Si_3N_4 copper current collector for High Energy Density and ultra-thin Lithium metal Batteries

Jihyeon Kang[1], Minjoon Park[*1]

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Lithium metal anode (LMA) with high energy density (400-500 Wh/kg) and theoretical capacity (3860 mAh g^{-1}) has been studied for high-capacity batteries. Although the LMA has a high theoretical specific capacity, there are issues such as unstable solid electrolyte interphase (SEI), and large volume expansion of Li metal anode during charging/discharging. Furthermore, Cu foil as a current collector is low lithiophilic to lithium, which causes difficulty in manufacturing a uniform LMA, thereby forming Li dendrite.

In this study, we report the fabrication of 10 to 50 µm ultra-thin Li metal anodes using copper foil consisting of Silicon Nitride (Si_3N_4) layers by a magnetron sputtering method. With the assistance of lithiophilic Si_3N_4 coating, the Li-Si_3N_4 alloy improved surface wettability, which helps realize the formation of uniform Li metal anodes. Compared to the bare LMA, the Li/Si_3N_4 anode (SNLMA) reduced the nucleation barrier, effectively inhibited the dendrite growth, and showed a long cycle life and high average Coulombic efficiency. We conducted XRD analysis to confirm the lithium silicon nitride alloy on SNLMA, and SEM analysis showed that silicon nitride layer can inhibit the growth of lithium dendrites after 200 cycles. This is because Li_3N and Li_8SiN_4 can homogenize the Li+ flux, contribute to uniform Li+ deposition, and inhibit Li dendrite growth. As a result, the SNLMA exhibited stable cycling with low overpotential (~18 mV), during 1000 cycles in symmetric cell test at 1 mA cm^{-2} and 2 mA cm^{-2}. SNLMA||LCO full cell showed improved capacity retention performance and coulombic efficiency(0.5C, 150 cycles). This work provides a new strategy for next-generation lithium-based batteries with high energy density.

Keywords : lithium metal anode, lithium metal battery

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Abstract No. : **OR-S14-0306**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

DFT Analysis of Bismuth Catalysts for Reduction of Nitrogen and Nitrogen Oxides: A Comparative Study of Activation Mechanisms and Investigation on Dopant Activity

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Extensive research has been conducted to explore synthetic ammonia production as a potential source of fertilizer ingredients and hydrogen energy carriers. However, the energy-intensive nature of the Haber-Bosch process has raised concerns. In contrast, electrochemical ammonia synthesis presents a promising alternative, where the effectiveness of the electrochemical catalyst is crucial. Bismuth, known for its ability to form strong bonds with nitrogen due to its p-electrons, has shown promise as a catalyst for this process. Due to these characteristics, bismuth is advantageous for nitrogen and nitrate adsorption. Therefore, a strategy to enhance the performance of bismuth is needed. In this study, we employ density functional theory (DFT) calculations to investigate the mechanisms of converting nitrogen and nitrate reduction (NRR and NO_3RR) to ammonia on bismuth catalysts. In the initial experiments, we obtained a yield of 533.28 $\mu g\ h^{-1}\ mg_{cat}^{-1}$ in the NO_3RR, and an FE of 20%, while in the NRR, we achieved a yield of 19.424 $\mu g\ h^{-1}\ mg_{cat}^{-1}$ and an FE of 3.20%. We determined through calculations that elements such as Mn, In, W, Zn, Cu, Co, along with several others, are potential candidates for doping in Bismuth. By comparing our theoretical predictions with experimental results, we demonstrate the selectivity of bismuth and highlight its potential for electrochemical ammonia synthesis.

Keywords : Bismuth, Nitrate reduction, electrochemical ammonia synthesis, DFT analysis, dopant

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Abstract No. : **OR-S14-0305**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Silicon photocathode with vertically aligned TiO_2 nanorods and Ni catalyst for enhancing Photoelectrochemical nitrate reduction to ammonia

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Ammonia is an essential chemical not only in agriculture as a raw material for fertilizer production, but also in diverse industries including pharmaceutical, metallurgical, explosives, textile, and automotive sectors. Furthermore, recent research has revealed its notable potential as a hydrogen carrier. The Photoelectrochemical Nitrate Reduction Reaction (PEC NO_3^-RR) offers a sustainable alternative to the environmentally destructive Haber-Bosch process for ammonia production. In addition, PEC NO_3^-RR enables the purification of polluted water that contains nitrate, an environmental pollutant originating from agriculture and industry sources. The implementation of a practical PEC NO_3^-RR system requires an efficient photocathode with high current density and stability.

Silicon (Si) is a promising material to realize highly efficient photocathodes due to its abundant reserves, narrow bandgap ($E_{g} \approx$ 1.1 eV), broad solar absorption, excellent charge carrier mobility and long carrier diffusion length. However, it is hard to optimize light harvesting due to poor catalytic activity, chemical contamination in liquid electrolytes, and unnecessary light reflection.

In this study, we address these challenges by employing an in-sequence TiO_2 nanorod and nickel (Ni) catalyst decoration on the p-Si using an e-beam evaporator. TiO_2 nanorods were precisely deposited using Glancing Angle Deposition (GLAD) method. The vertically aligned TiO_2 nanorods enhance the stability of Si-photocathodes in alkaline electrolyte and improved light adsorption by reducing surface reflectivity. Moreover, the Ni catalyst show prominent catalytic activity for NO_3^-RR. The Ni/TiO_2 nanorods/p-Si photocathode enables efficient ammonia production via PEC NO_3^-RR, achieving high current density and stability in alkaline environment.

Keywords : PEC NO3-RR, silicon photocathode, GLAD method

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Abstract No. : **PO-S01-0304**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Enabling ultra-high Zn deposition via step-wise activation carbon felt electrode for aqueous Zn-Br batteries.

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In recent years, the surge in supply and demand for eco-friendly energy has significantly increased interest in Energy Storage Systems (ESS), capable of storing energy and releasing it when needed. However, lithium-ion batteries, currently utilized in ESS, pose a substantial risk due to fire hazards. In response, research is being conducted on aqueous electrolyte-based ESS that do not catch fire, with Zn-Br batteries, known for their cost-effectiveness and environmental friendliness, gaining particular attention. Furthermore, to reduce system costs, there is active research on flowless Zn-Br batteries (FLZBB), where challenges such as Zn dendrite formation and polybromide crossover present difficulties in designing high-capacity batteries. Addressing these issues, our team proposes an anode with a Step-wise Activation (SWA) structure. By inserting an H-PVDF (VVLP) membrane between the electrodes, we artificially activate only the bottom part of the electrode, inducing the deposition of Zn at the bottom. This strategy has demonstrated stable cycling at an electrolyte utilization of 33% with a capacity of 392 mAh.

Keywords : Aqueous Zn battery, Zn metal, Zn dendrite, Step-wise activation, Flowless Zn Br battery

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Abstract No. : **PO-S14-0303**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Efficient Urea-assisted Water Electrolysis Using FeNi based Catalysts for Hydrogen Productio

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Water electrolysis is one of viable methods for generating green hydrogen energy. In general, water electrolysis is the active research field as an eco-friendly hydrogen production process, but it has the weakness of requiring significant overpotential due to the lean kinetics of oxygen evolution reaction (OER) compared to the hydrogen evolution reaction (HER) during the reaction. Also, OER can weaken the proton exchange membrane under electrolyte solution. Recently, urea oxidation reaction (UOR) is attracting attention as an environmental and efficient reaction instead of OER in electrolysis because of it less thermodynamic potential (-0.58 V vs. RHE) and much safer than the mixture of H_2 and O_2 in a traditional water electrolysis. In this study, we demonstrate a green approach for urea oxidation using bimetallic structures FeNi Which is non-noble metal electrocatalysts and have been interested due to their cost-effectiveness, and natural abundance. To further enhance the catalytic activity, S and P were introduced into the catalyst synthesis. The detailed characterization of the synthesized materials was measured and analyzed via scanning transmission electron microscopy (SEM), powder X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS), In additional, the electrochemical properties of FeNi catalyst tested for urea oxidation. Among the compared catalysts, the FeNiSP catalyst showed a potential of 1.49 V vs RHE at 100 mA cm^{-2}.

Keywords : Electrocatalyst, Urea oxidation, Hydrogen production, Assisted water electrolysis, Iron nickel

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Abstract No. : **OR-S04-0302**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Ultra Low Impedance PEDOT:PSS Neural Electrode Array for Simultaneous Two Photon Imaging and Electrophysiology Analysis

Hyun Woo Kim[1], Ki Jun Yu[*1]

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Integration of electrophysiology and photon imaging in neuroscience research has the potential to yield profound insights into the dynamics of neural circuits. While electrophysiological recording provides insights into neural electrical activity, it lacks the ability to visualize cellular morphology and connectivity. In contrast, photon imaging allows for submicron resolution visualization of cellular structures, complementing electrophysiological data. However, existing opaque neural electrode arrays hinder the seamless integration of these techniques, masking cell-specific dynamics and causing artifacts during imaging. To address these challenges, we introduce a fully transparent, ultra-low impedance neural implantable electrode array. Our device, comprising a 30-channel electrode array with optically transparent interconnect lines, enables simultaneous high-resolution optical imaging and electrophysiological recording without obscuring surrounding neuronal networks. We employ a "triple treatment" method to enhance the electrical conductivity of the transparent electrodes, ensuring low-noise high-quality neural signal recordings. Furthermore, the transparent nature of our electrode array minimizes tissue damage and inflammatory response, ensuring long-term stability and compatibility for chronic experiments in vivo.

Experimental validation demonstrates the feasibility of single spike activity recording on the cortical surface and photon imaging of neuronal cells cultured directly on our device. In addition to providing high-fidelity electrophysiological recordings and facilitating optical imaging without interference, our transparent electrode array offers a non-invasive means to observe single neuron spike activity. These findings highlight the potential of our transparent microelectrode array as a effective tool for seamless and artifact-free integration of optical and electrical modalities, opening new avenues for comprehensive neuroscience research.

Keywords : Electrophysiological Recording, Electrochemical Impedance, Photon Imaging

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Abstract No. : **OR-S06-0301**
Symposia : **Advanced Structural Materials**
Abstract Preference : **Oral**

Measurement and Prediction of Mechanical Anisotropy with Sheet-type Specimen in Additive Manufacturing Process of Superalloy

Jinsu Kim[1], Hyungsoo Lee[1], Kyung Mi Park[1], Seong Jun Bae[1], Yong Nam Kwon[1], Young-Seon Lee[1], Jong-Hwa Hong[*1]

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The additive manufacturing process continues to grow to manufacture the complicated shapes made of superalloy, such as the internal cooling passages of turbine vanes and blades in aerospace. Since additive manufactured products undergo high temperature gradients because of its unique “bottom-up and path-dependent process”, stacking order highly affects the final product quality with respect to anisotropy and its residual stress distribution. Most studies in additive manufacturing mainly deal with anisotropy in an out-of-plane direction which is perpendicular to the build-plate because the influence of the anisotropy between layers is normally considered more significant. The anisotropy within each layer, however, cannot be overlooked since in-plane temperature gradient is still high and in-plane anisotropy can also cause overall residual stress distribution and influence the quality of the final production. This study devises an anisotropy measurement method with the sheet-type specimens for various printing directions including anisotropy in the layer as well as the anisotropy in the direction perpendicular to the build-plate. The mechanical properties according to the printing directions are measured and characterized with a normalized anisotropy function. A carpet plot presenting material properties depending on the content ratio of the stacking layer direction is established based on the experiments.

Keywords : Additive Manufacturing, Powder Bed Fusion, Nickel-based Superalloy, Anisotropy

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Abstract No. : **PO-S14-0300**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

NiCuP Catalyst with the synergistic Effect of Ni and Cu for Hydrogen Production Using Ammonia Electrolysis

Chanmin Jo[1], Minseo Jeon[1], Soyoung Lee[1], Gyoung Hwa Jeong[1], Uk Sim*[1]

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To achieve carbon neutrality by reducing the use of fossil fuels, it is crucial to develop clean, renewable, and eco-friendly green energy sources. Consequently, hydrogen energy is emerging as one of the most promising future energy sources. Recent efforts have been focused on research into hydrogen transportation as well as hydrogen production. Notably, many scientists are exploring hydrogen carriers as alternatives to liquefied hydrogen. Among several candidates, ammonia is the most promising as a hydrogen carrier. In general, electrochemical ammonia electrolysis can enhance energy efficiency by the ammonia oxidation reaction (AOR) with a low reaction potential (0.77 V) compared to that of oxygen evolution reaction (OER) in water electrolysis (1.23 V). However, the AOR typically exhibits a higher overpotential than the theoretical value due to a poisoning phenomenon caused by the adsorption of NHx species during the electrolysis process. In this study, to address this challenge, a synergistic effect was identified by incorporating Ni, known for its strong AOR activity among non-precious metals, and Cu, which possesses good desorption properties through the dimerization of NHx species.

Moreover, Ni and Cu were co-synthesized in the form of phosphide, which improved the durability and nitrogen adsorption capacity of the catalyst. The AOR properties of the synthesized NiCuP were confirmed through its material physicochemical properties and electrochemical performance, including hydrogen production. the potential at 100 mA for AOR was 1.45 V vs. RHE.

Keywords : Ammonia, Hydrogen carrier, Ammonia electrolysis, Hydrogen production, Nickel copper phosphide

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Abstract No. : **OR-S02-0299**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Homogenous metallization of through-glass vias with floating plating based on the synergistic effect of capillary rise and van der Waals

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Through Glass Via (TGV) is a 3D package interposer that addresses the limitations of the tiling technique, which requires bezels for display IC circuit and an extra interposer during the transfer process, while simplifying the modularization and IC bonding processes. Compared to silicon, glass substrates are transparent, have advantage in defect detection. Through changing composition, we could even adjust dielectric property to reduce leakage current under high frequency or thermal expansion coefficient.

Moreover, through large scaling of display panel, low-cost display production is achievable, and it enables high speed and high density operation compared to wire bonding. Based on this, TGV is expected to be applied to thin-film transistor fabrication on plug, large-area panel implementation, process simplification and application fields such as large displays. In TGV with high aspect ratio, if poor step coverage due to bottleneck or residual air gaps inside occurs, it may lead to conduction defects with high resistance and subsequent process issues. Therefore, uniform seed layer and copper plug formation without voids or disconnections are essential.

This study focuses on low-resistance copper plug fabrication in TGV, aiming to improve the gap-filling properties within high aspect ratio via-holes using electrolytic plating technology employing capillary force. Ti adhesion layer and Cu seed layer were deposited on TGV substrates using sputtering, and electrolytic copper plating experiments were conducted to completely fill the via-holes with plating solution using capillary force to ensure no voids inside. As a result, it demonstrated 100% yield and feasibility for copper plugs with resistance below 1Ω. Additionally, foundational technology for high-efficiency transistors and large-area display production was discovered.

Acknowledgement

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Keywords : Glass substrate, gap-filling, via hole, electroplating, sputtering

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Abstract No. : **OR-S13-0298**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Oral**

A Strategy on Mitigating Defect States of All-Inorganic CsPbI2Br Perovskites for Efficient Photovoltaics

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In this study, a high-quality all-inorganic α-$CsPbI_2Br$ perovskite film could be fabricated by adding a multifunctional additive of 2-Amino-5-nitrothiazole (ANZ) into the perovskite precursor. This additive approach exhibited that the strong interaction between ANZ and the perovskite modulates the polycrystalline growth and efficiently passivates a variety of defects, including uncoordinated Pb^{2+} ions (dangling bonds) and negatively charged Pb-I anti-sites (PbI3-) arising from uncoordinated (I-/Br-) halide ions. This interaction leads to several improvements: 1) Enhanced surface uniformity and topography, 2) Improved crystallinity, 3) Prolonged carrier lifetime, and 4) Improved air stability.

Notably, the incorporation of ANZ into CsPbI2Br inorganic perovskite solar cell (PSC) demonstrated an impressive remarkable power conversion efficiency (PCE) of 17.1%, higher than the control device's PCE of 15.2%. Furthermore, the ANZ-tuned PSC revealed exceptional thermal stability, maintaining approximately 90% of its initial PCE at 85 ℃ over 700 hours. Additionally, the champion PSC displayed a superior indoor PV performance compared to the control device, attributed to the suppression of charge recombination phenomena due to the ANZ additive. Our findings suggest that the ANZ additive substantially improves film quality by mitigating defect states, leading to both high PCE and enhanced stability. Therefore, our multifunctional ANZ additive-based methodology offers a practical blueprint for the further development of efficient and stable all-inorganic perovskite solar cells.

Keywords : All inorganic; perovskite; solar cells

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Abstract No. : **PO-S13-0297**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Synthesis of NiOx Nanoparticles for Efficient and Stable Perovskite Solar Cells

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Inorganic NiOx (nickel oxide) nanoparticles have received significant interest as a hole transport layers (HTL) in perovskite solar cells. NiOx exhibits desirable electrical conductivity and hole mobility, accelerating charge transport. Its energy levels are well-aligned, enabling efficient charge collection. Additionally, NiOx boasts a wide bandgap and high transparency, allowing effective light penetration. From a stability perspective, its hydrophobic surface and low surface energy prevent moisture-induced degradation, while its intrinsic thermal and chemical stability protects against perovskite decomposition. It enhances the contact area between the NiOx layer and the perovskite, reducing charge recombination and promoting efficient carrier transport.

Various techniques exist for producing NiOx HTLs, broadly categorized into physical vapor deposition and chemical solution methods. The synthesis of NiOx nanoparticles focuses on creating a high-density, low-defect surface by controlling the pH using the chemical solution method. The impact of PH on the reaction is important for regulating the ratio of Ni2+ to Ni3+ because pH adjustment easily modulates the Ni3+/Ni2+ ratio and can affect redox reactions. The ratio of Ni2+ and Ni3+ ions determine the stability, efficiency, and other properties of NiOx.

Higher Ni3+ concentrations correlate with increased hole conductivity due to more Ni ion vacancies. Conversely, lower Ni3+ concentrations yield larger crystallite sizes, resulting in uniform film morphology and reduced oxidation-reduction reactions at the perovskite interface. The NiOx nanoparticle synthesis process by regulating pH allows tuning of the bandgap and surface crystallinity, which depend on the Ni3+/Ni2+ ratio.

Our study investigates pH-dependent crystallite size control to enhance stability and achieve higher hole conductivity in P-I-N structured solar cells. By efficiently synthesizing NiOx nanoparticles, we anticipate improved power conversion efficiency in perovskite solar cells.

Keywords : HTL, NiOx nanoparticle, p-i-n perovskite solar cell structure

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Abstract No. : **PO-S15-0296**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Forsterite-PI hybrid dielectric substrates blended Thermoset/Thermoplastic Polyimide for mm-wave communication devices

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The wireless communication standard is evolving from 5G to beyond 5G, and accordingly, it is critical to lower the dielectric constant (k) and loss tangent (Df) of build-up materials to enable high-speed transmission in signal paths. Hybridization of organic and inorganic materials can offer an effective way to satisfy these requirements by combining the polymer's low dielectric constant and the significantly low-loss character of ceramic materials. Forsterite (Mg_2SiO_4) and Polyimide (PI) were chosen as two end-members of the two-phase composite. However, a thermoset/thermoplastic polyimide blend is needed for embedding metal circuits onto substrates due to high temperature. Surface modification for the magnesium silicate filler particles was carried out by introducing a silane coupling agent, which can form stable chemical bonding with the PI chains. The well-distributed forsterite filler particles and their fine interfaces with the PI are responsible for improving mm-wave dielectric properties. The dielectric properties of the composite were measured at the 28 GHz band by adjusting the fraction of thermoset polyimide and thermoplastic polyimide. As a result, Forsterite – PI hybrid composite with a thermoset/thermoplastic polyimide blend enhances thermal properties and mm-wave dielectric properties.

Keywords : microwave, mm-wave, Forsterite, Polyimide

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Abstract No. : **OR-S05-0295**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Spatially-controlled exciton localization in mixed-dimensional van der Waals heterostructures

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The optical porperties of two-dimensional (2D) transition metal dichalcogenides (TMDs), characterized by excitonic emissions stemming from quantum confinement with large binding energies, have stimulated considerable research interest in exploration of their emission modes. Furthremore, controlling excitonic emission in 2D TMDs by assembling van der Waals (vdW) heterostructures offers numerous opportunities for engineering their photonic and optoelectronic properties. Here, we demonstrate a new class of mixed-dimensional vdW heterostructure, integrating 2D semiconductors with one-dimensional (1D) semiconductor nanowires composed of vdW layered crystals. This configuration fosters spatially-unique excitonic emissions via a customized arrangement of atoms at the interface. By fine-tuning the axial and sidewall facets of PbI_2 vdW nanowires grown from the bottom up and aligning them with single-layer WSe_2 flakes, we have engineered vdW heterointerfaces with both vertical and horizontal orientations. Specifically, heterojunctions with vertically oriented PbI_2 promote enhanced charge transfer and localized states along their edges, resulting in a noticeable redshift about 50 meV in excitonic emissions. In contrast, horizontally stacked PbI2 layers yield a marked quenching effect due to the presence of deep mid-gap states in a type-II band alignment configuration, a phenomenon substantiated by power-dependent measurements and density functional theory calculations. These results lay the foundation for fine control over excitonic emissions in 2D TMD semiconductors via edge engineering, underscoring their vast potential for future quantum device applications.

Keywords : 2D materials , nanowire, heterostructure, exciton, photoluminescence

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Abstract No. : **PO-S04-0294**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

Yb doped $BaTiO_3@Ca_2Nb_3O_{10}$ Core-Shell nanoparticles for temperature stability

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Recently, Multilayer Ceramic Capacitors (MLCCs) with thin dielectric layers have led to increased demand for stability over a wide temperature range. To achieve these characteristics, a common approach involves incorporating $BaTiO_3$ (BT) with other perovskite materials to form complex perovskite compounds. Among these, there is a $KCa_2Nb_3O_{10}$ (KCNO) of Dion-Jacobson layered perovskite materials. The layered structure of KCNO can be fabricated into 2D nano sheets via a top-down approach, including exfoliation process, resulting in the formation of $Ca_2Nb_3O_{10}$ (CN) of 2D nano sheet structure.

In this study, we fabricated 2D nano-sheets of CN through an ion exchange process and an exfoliation process using TBAOH. We achieved an exfoliation rate of 92% as determined by UV-vis analysis. And when CN incorporated into BT, we confirmed a wrapped core-shell structure of BT-CN by TEM, assembly of BT nano particle and CN nano sheets. As a result of sintering BT-CN, Ca and Nb substitution at the A and B sites in BT leads to an improvement of temperature stability. Additionally, we conducted fast firing to improve the temperature stability by preventing the diffusion of Ca and Nb from the shell to the core. After fast firing, the temperature stability at the Curie Temperature increased, yet it still did not meet the X7R requirements. To address this, we aimed to further improve by doping Yb into BT-CN.

Keywords : BaTiO3, Ca2Nb3O10, Yb, Core-shell, fast firing

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Abstract No. : **PO-S01-0293**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Fast charging lithium-ion battery design using carbon-coated aluminum current collector

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Lithium-ion batteries (LIBs) have been highlighted as growing demand for electric vehicles (EVs). Simultaneously, research on batteries with high energy has been pursued for a long time, also fast charging has recently attracted attention. The fast charging property has become one of the key characteristics targeted by the battery and EV industries. However, charging batteries at high rates can cause degradation in both capacity and power capability.

Current collectors(CCs) can greatly influence the performance of LIBs. For example, improving the electrical conductivity and reducing resistance is beneficial to increase the rate capability of LIBs. More importantly, the CCs are indispensable components for the present LIBs, and an aluminum(Al) current collector is used for the cathode. Pristine Al current collector was corroded by using LiFSI-based electrolyte.

In this work, we designed fast-charging LIBs using carbon-coated aluminum. The carbon-coated aluminum collector reduced internal resistance and improved adhesion between the active material and the CC. Moreover, the carbon-coated Al CCs could hinder the corrosion of the current collector electrolyte using LiFSI-based electrolyte. Especially, the batteries using carbon-coated aluminum foil showed stable cycling performance, retaining high capacity (>97.3%) over 300 cycles at 15 C. The voltage profile and resistance characteristics of the manufactured half-coin cell were analyzed via a galvanic charge/discharge test (GCD). This strategy is promising a huge impact on the electric vehicle industry.

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Keywords : fast charging

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Abstract No. : **OR-S09-0292**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Oral**

Low temperature growth of GaN films with ion beam assisted magnetron sputtering

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Gallium nitride (GaN) based semiconductors have been promising optoelectronic devices due to their superior properties, e.g. wide range of tunable direct bandgap spanning from infrared to ultraviolet wavelength. Metal organic chemical vapor deposition (MOCVD) and molecular beam epitaxy (MBE) are typical methods to grow GaN thin films. However, growth through MOCVD occurs at high temperature (~1000 ℃) and uses toxic precursors. For MBE, growth rate is low and it is difficult to apply to large-area deposition.

When growing GaN films through magnetron sputtering epitaxy (MSE), it is possible to achieve high quality films even at low temperature, with the assistance of ion bombardment, and avoid the use of harmful precursors. MSE enables the deposition of films on the large-area substrates such as glass.

We induced 2D growth of GaN films by irradiating ion beams onto the substrate to transfer energy from ions to adatoms. The relationship between ion beam intensity was studied by analyzing characteristics of films, and experiments were conducted at temperatures ranging from 450 to 650 ℃ to explore whether the ion beam provided energy to adatoms. Various analytic techniques, including scanning electron microscopy with energy-dispersive X-ray spectroscopy, high-resolution X-ray diffraction, atomic force microscopy, transmission electron microscopy, Raman spectroscopy, Hall measurement, transmittance measurement, and photoluminescence spectroscopy were utilized to analyze the structural and optoelectronic properties of the films. Also, for InGaN thin films, uniform Indium distribution in depth profile of approximately 43% was confirmed through Rutherford backscattering spectrometry (RBS). We demonstrated the potential for low-temperature deposition process below 600 ℃ by growing high quality GaN and InGaN films with uniform composition of indium using ion beam-assisted sputtering.

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Keywords : GaN, InGaN, LED, Deposition, Magnetron sputtering, Low temperature, Ion beam

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Abstract No. : **PO-S15-0291**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Effects of Deposition Pressure on EC Properties of InN Films Fabricated by Glancing-angle Reactive Evaporation

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Indium nitride (InN) has been reported to exhibit an adsorption-induced electrochromic (EC) phenomenon. Previous studies have shown that differences in crystallinity and surface morphology of the InN films affect the color-change magnitude of the EC phenomenon. The purpose of this study is to investigate changes in the crystallinity, columnar gaps, and shape of InN thin films by controlling the deposition pressure, and to investigate the effects of the deposition pressure on the EC properties.

InN thin films were deposited on ITO-coated glass substrates by reactive evaporation. The substrate angle to the indium flux axis was set to 85°, in order to introduce discrete columnar structures by applying the glancing-angle deposition (GLAD) scheme for expanding surface area of the films. The crystallinity of the InN films was evaluated by XRD, and the surface microstructure of the films was observed by SEM.

It was confirmed that discrete columnar structures were formed in all samples. The topmost surface became larger and smoother as the deposition pressure increased, and the gaps among the columnar crystals decreased. All samples were preferentially oriented in the (101) plane, while the crystallinity was improved by increasing the deposition pressure. The higher the deposition pressure, the smaller the change in absorption coefficient between anodic and cathodic polarization of the InN thin film, and the color change wavelength region shifted to the longer wavelength side.These effects of the deposition pressure on the morphological, crystallographic, and EC properties were discussed.

Keywords : InN，EC

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Abstract No. : **PO-S05-0290**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

MOCVD growth of WS_2/MoS_2 vertical heterostructure

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Two-dimensional transition-metal dichalcogenides (TMDCs) have become prominent in advanced electronic and optoelectronic devices due to their unique properties over other materials. Constructing 2D heterostructure through stacking layers via van der Waals interactions or heteroepitaxial growth using chemical vapor deposition (CVD) techniques offers promising avenues. However, the presence of a polycrystalline underlayer introduces complexities, as it influences the crystalline structure of the overlaying layers, presenting obstacles to attaining high-quality heterostructure. In this study, we employ metal-organic chemical vapor deposition (MOCVD) to grow WS_2 on MoS_2, aiming to unravel the growth mechanism within their heterostructures. Additionally, we delve into substrate interactions with adatoms, exploring the influence of MoS_2 thickness variation. Raman mapping analysis demonstrates the formation of WS_2 vertical heterostructures on single and bilayer MoS_2. The growth rate of WS_2 is higher on bare SiO_2 than on MoS_2. However, as the number of layers increases, the growth rate diminishes.

Keywords : MoS2, WS2, MOCVD, heterostructure

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Abstract No. : **PO-S06-0289**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Precipitation behavior according to different chemical compositions and heat treatment temperatures in heat-resistant steel for power plants

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Austenitic stainless steel is known to have excellent mechanical properties such as excellent corrosion resistance, ductility, oxidation resistance, and creep resistance at high temperatures, and is therefore used as a material for power plants. Ni, one of the main alloying elements of these austenitic stainless steels, is expensive and has an unstable price. Therefore, high-nitrogen austenitic stainless steels with reduced Ni content are being commercialized. However, in high nitrogen austenitic stainless steel, Z-phase precipitation occurs. Precipitation of the Z-phase within the microstructure has a siginificant impact on the strength, elongation, and creep resistance of materials used at high temperatures for long terms of time. Therfore, controlling the precipitation behavior of Z-phase is essential for the excellent mechanical properties and creep characteristics of high-nitrogen austenitic stainless steel. In this study, steel samples were prepared with different contents of N, Nb, and V, which have a big influence on Z-phase precipitation. And the precipitation behaviors of Z-phase and other phases were investigated according to different chemical compositions, solid-solution temperatures and aging temperatures.

Keywords : Austenitic stainless steel, Z-phase, High nitrogen, Aging treatment, Precipitation

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Abstract No. : **PO-S13-0288**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Effect of MACl as an additive for stabilization and high efficiency of $FAPbI_3$ solar cells

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$FAPbI_3$ has received much attention as an appropriate candidate for solving the thermal-moisture instability of $MAPbI_3$. Formamideinium lead triiodide ($FAPbI_3$) exhibits a lower band gap than $MAPbI_3$, which is much closer to the Shocky-queueisser limit. However, $FAPbI_3$ has a delta-phase structure called non-perovskite at room temperature and requires a specific temperature (>160 degrees) to get a desired alpha phase. To prevent these properties, adding a MACl as an additive into $FAPbI_3$ causes a positive effect.

Potentially, filling the A site with MA instead of FA may reduce strain on the unstable crystal lattice of FAPbI3, resulting in a stable lattice. Furthermore, Chloride could enhance crystallization and reduce the non-radioactive recombination of perovskites. The A-site cation substitution through the Cl base compound requires lower energy than other halide-based compounds, which positions MACl as a promising substitution method. In this study, we achieved an efficiency of 19.8% of $FAPbI_3$ by adding methylammonium chloride to prevent unstable properties. We also delve into the crucial role of MACl in stabilizing $FAPbI_3$. Consequently, our findings suggest that adding MACl at an appropriate ratio could stabilize the lattice and achieve a desired phase with low energy, an essential advancement in perovskite research.

Keywords : Perovskite solar cells, Solar cells

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Abstract No. : **PO-S01-0287**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Recycling NCM cathode by electrodeposition with redox flow battery system

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With the recent growth of the electric vehicle market, the consumption of lithium-ion batteries (LIBs) is increasing significantly. Recently, recovering the critical metals such as cobalt and nickel from the waste batteries have received great attention to solve material exhaustion. The pyrolysis process has disadvantages as low yields of transition metal recycling, unavailable lithium recovery, and harmful gases. Likewise, hydrometallurgical process has a risk of electric shock and treating acid. Therefore, waste battery recycling technologies should be investigated to raise recovery yield and reduce process time and safety problems.

Herein, we introduce a new technology for recycling battery cathode materials using a simple redox flow battery (RFB) system. The RFB-based cathode material can be recycled through a simple strategy of charging and discharging process. During charging process, transition metal were deposited to carbon electrodes, and electrodeposited electrodes could be applied to a new bath. After discharging process, we could get a precursor solution as LIB cathode materials. Our method has advantages that we can recover cathode materials without high temperature treatment and harmful chemicals. About 95% of NCM cathode material was recycled through our RFB system-based recycling method. Ni, Mn, and Co were recycled under proper pH which was controlled by ammonium hydroxide. This result demonstrates that our RFB system can recover and recycle transition metals conveniently and easily with simple charging and discharging process.

Keywords : recycling, NCM, redox flow battery

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Abstract No. : **PO-S06-0286**
Symposia : **Advanced Structural Materials**
Abstract Preference : **Poster**

Mechanical and Thermal properties of Ceramic fiber composites with polyimides at high temperature

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Thermal setting polymer matrices such as epoxy, vinyl ester and phenol have been widely applied to FRP (Fiber Reinforced Plastics) based on ceramic fibers for thermal reisistant or insulating materials. Yet, low degradation temperature of the aforementioned polymers limits their applications. To improve this, various types of the polyimides with a superior thermal/mechanical property, solvent resistance, dimesional stability and electrical insulation are applied on FRPs including aerosapce fields. Although early reports have demonstrated the excellent thermal resistance of polyimides, most investigations related to the thermal degradation have been conducted in inert gas environments. Consequently, polyimides are not used on FRPs at high temperatures as referred in the reports because it is exposed to real aery condition. In this work, we developed a polyimide with over 450°C (Td 5%) in air and improved the polyimide film hardness adding silica powders gradually (0~7%). We also fabricated ceramic fiber composites impregnating this new polyimide as a matrix and observed the result of the same mechanical properties of the composite at 450°C compared to room temperature in the air condition.

Keywords : FRP polyimide

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Abstract No. : **OR-S06-0285**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Analysis of microstructure and tensile properties of Al-Mg-Si alloys produced by horizontal and vertical twin-roll casting

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Aluminum alloys are widely utilized in automotive applications due to the increasing demand for lightweight vehicles with improved fuel economy and reduced emissions. Al-Mg-Si alloy plates are used in automotive body panels due to their high specific strength, formability, and good corrosion resistance. These alloys are typically manufactured through direct cooling (DC) casting and pyrometric processes, which include casting, homogenizing, rolling processes, and solution treatments. Conventional processes are therefore complex, time-consuming, and costly. Twin-roll casting (TRC) has economic advantages because it can directly fabricate thin strips from molten metal. In this study, the effect of casting speed on the center deviation of Al-Mg-Si TRC strips fabricated by horizontal (HTRC) and vertical twin-roll (VTRC) casting machines was analyzed in detail. Moreover, the tensile properties of cast and thermomachined sheets as well as the evolution of secondary phases, texture and age hardening were discussed in detail. This study aims to provide a deeper understanding of the microstructure evolution and tensile properties of Al-Mg-Si alloys by utilizing different twin-roll casting machines, HTRC and VTRC.

Keywords : Al-Mg-Si alloy; Twin roll casting; Casting speed; Microstructure evolution; Tensile properties.

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Abstract No. : **PO-S07-0284**
Symposia : **Computational Materials Science**
Abstract Preference : **Poster**

Synaptic properties of interfacial switching model using two level simulations.

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This study comprises interfacial switching mechanisms of memory devices by using two level simulation method. Level one typically includes drift and diffusion of oxygen vacancies with the oxide material by applied external bias voltage whereas second level deals with measurement of current by modulation of Schottky barrier height at the interface between metal and oxide. This level takes concentration observed inside the active layer into account to quantify the current by modulating SBH.
By adjusting the Schottky barrier height within this layer, we observe a significant influence on the current flow, helping us understand its crucial role in switching of memristive model. Furthermore, we scrutinize the device performance through an extensive exploration of material parameters and synaptic properties, aiming to unravel the intricate relationship between these factors and the operational efficacy of the memristive devices.
With our detailed simulation model, our goal is to provide valuable understanding of the fundamental mechanisms guiding the function of memristive devices employing oxide materials. This study carries important implications for the progress of neuromorphic computing and other innovative technologies relying on memristive devices, offering deeper insights into their performance and facilitating improved design and functionality of these devices.

Keywords : RRAM, Resistive switching, Finite element modeling, Schottky barrier modulation, Interfacial switching mechanism.

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Abstract No. : **OR-S02-0283**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Anion exchange in discretely grown semiconductor nanomaterials

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Ion exchange is emerging as a powerful post-synthetic strategy to engineer unprecedentedly high-quality nanomaterials by tuning chemical composition, crystal phase, doping, and morphology. Several heterostructured nanocrystals have been prepared through cation exchange (CE) reactions. However, in contrast to CE, the study of anion exchange (AE) processes is still in its infancy. Since the larger size and slower migration rate of anions, the exchange process usually requires high reaction temperatures, which leads to the reconstruction of the original frameworks, thus causing structural changes or collapse. Here, we used magic size clusters (MSCs) and nanoplatelets (NPLs), two discretely grown nanomaterials, as model systems to study the AE. We showed that two different AE pathways exist in the transition of MSCs, which are determined by the MSCs' compositions and structures. In addition, we achieved AE in two-dimensional nanocrystals, by which either type I or type II NPLs can be obtained without the Kirkendall effect. The heterostructured NPLs show improved optical properties. For example, the quantum efficiency of CdSe-CdS NPLs at 462 nm can be increased from 13.63% to 63.68%.

Keywords : Cluster, Nanoplatelet, Anion exchange, Heterostructure

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Abstract No. : **OR-S06-0282**
Symposia : **Advanced Structural Materials**
Abstract Preference : **Oral**

Mechanical and electrical properties for carbon nanotube yarns with large diameters drawn from carbon nanotube arrays

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CNT yarn have advantages such as low density, large surface area per unit area, excellent electrical properties, and mass production at low cost. Dry spinning, one of the methods for making CNT yarn, is a method of making bundles of vertically grown CNT arrays with van der Waals force. However, dry-spun CNT yarns still exhibit significantly lower mechanical and electrical properties compared to individual CNTs due to weak interfacial bonds between nanotubes. Therefore, numerous approaches have been developed to improve the interfacial strength and increase packing density of CNT yarns.

As one of the various approaches, We tried to fabricate a multi-jig for merging CNT webs by adjusting the number of CNT arrays for different turn per meter in the dry spinning process. The sample used a CNT arrays with a width of 2.5 cm and a length of 300 μm. The multi-jig was fabricated by setting the angle for each sample to 10 degrees and can easily control the number of CNT arrays. We can manufactures CNT yarns with large diameters from 103 um to 280 um. The twist angle of CNT yarn from 15 degree to 80 degree was checked from FE-SEM according to turn per meter and the number of CNT arrays.

The mechanical and electrical properties of CNT yarn produced from multi-jig were investigated according to twist angle. Both the mechanical strength and electrical properties of CNT yarn tend to decrease as the twist angle increases. The fracture mechanism for mechanical strength according to twist angle was explained through the strain-stress curve. In addition, we analyzed the trend of CNT resistivity according to the twist angle.

Keywords : Carbon nanotube, twist angle

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Abstract No. : **PO-S15-0281**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Optical properties of microstructured copper-oxide thin films prepared by glancing-angle deposition

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Electrochromic (EC) phenomenon is a reversible color change of a material by injecting an electric charge into the material. Adsorption-induced EC (AiEC) phenomenon, in which the color change is caused by alternation of surface adsorbates, has been reported for n-type degenerate semiconductors such as indium nitride, indium-tin oxide (ITO) etc. The AiEC phenomenon is based on a Fermi-level shift as the surface adsorbates change. Based on this principle, a similar phenomenon should occur in p-type semiconductors. In this study, we prepared copper oxide thin films, which have been reported to exhibit p-type semiconductor characteristics, to investigate whether the AiEC phenomenon occurs. Copper oxide thin films were prepared on ITO-coated glass substrates tilted at 85° with respect to the target normal (glancing-angle deposited (GLAD) samples) using a RF magnetron sputtering system. The prepared samples were characterized using SEM, XRD, and spectrophotometry. Cu_2O crystalline phase was observed at an oxygen flow rate of 0.15 sccm, while the CuO phase became dominant at 0.40 sccm. When the O_2 flow rate was increased, the gaps among the columnar crystals were observed to be prominent. Reversible transmittance changes with polarization were observed in the films deposited at all O_2 flow rates. The bright state during cathodic polarization and the dark state during anodic polarization were similar to the AiEC phenomenon reported for InN.

Keywords : Glancing-angle deposition, Electrochromic, RF magnetron sputtering, Copper

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Abstract Preference : **Poster**

Effect of Glancing-angle-deposition Temperature on Electrochromic Response of InN Films

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Indium nitride (InN) is known to exhibit electrochromic (EC) phenomena and has the practical advantage of faster color change than conventional EC materials such as tungsten oxide. However, the factors that determine this speed have not been clarified. Previous studies have suggested that the size of the gaps among columnar crystals in InN thin films with discrete nanocolumnar structures is related to the color change response characteristics. In this study, we fabricated InN thin films with controlled porosity by heating the substrate and investigated the correlation between the porosity and the color change response.

InN films with discrete columnar structures were prepared by glancing-angle reactive evaporation. The substrate temperature during deposition was controlled in the range of non-heated to 225°C using a lamp heater. The morphology of the InN thin films was observed using SEM. The crystallinity was evaluated using XRD. The EC properties were evaluated in a 0.1 mol/L Na_2SO_4 solution.

The surface of the columnar crystals became smoother, and the porosity increased with increasing substrate temperature. The color-change response time decreased with increasing substrate temperature for both anodic and cathodic polarizations. We suppose that the substrate heating assisted the surface migration of the evaporated atoms, which prevented new nucleation on the surface of InN grains and smoothened the columnar structure. The smooth side walls of the columns resulted in wider gaps, which facilitated the transportation of ions from the solution, and the color change response was improved.

Keywords : Indium nitride

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Abstract No. : **OR-S04-0279**
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Abstract Preference : **Oral**

Retina-like Stretchable Multiplexed Arrays using Quantum Dot Semiconducting Nanocomposites

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Although advances in soft optoelectronic devices that mimic retina with a unique functionality capable of accurate detection of a wide spectrum of colors in a visible light range have been extensively reported, there still remains challenges associated with several issues such as the lack of stretchability, low areal density, and unavoidable electrical errors originating from either materials fatigue or mechanical deformation. Here, we report novel materials strategies and fabrication/integration processes of a retina-like stretchable multiplexed arrays. The new class of the intrinsically stretchable artificial retina consisting of organic-inorganic hybrid semiconducting nanocomposites, crack-based gold nanomembrane electrodes, and supporting/encapsulating layers. In light of light-sensing capability, various size-tunable quantum dots that are vertically phase-separated to top and bottom interfaces in the composite, are effective in achieving efficient charge transfers. The as-prepared individual phototransistor cells can be either multiplexed or stacked in a way that was integrated in a misaligned manner using a transfer-printing method to better achieve high areal density as well as efficient structural configuration that prevents shadiness or optical interference. In addition to optimization of our array configuration, a deep learning algorithm is also able to fully support complete compensation for optical distortions during repetitive mechanical deformations of the devices. Taken together, the accurate recognition of specific color patterns such as red, green, and blue, even in harsh strained conditions, was highly feasible for mimicking the unique biological functionality of retina. Our research combining soft bioelectronics and machine learning techniques would extend beyond traditional imaging systems, offering promising prospects for wearable electronics, and biomedical devices that require high-fidelity visual sensing capabilities.

Keywords : Retina-like, Phototransistor, Nanocomposites, Quantum dot, Multiplexed array

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Abstract No. : **PO-S04-0278**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Offset-stacked silicon machine vision sensor for in-sensor edge detection

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Image processing techniques, such as edge detection, are prominently utilized in the field of machine vision. However, in conventional computing architectures, sensors and processing units are separated, leading to inefficiencies in energy and time during data transfer. To mitigate these challenges, advancements in in-sensor computing have emerged, enabling data processing within the sensor itself. Despite these advancements, traditional in-sensor image processing techniques employing 3×3 kernels for image filtering suffer from significant resolution loss, with the ratio between input and output pixels being 1/9. In this study, we present a solution by offset-stacking four layers of 2×2 kernels to eliminate resolution loss. To implement the kernels, 4 layers of dual-gate silicon image sensor array were fabricated, and each layer was stacked using diluted PDMS for adhesion with offset. Using electrostatic-doping, the responsivity to light was utilized as kernel weight. By adjusting the gate bias applied to the dual gate, the kernel composition could be modified, enabling edge detection in the x, y, and diagonal directions. By implementing high-resolution edge detection within the sensor itself, we achieved ultrafast edge detection without pixel loss, thereby enhancing the efficiency of data processing.

Keywords : In-sensor computing, Machine vision, Silicon image sensor

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Abstract No. : **PO-S05-0277**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

Effective Electrostatic Modulation of MoS_2 FETs via Dual Gating Effect

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Upon the technology-nodes-driven scaling, two-dimensional (2D) semiconductors such as MoS_2 have been regard as promising candidates to further push the lateral dimension shrinkage thanks to their atom-scale body thickness and excellent electrical properties. The ability to modulate and manipulate the electrostatic potential and local charge densities within the 2D channel is essential in the field of nanoscale field-effect transistors (FETs). However, in the case of routinely employed single-gate FET, there are still a number of technological challenges to effectively enhance electrostatic coupling to channel via solely single gating. In other words, it is hard to achieve large drive current density within monolayer MoS_2 and/or minimize leakage current within multilayer MoS_2. Herein, we fabricate multilayer MoS_2 based dual-gate field effect transistors (DG-FETs) simultaneously exhibiting greatly improved on-current density as well as low leakage current compared to single-gate FET. Specifically, MoS_2 DG-FET shows high on-state current of $I_{ON} = 3.9 \times 10^{-6}$ A, low off-state current of $I_{OFF} = 1.5 \times 10^{-15}$ A, high on/off ratio (2.6×10^9), and steep subthreshold swing (SS) (~192 mV/dec). This can be attributed to dual gate sturcture that can further suppress short channel effects (SCEs) (e.g. DIBL) as the characteristic scaling length (λ) of dual gate structure becomes shortened compared to that of single gate device. Furthermore, dual-gate (DG) structure provides capability to manipulate the electrostatic channel potential and moderates device performances (e.g. SS, V_{th}) by applying each gate bias separately. Our results can provide a paved way for the development of low-power, high-speed 2D semiconductor based transistors with dual gate sturcture toward state-of-the-art future electronics.

Keywords : MoS2, single-gate, dual-gate, field effect transistors, electrostatic channel potential

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Abstract No. : **PO-S07-0276**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Tailoring MXene Scavenger Reactions: Unveiling H2O2 Adsorption via DFT+U/D3

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The ever-growing need for efficient and environmentally friendly methods for wastewater treatment necessitates the development of novel and powerful catalysts. Hydrogen peroxide (H_2O_2) holds immense promise as an oxidant in scavenger reactions due to its ability to generate highly reactive hydroxyl radicals (OH•) that effectively degrade pollutants [1]. Transition metal carbides or nitrides (MXenes), have emerged as a class of promising materials for these applications owing to their unique combination of metallic conductivity, hydrophilic surfaces, and tunable surface functionalities [2].

This study delves into the adsorption behavior of H_2O_2 on MXenes. Density functional theory (DFT) calculations augmented with the dispersion-corrected (D3) DFT+U method are employed to achieve a more accurate representation of the realistic interactions between O and H atoms (H-bonding) as well as the d-orbitals of Ti and the p-orbitals of O in H_2O_2. This approach accounts for the crucial role of electron correlation effects, particularly relevant for transition metal systems. The results of our investigation shed light on the adsorption characteristics of H_2O_2 on freestanding MXenes. By employing the DFT+U/D3 method, we gain valuable insights into the interplay between the electronic structures of MXenes and H_2O_2. These insights provide a foundation for understanding and predicting the catalytic performance of MXene-based nanomaterials in H_2O_2-mediated scavenger reactions. By elucidating the interaction between H_2O_2 and MXenes at the atomic level, this study paves the way for the rational design of MXene-based catalysts optimized for H_2O_2 activation and pollutant degradation.

[1] G. Sun, et al., App. Catal. B: Environmental, 313 (2022) 121461.
[2] Y. Jiang, et al., Proc Natl Acad Sci U S A. 3 (2023) 1.

Keywords : Scavenger reactions; MXenes; DFT+U; H2O2; Adsorption

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Abstract No. : **OR-S16-0275**
Symposia : **ICYRAM Young Researcher Symposium**

Abstract Preference : **Oral**

Phase Controlled W Electrode for Low Voltage Switching of Ferroelectric $Hf_{0.5}Zr_{0.5}O_2$ Thin Film

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Owing to their superior scalability (thickness < 10 nm) and compatibility with CMOS (complementary metal-oxide-semiconductor) technology, the ferroelectric HfO_2–based thin films have emerged as promising materials for the memory devices.[1] The ferroelectric polarization switching is initiated when the external electric field applied exceeds the coercive field (E_c). Compared to perovskite ferroelectrics (0.01-0.1 MV/cm), the E_c for HfO_2-ferroelectrics (1.0-2.0 MV/cm) is considerably higher. Because of this, decreasing the operation voltage of ferroelectric memories based on HfO_2 films below a certain value can be challenging. Therefore, if E_c may be decreased, the operation voltage of the HfO_2 thin film could also be decreased. In this research, the ferroelectric capacitor, with 8 nm HZO ($Hf_{0.5}Zr_{0.5}O_2$) thin film and W electrodes, operating at a low voltage (<1.6 V) is discussed. The W can show W-α and W-β phase depending on the sputtering working pressure. Low (<4 mTorr) and High (>8mTorr) working pressures tend to promote the W-α and W-β phase, respectively. The HZO films on the W-α/-β electrode show a double remanent polarization ($2P_r$) of 33.58 μC/cm^2 (on W-α) or no electrical breakdown after 10^9 cycles of electric field cycles (on W-β), at 1.6 V. This could be understood by the low E_c of 0.78 and 0.69 MV/cm for the HZO films on W-α and W-β electrodes, respectively. The significantly low E_c not only facilitates low-voltage operations but also enhances endurance by reducing the electrical stress on the HZO film. This result indicates that electrode engineering could be a strategic approach for low-voltage operations and high reliability for ferroelectric HZO films.

[1] Böscke, T. S., et al., Appl. Phys. Lett. (2011)
[2] Lee, J., et al., Nano Converg. (2023)

Keywords : Ferroelectric, HfO2, ZrO2, electrode

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Abstract No. : **PO-S07-0274**
Symposia : **Computational Materials Science**

Abstract Preference : **Poster**

Tailoring MXene Scavenger Reactions: Unveiling H2O2 Adsorption via DFT+U/D3

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The ever-growing need for efficient and environmentally friendly methods for wastewater treatment necessitates the development of novel and powerful catalysts. Hydrogen peroxide (H_2O_2) holds immense promise as an oxidant in scavenger reactions due to its ability to generate highly reactive hydroxyl radicals (OH•) that effectively degrade pollutants [1]. Transition metal carbides or nitrides (MXenes), have emerged as a class of promising materials for these applications owing to their unique combination of metallic conductivity, hydrophilic surfaces, and tunable surface functionalities [2].

This study delves into the adsorption behavior of H_2O_2 on MXenes. Density functional theory (DFT) calculations augmented with the dispersion-corrected (D3) DFT+U method are employed to achieve a more accurate representation of the realistic interactions between O and H atoms (H-bonding) as well as the d-orbitals of Ti and the p-orbitals of O in H_2O_2. This approach accounts for the crucial role of electron correlation effects, particularly relevant for transition metal systems. The results of our investigation shed light on the adsorption characteristics of H_2O_2 on freestanding MXenes. By employing the DFT+U/D3 method, we gain valuable insights into the interplay between the electronic structures of MXenes and H_2O_2. These insights provide a foundation for understanding and predicting the catalytic performance of MXene-based nanomaterials in H_2O_2-mediated scavenger reactions. By elucidating the interaction between H_2O_2 and MXenes at the atomic level, this study paves the way for the rational design of MXene-based catalysts optimized for H_2O_2 activation and pollutant degradation.

[1] G. Sun, et al., App. Catal. B: Environmental, 313 (2022) 121461.
[2] Y. Jiang, et al., Proc Natl Acad Sci U S A. 3 (2023) 1.

Keywords : Scavenger reactions; MXenes; DFT+U; H2O2; Adsorption

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Abstract No. : **PO-S02-0272**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Fast turn-on, highly efficient and bright perovskite light-emitting diode by interfacial engineering on NiOx inorganic hole transport layer

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Nickel oxide (NiOx) has been broadly used as a hole transport layer (HTL) in perovskite light-emitting diodes (PeLED) due to its high carrier transport ability and intrinsic stability compared to organic materials. Despite of these advantages, NiOx has suffered from poor hole injection to the perovskite emission layer for fabricate highly efficient optoelectronic devices. To overcome this issue, introducing an interlayer between NiOx and the perovskite is one of the strategy by improving balanced hole injection via energy level tuning, reducing carrier loss at the interface, and so on. In this work, we apply carbazole-based functional self-assembly monolayers (SAM) as an interlayer between NiOx and the perovskite emission layer to improve hole injection using a facile solution process. We confirmed that functional self-assembly monolayers promote hole injection into the perovskite, forming the dipole between interface which roles as hole selection and electron blocking. In addition, we successfully modified SAM molecule structure and showed improved charge injection to perovskite emission layer than control. Finally, we demonstrate green perovskite light-emitting diodes using functional self-assembly monolayers as an interlayer and achieved improved maximum luminance over 10,000 cd m-2 and maximum external quantum efficiency (EQE) over 10 %. In addition, we also achieved very fast turn-on (2.1 V), highly efficient (10.25 %) and bright (80,772 cd m-2) PeLED by improving electron injection via electron transport layer (ETL) engineering. It is expected that highly efficient and bright perovskite light emitters can be achieved using metal oxide based inorganic charge transport materials.

Keywords : Metal oxide, perovskite LED, hole transport layer, self-assembly monolayers, dipole monent

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Abstract No. : **IN-S02-0271**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Technological Challenges for OLED-on-Silicon (OLEDoS) Display Backplane Circuits in for AR & VR Devices

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The market for augmented reality (AR) and virtual reality (VR) devices, exemplified by Apple's Vision Pro, is experiencing rapid growth. Consequently, there is increasing interest in on-silicon microdisplays, which are gaining attention as key components of AR/VR devices. On-silicon microdisplays for AR/VR devices have significantly different requirements compared to conventional flat panel displays. Firstly, to provide users with a high level of immersion, a wide field of view (FoV) of around 120 degrees in both horizontal and vertical directions must be achieved. Secondly, considering the human eye's resolution, a resolution of approximately 60 pixels per degree (PPD) is required. Therefore, based on the required FoV and PPD, a high resolution of about 7.2k × 7.2k must be supported. Thirdly, microdisplays should be manufactured in a very small size of around 1 inch, considering the size of AR/VR devices. Given these requirements, microdisplays must implement high-resolution displays on small-sized panels. Microdisplays utilize panels fabricated on silicon substrates that enable fine processing rather than conventional panels made on glass or plastic substrates to achieve this. Representative on-silicon microdisplays include liquid crystal-on-silicon (LCoS), OLED-on-silicon (OLEDoS), and LED-on-silicon (LEDoS). In this study, we aim to explain the technical challenges of pixel circuits and driving circuits, which are the backplane circuits required to implement the on-silicon displays and discuss the methods being explored as solutions to these challenges.

Keywords : On-silicon display, microdisplay, backplane circuit, OLED-on-silicon, LED-on-silicon

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Abstract No. : **PO-S11-0270**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Tailoring Thermoelectric Properties of Large-Area MoS_2 Films with effective doping strategies

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Thermoelectric generators have attracted much attention as an eco-friendly energy harvesting system by converting waste heat to useful electricity. As a thermoelectric material, two-dimensional transition metal dichalcogenides (TMDs) are most promising candidates due to their attractive properties such as high Seebeck coefficient and low thermal conductivity. Especially, molybdenum disulfide (MoS_2), n-type semiconducting TMDs, exhibits a high Seebeck coefficient with wide tunability between $-4x10^2$ and $-1x10^5$ uV K-1 of single-layer MoS2.[3] However, there are many challenges to realize practical 2D thermoelectric applications due to its extremely low electrical conductivity, which results in low figure of merit and has trade-off relationship with Seebeck coefficient. Moreover, most thermoelectric generators (TEGs) have been demonstrated with mechanically exfoliated 2D flakes which are not suitable for large-area practical applications.

In this presentation, we suggest efficient doping methods for tailoring thermoelectric properties of chemical vapor deposition (CVD)-grown large-area MoS_2. To widely modulate the carrier concentration corresponding to high conductivity, we employed both doping strategies: surface charge transfer doping (SCTD) and electrostatic doping. Benzyl viologen (BV), which is an air-stable n-type dopant, was selectively deposited using inkjet printing and electrostatic doping was conducted by introducing bias on a underlying electerode. The proposed doping for large-area 2D MoS_2 enabled us to increase the power factor value up to approximately 1.5 mW/mK^2. The thermoelectric properties of pristine and doped TEGs were evaluated using a gated 4-point probe(4PP) measurement system with a temperature gradient. We believe that our results can be promising pathways to enhance the thermoelectric performance of practical 2D nanoelectronics.

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[1] ACS Nano, 2022, 4, 6215–6223 [2] J. Mater. Chem. C. 2017, 5, 7684 [3] Nano Lett. 2013, 2, 358–363

Keywords : 2D-TEG, MoS2, Doping

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Abstract No. : **PO-S01-0269**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Understanding of performance degradation and moisture uptake of LiNi0.80Co0.10Mn0.10O2 cathode material with different calendaring conditions

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Lithium-ion batteries(LIBs) are excellent energy storage devices with their high energy density, high open circuit voltage, and long lifespan. To increase the energy density, a calendering process is essential. After the calendering process, the coating density increases, and the microstructure changes. The microstructure of the cathode affects the porosity, specific surface area, and tortuosity, accordingly affecting the rate capability and capacity retention.

Moreover, microstructure also affects the moisture content. The moisture content of the cathode greatly depends on the material properties and microstructure of the cathode. Moisture content has a great influence on the performance of the LIB because it causes fatal contamination of the LIB. In this regard, studies on the calendering effect of LiNi0.33Mn0.33Co0.33O2 (NMC111) and LiNi0.60Mn0.20Co0.20O2 (NMC622) have been actively conducted. However, despite the importance of LiNi0.80Mn0.10Co0.10O2 (NMC811) according to high specific capacity and high operating potential, studies on the calendering effect on NMC811 are insufficient. In particular, research on NCM811, a high-nickel cathode active material, is essential because NMC's moisture vulnerability increases with increasing Nickel content. Therefore, we analyzed the moisture content and electrochemical performance degradation according to different calendering conditions of NMC811 and identified the deterioration mechanism that occurs at the highest coating density.

The high-density electrodes absorbed more moisture and experienced reduced ion conductivity, affecting performance negatively at high C-rates. High-density cathodes also featured smaller pore sizes and a more uniform distribution, contributing to their increased moisture absorption. The low Li-ion conductivity of the higher-density coating led to capacity loss at higher C-rates despite the better electric conductivity due to the increased electrochemically active surface area by the crack of particles.

Keywords : Lithium-ion battery, Calendering effects, Moisture uptake, NMC811, Electrochemical performance degradation

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Abstract No. : **IN-S02-0268**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Invited**

Defect passivation for perovskite light-emitting diodes

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Solution-processable optoelectronic materials have several advantages such as light-weight, flexibility, transparency, low cost, and large-area processing compared to conventional crystalline inorganic elemental semiconductors. Among them, metal halide perovskites have been explored in light-emitting applications, a testament to their facile bandgap tuning, high color purity, and high absorption coefficient. However, these materials easily contain defect sites in surfaces, creating electronic traps within the bandgap. Furthermore, the performance of light-emitting diodes ─ which consist of several thin layers ─ depends on interface quality. A promising approach to overcome the issue is surface engineering that can passivate defects, adjust energy levels and control surface characteristics for better wettability.

In this presentation, we will introduce recent results regarding perovskite light-emitting diodes, and mainly discuss the beneficial effects of surface engineering on the device performance. In particular, we will introduce significant beneficial effects using amine-based passivating materials to passivate defect sites on the surface of perovskite films. Furthermore, we will present a method to grow perovskite films composed of uniform nano-sized single crystals by employing phenylmethylamine as a ligand. In the last chapter, we will discuss about the effect of bottom charge transport layers on the perovskite crystal growth and the resulting interface quaility using mulifunctional (defect-passivating and hole-transporting) conjugated polyelectrolytes bearing different ions.

Keywords : Perovskites, Light-emitting diodes, Defect passivation, Surface engineering

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Abstract No. : **OR-S01-0267**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Oral**

A Physical Approach to Practical Applications of Lithium Metal Anode Using High-Flatness Cu Mesh Inducing Epitaxial Li Plating

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Lithium metal batteries (LMBs) have been highlighted as next-generation energy storage system due to its high energy density. However, dead and dendritic Li induced by large volume change of Li and inhomogeneous Li+ flux during Li plating/stripping hinder the practical application of the LMBs. Especially, the copper foil, which is a two-dimensional substrate, increases the local current density and forms sharp Li nuclei. Furthermore, the repeated volume expansion ruptures the solid electrolyte interface, leading poor battery cycle stability. Therefore, numerous papers introduced 3D hosts (mesh, foam, gauze, and coil) to induce the dense Li deposition via reducing the local current density. In addition, mechanically stable and spacious structure of 3D hosts easily accommodates the internal stress fluctuation. Although these strategies homogenize Li+ flux and buffer volume change, they still have low applicability due to the thick thickness of 3D hosts and the poor flexibility of the cathode.

Herein, we report high-energy (1-Ah-scale) LMBs with highly flat metal (Cu and SUS) mesh substrates using a simple roll-to-roll process. The pressed Cu mesh anode induced dense Li deposition and accommodated volume expansion, exhibiting long-cycle stability over 1,000 cycles in symmetric cell evaluation under a current density of 1mAh cm−2@1mA cm−2. Interestingly, the dry NCM electrode coated on pressed SUS mesh achieved a high active material loading level of 45 mg cm−2 without any performance degradation. Finally, flexible LMB represented high energy density (>400 Wh kg−1) and cyclic lifespan of 150 cycles under frequent mechanical bending. This result demonstrates commercially plausible flexible LMB, broadening the scope of next-generation lithium-based batteries.

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Keywords : Lithium metal anode, Pressed metal mesh, Dry coating, Epitaxial Li plating

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Abstract Preference : **Oral**

The recycling of used LMO cathode active material for high-voltage redox flow batteries

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As renewable energy plays a vital role in the energy industry, redox flow batteries (RFBs) are in the spotlight as energy storage systems (ESSs) that can increase efficiency by storing generated electricity. Among various aqueous electrolytes, zinc-manganese redox flow batteries (ZMRFB) using the alkaline anolyte and the acidic catholyte separated by two membranes independently have higher voltage (2.442V vs. SHE) compared to other RFBs. Also, battery demand continues to surge dramatically, research into the recycling of battery materials is being explored extensively. Although numerous studies have been conducted, there is a lack of research on recycling strategies utilizing RFBs.

In this study, we reported that used LMO cathode active material can be recycled to the RFB cathode electrolyte. We flowed LMO powder containing sulfuric acid solution through a carbon felt electrode, enabling the electrochemical reaction for the Mn reduction occur. Compared to conventional ZMRFB, recycled LMO RFB (RLRFB) showed higher energy efficiency due to conductive material in the powder. Also, we introduced bipolar membrane (BPM) with each cation and anion exchange combined membrane to achieve high voltage battery without electrolyte crossover problem.

In summary, the RLRFB showed the high open-circuit voltage of 2.65 V with a cycling performance for 300 cycles, which was comparable to those of other aqueous RFBs. We proposed the new strategy for recycling lithium-ion battery cathode materials and expected to be applied to other materials using RFB recycling method.

Acknowledgments
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Keywords : LMO, RFB, recycling, electrochemically

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Abstract No. : **OR-S04-0265**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Oral**

Low-Impedance Tissue-Device Interface using Homogeneously Conductive Hydrogels Chemically-Bonded to Stretchable Bioelectronics

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Stretchable bioelectronics has made a noteworthy contribution to the advance of continuous health monitoring and point-of-care type healthcare. However, microscale non-conformal contact and locally dehydrated interface limit performance, especially in dynamic environments. Therefore, hydrogels can be a promising interfacial material for the stretchable bioelectronics due to their unique advantages including tissue-like softness, water-rich property, and biocompatibility. However, there are still practical challenges in terms of their electrical performance, material homogeneity, and monolithic integration with stretchable devices. Here, we report the synthesis of a homogeneously conductive polyacrylamide hydrogel with an exceptionally low impedance (~21 ohm) and a reasonably high conductivity (~24 S/cm) by incorporating polyaniline-decorated poly(3,4-ethylenedioxythiophene:polystyrene). We also establish robust adhesion (interfacial toughness: ~296.7 J/m^2) and reliable integration between the conductive hydrogel and the stretchable device through on-device polymerization as well as covalent and hydrogen bonding. These strategies enable the fabrication of a stretchable multichannel sensor array for the high-quality on-skin impedance and pH measurements *in vitro* and *in vivo* circumstances.

Keywords : Conductive hydrogel, low-impedance hydrogel, hydrogel adhesion, bioelectronics

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Abstract No. : **PO-S02-0264**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Surface chemistry enabled 2D patterning of quantum dots

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Next generation displays based on quantum dot light-emitting diodes (QLEDs) require robust patterning methods for quantum dot (QD) layers. However, existing patterning methods mostly yield QLEDs with performance far inferior to the state-of-the-art individual devices and the way these methods affect the optoelectronic properties of QDs remains elusive. Here, we developed two different patterning methods based on the surface chemistry of QDs. Through the design of ligands and photoadditives, UV-exposed QDs will alter their colloidal stability in pristine solvents under photochemical reactions, achieving high-resolution patterning similar to regular photolithography. One the one hand, we designed different crosslinkers to photocrosslink adjacent QDs and elaborate the role of photochemistry of nitrene- and carbene-based crosslinkers in the patterning of QDs. These molecules, far beyond physical linkers, strongly affect patterning capabilities and photophysical properties of patterned QDs and devices.

These can be traced to their molecular designs and associated changes in light absorption properties, electronic structures, spin states, and reaction pathways. Rationally designed carbene-based crosslinkers enable high-fidelity QD patterning at 365nm and the formed patterns show well-retained photoluminescent and electroluminescent properties of QDs. On the other hand, we reported a light-triggered, carbocation-enabled ligand stripping (CELS) approach to pattern QLEDs with high efficiency and stability. During CELS, photogenerated carbocations from triphenylmethyl chlorides remove native ligands of QDs, thereby producing patterns at microscale precision. Chloride anions passivate surface defects and endow patterned QDs with preserved photoluminescent quantum yields. It works for both Cd-based and heavy-metal-free QDs. CELS-patterned QLEDs show remarkable external quantum efficiencies (19.1%, 17.5%, 12.0% for red, green, blue, respectively) and a long operation lifetime (T_{95} at 1000 nits up to 8700 h). Both are among the highest for patterned QLEDs and approach the records for nonpatterned devices. Surface chemistry enabled patterning of QDs is promising for building high-performance QLED displays and related integrated device.

Keywords : quantum dots, photopatterning, light-emitting diodes, photochemistry, ligand chemistry

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Abstract No. : **PO-S01-0263**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Homogeneous and ultra-thin lithium metal anode for high-energy density lithium metal batteries

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As the use of electric vehicles increases, the amount of lithium-ion batterie (LIB) used also expands. However, graphite, anode material in commercial LIB, has a low theoretical capacity (372 mAh g^{-1}) and energy density (350 Wh kg^{-1}). Thus, commercial LIB is difficult to apply for Next-generation energy storage systems. To overcome these limitations of LIB, lithium metal batteries (LMBs) with high theoretical capacity (3860 mAh g^{-1}) and energy density (400-500 Wh kg^{-1}) has been studied. Despite these advantages, lithium metal anodes (LMA) formed lithium dendrites, causing large volume expansion during Li plating/stripping. In addition, Cu foil is lithiophobic for lithium which is difficult to manufacture a uniform lithium metal anode resulting in unstable cycling performance.

In this study, we report an ultra-thin lithium metal anode with lithium layer using ZnF2 powder and molten Li. ZnF2 can provide superior wettability between lithium and Cu foil, leading to uniform Li deposition and inhibiting the growth of lithium dendrites. SEM analysis exhibited that the Li-ZnF2(LZnF) fabricated a uniform lithium layer on a Cu foil without pores. XRD analysis confirmed that Li-Zn alloy and LiF compound were formed on Cu foil. These layers can enhance lithium-ion conductivity and reduced interfacial resistance.

Li-Zn alloy provided abundant Li nucleation sites with fast electron transport during Li deposition. Additionally, LiF alloy provided high interface energy and inhibited the growth of Li dendrite.

As a result, LZnF electrode exhibited a low overpotential of 20 mV for 350 cycles in symmetric cell test at 1 mA cm^2 and low resistance of 13.2 Ω in EIS test. These results can provide a method of commercializing next-generation lithium metal batteries.

Keywords : lithium metal battery, lithium metal anode

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Abstract No. : **PO-S01-0262**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Stabilizing P2-type Cathode Material and Tuning Its Oxygen Redox Chemistry via Co-substitution for Sodium-ion Battery

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Lithium-ion batteries (LIBs) have received great attention as one of the most promising energy storage systems (EES) due to their high energy density. However, lithium sources in the earth are limited, making the cost and supply of LIBs unstable. With respect to this problem, sodium-ion batteries (SIBs) have been studied as one of the low-cost EES, owing to the abundance of sodium sources. Currently, layered oxides, polyanion compounds, and Prussian blue analogue have been reported for the cathode materials of SIBs. Among them, prismatic Mn-based layered oxides have high theoretical capacity due to the redox reaction of transition metals and the oxygen that occurs at high voltage. The oxygen redox reactions severely degrade the operating voltage during discharge, which could be ascribed to their slow kinetics and structural instability.

In this study, Cr and Mo were adopted as doping elements in P2-type $Na_{0.67}Li_{0.2}Mn_{0.8}O_2$ (NLMO) to improve oxygen redox reaction and structural stability. The average discharge voltage of $Na_{0.67}Li_{0.2}Mn_{0.7}Cr_{0.05}Mo_{0.05}O_2$ (NLMCMO) was ~3.1 and ~2.85 V at 10 mA g^{-1} and 500 mA g^{-1}, respectively, showing a significantly lower voltage gap than pristine NLMO. NLMCMO clearly demonstrated higher cycle stability than NLMO, showing a capacity retention rate of about 87% after 200 cycles. The cycle stability arose from a significant reduction of plateau regions at high voltage above 4.2 V, along with the restricted P2-O2 phase transition. Moreover, NLMCMO with improved structural stability showed excellent high-rate capabilities at high current densities. We believe that this research can contribute to improving the oxygen redox kinetics for stable and high-voltage operation in fast charging SIBs.

Keywords : sodium-ion battery, P2-type, cathode materials, layered structure

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Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Oral**

以玉米芯粉为积木：促进儿童创造力和安全的生物材料生态创新

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我国东北地区是玉米种植主产区，每年产生大量玉米芯等农业废弃物。虽然玉米芯废物可以通过化学活化等方法进行转化和再利用，但本研究旨在探索一种合成可生物降解聚合物的方法来处理玉米芯，将其转化为刺激儿童创造性思维的环保积木。该材料由玉米芯粉、高直链玉米淀粉、食用碳酸钙等天然物质组成，在模具中40℃固化36小时。作者设计并进行了五项对照实验，研究不同原料比例对合成聚合物性能的影响，包括着色性、防水性、机械性能、耐腐蚀性和食品级安全性。

结果表明，该材料在上述五项性能上均表现出令人满意的性能。此外，孩子们可以在材料凝固之前自由设计玩具的形状，与传统的木制积木相比，有效培养创造性思维能力。另一方面，用这种材料制成的玩具如果丢弃，可以在土壤中完全降解，不会污染环境。该材料目前正处于小规模工厂测试的初级阶段，用于创意玩具生产，例如儿童积木。

Keywords : Synthesis of biodegradable polymers, Corncob powder, Children-friendly, Creative thinking, Building blocks

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Abstract No. : **OR-S16-0260**
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Abstract Preference : **Oral**

Process Engineering in a Novel Molybdenum Nitride Electrode for Wake-up Mitigated (Hf,Zr)O_2 Ferroelectric Capacitor

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Since ferroelectricity in HfO_2-based film was reported in 2011, (Hf,Zr)O_2 film has attracted notable interest from various researchers for its CMOS(complementary metal-oxide-semiconductor) process compatibility and scalability.[1] However, a P_r(remnant polarization) increase during field cycling of ferroelectric capacitor, known as the wake-up effect, emerges as a major reliability issue.[2] Some metal electrodes have been suggested to mitigate the wake-up effect of (Hf,Zr)O_2 film, however, metal electrodes face a reliability issue due to their relatively easier oxidizing property compared to nitride electrodes.[3]

In this study, a novel molybdenum nitride electrode under various processing conditions is studied. With a 1:1 mixture of Ar and N_2 sputtering gas, the electrode was identified as a γ-Mo_2N by XRD(X-ray diffraction) analysis. To investigate the impact of nitrogen content and deposition temperature on the electrode, the N_2 gas ratio in the total sputtering gas ($Ar+N_2$) was adjusted at various deposition temperature. Each electrode was used to fabricate ferroelectric HZO($Hf_{0.6}Zr_{0.4}O_2$) capacitors to study the electrode's impact on ferroelectricity. All the samples showed superb wake-up mitigation properties with a 3.0 MV/cm fatigue pulse, where the $2P_r$ value increase was less than 15% after 10^5 of electric field cycles. Furthermore, the effect of electrode deposition temperature on ferroelectric capacitor is investigated. Some electrodes deposited at 30℃ experienced fatigue after 10^7 cycles of 2.0 MV/cm fatigue pulse, which was mitigated at 100℃ of deposition temperature. These results suggest that optimizing the proper electrode deposition process is important to mitigate the wake-up effect and enhance the endurance of ferroelectric HZO films.

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[2] Park,M.H., et al., ACS Appl. Mater. Interfaces. (2016)
[3] Kim,S.E., et al., Adv. Mater. Technol. (2023)

Keywords : Molybdenum Nitride, Ferroelectric, HZO, FeCAP

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Abstract No. : **PO-S06-0259**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Cryogenic Characteristics of O-ring and Spring for Valves under Compressive Load

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With the increasing demand for small artificial satellites, there are growing need for space rockets. Consequently, lightweighting of components in space rockets has become a critical factor, offering significant economic advantages. Such components are composed of numerous pipelines and check valves, which are used to inject the fuel and liquid oxygen. In this experiment, therefore, we focused on evaluating the physical and deformation properties of O-ring and spring for check valves at room and cryogenic temperatures under compressive load. The Nitrile O-rings(P41, P4), Teflon O-rings(PI, PCTFE, PFA) and STS304 spring were subjected to cryogenic treatment in liquid nitrogen at -196°C for 10 min, followed by exposure to room temperature for 1 min. After cryogenic treatment, there were no differences in thickness of P41, P4, PI, PCTFE, PFA O-rings and in length of spring. The P41, P4, PI, PCTFE, PFA O-rings and spring were subsequently subjected to compressive load (1500kgf for O-rings and 500kgf for spring) for 10 min at room temperature. The thickness of O-rings obviously decreased by compressive load. On the other hand, after applying compressive load, the length of spring without cryogenic treatment decreased from 25 to 24mm, while the cryogenic treated one showed 22mm in length.

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Keywords : O-ring, Spring, Compressive load, Cryogenic treatment

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Abstract No. : **OR-S14-0258**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Dual-Atoms Supported Nitrogen-Modified Graphene as a Bifunctional Electrocatalyst for HER and OER

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The development of cost-effective, highly efficient, and durable electrocatalysts remains a significant challenge in advancing the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). In this study, we introduce a novel electrocatalyst comprised of dual metal single atoms site coordinated with nitrogen-doped porous graphene (NGr), demonstrating a cutting-edge approach for improving electrocatalytic performance for water-splitting applications in an alkaline environment. Through the synthesis process, a well-dispersed dual-metal, single-atom catalyst was fabricated onto porous NGr using the pyrolysis method, aimed at enhancing the HER and OER performance through the construction of abundant active sites and bimetallic synergistic effects The resulting materials features uniformly distributed and richly co-doped dual single atom sites on porous NGr. The structural and electrochemical characterizations were conducted utilizing the advanced techniques such as field emission electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDX), X-ray spectroscopy (XRD), X-ray photoelectron spectroscopy (XPS), inductively coupled plasma mass spectroscopy (ICP-MS), cyclic voltammetry (CV), linear sweep voltammetry (LSV) and electrochemical surface area (ECSA). This work provides a comprehensive understanding of the electrocatalytic performances of dual atom catalysts, thereby contributing to the design of novel atomic catalysts with superior electrocatalytic activity.

Keywords : Water splitting, Dual single atom, Hydrogen evolution reaction, Oxygen evolution reaction

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Abstract No. : **PO-S06-0257**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Micro-/macro-structures and Hardness of Vacuum Induction Cast Al-Dy alloys

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From the perspective of lightweighting materials, aluminum offers significant advantages due to its low density. Additionally, its low melting point contributes to excellent casting and processing characteristics. However, aluminum exhibits low mechanical properties at room and high temperatures. The addition of rare earth elements is generally effective to enhance the room and high temperature properties of aluminum alloys. In this study, therefore, the micro-/macro-structures and vickers micro-hardness of Al-Dy (3, 5, 10 wt%) alloys prepared by vacuum induction casting were investigated. Al-Dy (3, 5, 10 wt.%) were cast after holding for 30 minutes at 1073K. Micro-and macro-structures were observed using optical microscopy(OM), and elemental component analysis was performed using energy-dispersive X-ray spectroscopy(EDS). The hardness was measured using vickers micro-hardness tester. Additionally, the phase formation in the obtained AL-Dy alloys was confirmed using X-ray diffraction (XRD). As the content of Dy increased, the equiaxed zone expanded. Conversely, reducing the content of Dy led to an expansion of the columnar zone. The vickers micro-hardness in the equiaxed zone of Al-Dy (3, 5, 10 wt.%) alloys was approximately 27, 30 and 43Hv, respectively, while, in the columnar zone, it was 28, 32, and 41Hv.

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Keywords : Vacuum induction casting, Micro-/macro-structure, Vickers micro-hardness, Al-Dy alloys

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Abstract No. : **PO-S14-0256**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Air-oil interface-operating photocatalytic organogel nanocomposites for efficient solar jet-fuel production

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Aromatic compounds such as biphenyl and naphthalene, which constitute 20% of jet fuel, have been mainly generated by conventional petroleum chemical processes accompanying massive amounts of carbon emission. Therefore, photocatalysis, driven by solar energy under ambient temperature and pressure, emerges as clean and energy-efficient alternatives to conventional petroleum chemical processes. While recent research on photocatalytic fuel production has garnered considerable attention, studies specifically focusing on the photocatalysis in organic phase for efficient production of jet fuel, particularly biphenyl, remain limited.

Here, we present efficient photocatalytic biphenyl production using PVA-based organogel nanocomposites operating on an air-oil interface. The nanocomposites consist of two layers, with a porous layer containing photocatalyst at the top and another layer below that provides floatability on the low-density oil phase via aerogel. These nanocomposites successfully produce biphenyl using various combinations of metals and supports and Pd/TiO_2 demonstrates superior performance. Furthermore, by positioning the floating organogel nanocomposites at the air-oil interface, they effectively absorb light and mitigate the light dispersion issue inherent in photocatalyst suspension systems. Consequently, it exhibits notable improvement in biphenyl production compared to a conventional system where the catalysts are settled. This novel floatable photocatalytic organogel device opens up possibilities to produce all components of jet fuel through eco-friendly photocatalysis, replacing conventional energy-intensive chemical processes.

Keywords : photocatalysis, jet fuel, organogel, air-oil phase, biphenyl

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Abstract No. : **PO-S09-0255**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Study of Resistive Switching Device by Integrating Phase-field and Thermo-electric Equations Using Finite Element Method

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Resistive random-access memory (RRAM) has a very simple structure compared to commercial memory. This simple structure allows for a three-dimensional stacked structure, which can be used to form a very high-density cell array. RRAM operates by changing the resistance state of the device by external electrical bias and has lower operating voltage characteristics and faster operating speed than charge-based memory. If a conductive filament is connected between electrodes, the device is in a low-resistance state (LRS). Conversely, if the conductive filament is missing or broken, the device is in a high-resistance state (HRS). Most of the existing finite element-based filament RRAM simulation models are concentration-based models that start from the initial formation state using a predefined filament structure. The problem with these concentration-based models is that they cannot represent the metastable state of the resistive state of RRAM. In this study, we introduce a fully coupled equation model that integrates electrical, thermal, and phase field equations for filamentary resistive memory devices. This model applies physics-based formulas such as electro-migration, recombination, and generation to the conductive filament and sequentially processes the forming, reset, and set states. Using this model, both unipolar and bipolar properties were successfully analyzed by adjusting the boundary conditions. Additionally, the flexibility in geometry setup allowed the analysis of a wide range of three-dimensional device structures, such as 3D vertical RRAM.

Keywords : Finite Element Simulation, Resistive Memory, Filamentary Switching, Phase-field model

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Abstract No. : **IN-S05-0254**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

Realizing neuromorphic computing with solution-processed low-dimensional materials

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With the rapid advancement of artificial intelligence and machine learning, the traditional von Neumann computing is facing challenges in the computational power and energy consumption. Inspired by the human brain, neuromorphic computing by mapping the structural and functional architectures of the neural networks has emerged as a promising alternative paradigm. Solution-processed low-dimensional materials, with their unique electronic properties, allow device fabrication and engineering towards the implementation of neuromorphic computing. In this talk, I will discuss the recent progress of our research on neuromorphic computing using solution-processed low-dimensional materials and devices. The first part of my talk will focus on solution processing of low-dimensional materials, such as two-dimensional materials and carbon nanotubes, for the development of printed electronics. Specifically, I will discuss the fabrication of memristor and memristive transistor devices, and the exploitation of the device characteristics in the design of artificial neurons and synapses. On this basis, the second part of my talk will discuss the implementation of neuromorphic computing approaches, including the convolutional computing, spiking neuromorphic computing, and reservoir computing, using the devices and the artificial neurons and synapses. The demonstrations leveraging the device characteristics hold the promise to enable efficient computation in autonomous driving, virtual reality, medical diagnosis, industrial automation, and beyond.

Keywords : Solution processing, low-dimensional materials, neuromorphic computing

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Abstract No. : **PO-S04-0253**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Poster**

All-solid-state Proton-based Electrochemical Random Access Memory for Neuromorphic Computing

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For neuromorphic computing, researchers are actively investigating resistance-based non-volatile devices, including Resistive Random Access Memory (RRAM) and Phase Change Random Access Memory (PCRAM). However, these devices face challenges such as high power consumption and slow switching speeds. Accordingly, we explored Electrochemical Random Access Memory (ECRAM), a device that mimics the information processing of the human brain by controlling resistance across multi-levels through ion intercalation/deintercalation within the channel material.
In this study, we present an all-solid-state three-terminal proton-based non-volatile Electrochemical Random Access Memory (ECRAM) device inspired by the operational principles of human biological synapses. Protons, being smaller in mass and size compared to other ions, form chemical bonds with tungsten oxide (WO₃), a channel material, via Yttria-Stabilized Zirconia (YSZ), a proton-conducting solid electrolyte, thereby creating an electrically conductive pathway in the channel material. The three-terminal configuration of the device separates the programming path from the reading path, ensuring no interference between training and inference processes. By applying voltage to a gate electrode, protons are supplied to the device through the electrolysis of water molecules in the ambient environment. Protons from the atmosphere change the channel resistance through redox reactions. Specifically, protons combine with tungsten oxide (WO₃) to form hydrogen tungsten bronzes (H_XWO₃), thereby modifying the channel resistance depending on the amount of protons. We modulate the channel resistance more than one order of magnitude through protonation and deprotonation mechanisms. Additionally, these proton-based devices are compatible with silicon technology, enhancing their potential for integration into various computing architectures and systems. This research demonstrates the potential use of proton-based Electrochemical Random Access Memory (ECRAM) in low-power neuromorphic devices.

Keywords : Electrochemical Random Access Memory (ECRAM), Proton, Redox Reaction, Neuromorphic Computing

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Abstract No. : **PO-S10-0252**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

3D Bioprinted Gradient Scaffolds for Integrated Osteochondral Tissue Regeneration

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Osteochondral (OC) tissue, comprising both bone and cartilage, is crucial for distributing loads, absorbing shock, and facilitating smooth movement within joints, making it essential for joint health and mobility. OC tissue has poor self-renewal property due to avascular nature of cartilage, and thus dysfunction or damage to this tissue can lead to conditions such as osteoarthritis, highlighting its importance in musculoskeletal health. However, osteochondral defect regeneration still remains challenging due to its heterogeneous composition and anisotropic features, including ECM composition, collagen orientation, cytokines and oxygen tension. Biological, mechanical and physiological characteristics are varying along different axes, necessitating precise replication of these complex properties to accomplish successful tissue regeneration. To address osteochondral defect repair, it is imperative to consider the bone, cartilage and the bone-cartilage interface. Herein, we developed a 3D-bioprinted gradient scaffold laden with bone marrow–derived mesenchymal stem cells (BMSCs) for repairing OC defects. The hybrid printing technique combined polycaprolactone (PCL) with a hydrogel, ensuring mechanical stability compared to native tissue and exhibiting excellent biocompatibility. Bone, cartilage and interface layer were successfully integrated into a single construct by spatial control of BMSC differentiation based on hydrogel stiffness and scaffold porosity. We found that the stiffness of the hydrogel influenced BMSC differentiation, with stiffer gels promoting osteogenesis and softer gels supporting chondrogenesis. Moreover, gradient porosity in the scaffold indirectly led to varied nutrients and oxygen distributions, creating nutrient-rich areas in subchondral bone or hypoxic conditions in cartilage, which could potentially accelerate the osteogenic/chondrogenic processes of the stem cells. Through the synergistic effects of both biophysical and biomechanical stimuli, our 3D-bioprinted gradient scaffoldhold great potential for regenerating complex osteochondral defect in tissue engineering.

Keywords : 3D bioprinting, Osteochondral tissue, Tissue engineering, Mesenchymal stem cell, Biomaterial

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Abstract No. : **PO-S10-0251**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Optoelectronic Interfaces Based on Organic Semiconductors: Precise Multiscale Control and Efficient Energy Transfer in Biointerface Applications

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Remote optical modulation of nerves is essential for the treatment of nervous system related diseases. Organic semiconductors have the advantages of flexibility and excellent photoelectric response, which makes it more possible to achieve precise modulation of nerves and neural tissues. However, the mismatched surface properties of organic semiconductors with biological systems, including their hydrophobic surfaces and high impedance, currently limit their broader application in biological systems. Here, we developed a more practical and robust optoelectronic biointerface for biological systems by incorporating conductive metal-organic frameworks (MOFs) materials as a bridging layer between organic electronics and biological systems. The effective activation of nerve bundles and subsequent triggering of skeletal muscle contractions is achieved by utilizing extremely low optical power density light pulses through our biointerface. The device is validated at the level of DRG cell electrophysiology and Ca^{2+} fluorescence imaging. At the same time, the peripheral nervous system (PNS) of rats is stimulated with light pulses using flexible biological devices. These results indicate that our biointerface can effectively wirelessly provide photocurrent to stimulate the biological system and realize the wide application of organic semiconductor optoelectronic biointerfaces in the field of neural modulation.

Keywords : Optoelectronic biointerfaces; Organic semiconductors; MOFs; Flexible; Neural modulation

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Abstract No. : **IN-S03-0250**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Invited**

3D-printing-assisted sensors, actuators, and surfaces for various engineering applications

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Sensors and actuators that perform various functions are one of the important devices used in various fields such as mechanical, electrical, biomedical, chemistry, and industrial engineering. These sensors and actuators have a pattern of several millimeters or less, and many studies have recently been conducted to improve the sensitivity of sensors or the movement of actuators in combination with various three-dimensional (3D) structures. Although the top-down method using micro-processes is widely used as a process method for making sensors and actuators, there were limitations such as multi-steps, post-treatment processes, and the use of clean rooms and expensive equipment. FDM (fused deposition modeling)-type 3D printing is one of the most widely used additive manufacturing methods due to its inexpensive materials and fast printing speed. However, output printed in this way has the disadvantage of having a very rough surface. Looking closely at these fine patterns, several studies have recently been conducted that various patterns, which are difficult to make with the existing semiconductor process, can be achieved through the shortcomings of 3D printing. This presentation introduces various 3D printing-based manufacturing methods that can replace existing micro-processes, and shows the performance evaluation and reliability test results of sensors and actuators manufactured using them.

Keywords : Additive manufacturing, Staircase effect, Sensors, Actuators, Reliability

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Abstract No. : **OR-S07-0249**
Symposia : **Computational Materials Science**
Abstract Preference : **Oral**

First-principles flexoelectricity to predict triboelectricity

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Triboelectrification is one of the oldest-studied physical problems, being investigated since the birth of modern science. Despite that, the causes of the phenomenon have not been fully understood yet, even with the renewed interest in triboelectrification brought on by the development of triboelectric nanogenerators, which use the effect to produce electricity from motion in the environment. Recently, it has been suggested that flexoelectricity, the polarization response to strain gradients, is key in promoting triboelectrification. As contact induces a strain gradient at the interface, this can tilt the electrostatic potential and the bands, favoring – or hindering – charge transfer. Here, we employ a rigorous first-principles theory of flexoelectricity to investigate its effect on triboelectrification in the context of Density Functional Perturbation Theory. With this treatment, it is possible to explore the effect of a general deformation on the electrostatic potential and the energy levels. This allows, on the one hand, for the quantitative evaluation of the tilt in the electrostatic potential, which determines the interface dipole driving charge transfer. On the other hand, the evaluation of the band tilt allows determining how much the barrier between the energy levels of materials at the interface is lowered by the flexoelectric band bending, facilitating charge transfer. The rigorous formalism paves the way for the theoretical prediction of the triboelectric effect and better development of the triboelectric nanogenerators.

Keywords : Flexoelectricity; Triboelectrification; Density Functional Theory; Density Functional Perturbation Theory

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Abstract No. : **PO-S04-0248**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Bio-inspired eye camera capable of observing objects without distortion in multi-media environments

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As camera technology advances, bio-inspired electronic eye cameras have been extensively studied to realize specialized vision systems. These cameras, typically comprised of a pupil, a single lens, and a photosensitive array, can acquire aberration-free, wide field-of-view, and panoramic-view images for higher accuracy of object recognition. However, achieving such clear images in multi-media environments is still challenging due to the disparity in refraction angle of light incident through a single circular lens. Meanwhile, four-eyed fish, *Anableps anableps*, has a unique eye structure, divided into two different parts with a single ellipsoidal lens, that allow clear object observation both underwater and in the air. Here, we present a high-resolution, aberration-free electronic eye camera inspired by the four-eyed fish, capable of simultaneously observing objects in two different media. Just as the split eye with one lens, this camera comprises two aquatic and aerial pupils, a single ellipsoidal lens, and a photodiode array (PDA). The ellipsoidal lens enables multi-focus capability by adjusting the direction of light from different media, since light incident through the major axis and the minor axis of the ellipsoidal lens each deflects to aquatic and aerial parts of the PDA respectively. Our bio-inspired camera, placed on the water surface, could simultaneously focus on both prey inside water and a predator above water.

Keywords : Bio-inspired electronic eye cameras, Multi-media environments, Multi-focus capability, Simultaneous observation

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Abstract No. : **PO-S02-0247**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Crosslinking-induced patterning of MOFs by direct photo- and electron-beam lithography

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Metal-organic frameworks (MOFs) with diverse chemistry, structures, and properties have emerged as appealing materials for miniaturized solid-state devices. The incorporation of MOF films in these devices, such as the inte-grated microelectronics and nanophotonics, requires robust patterning methods. However, existing MOF patterning methods suffer from some combinations of limited material adaptability, compromised patterning resolution and scalability, and degraded properties. Here we report a universal, crosslinking-induced patterning approach for various MOFs, termed as CLIP-MOF. Via resist-free, direct photo- and electron-beam (e-beam) lithography, the ligand crosslinking chemistry leads to drastically reduced solubility of colloidal MOFs, permitting selective removal of unexposed MOF films with developer solvents. This enables scalable, micro-/nanoscale (≈70 nm resolution), and multimaterial patterning of MOFs on large-area, rigid or flexible substrates. Patterned MOF films preserve their crystallinity, porosity, and other properties tailored for targeted applications, such as diffractive gas sensors and electrochromic pixels. The combined features of CLIP-MOF create more possibilities in the system-level integration of MOFs in various electronic, photonic, and biomedical devices.

Keywords : Metal-organic frameworks Devices Pattern EBL

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Abstract No. : **PO-S15-0246**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Effect of Substrate Temperature on Microstructure of TiO_2 Films Deposited by Glancing-angle Sputtering

CHEN YUCONG*[1], INOUE YASUSHI[1], TAKAI OSAMU[2]

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Titanium dioxide (TiO_2) has been known as one of the photocatalytically active materials. Since the photocatalytic reactions occur on the surface, it is expected that high photocatalytic properties can be achieved if TiO_2 thin films with discrete nanocolumnar structures (DNS) are fabricated by a glancing-angle deposition method. The purpose of this study is to confirm that increasing the substrate temperature is useful for the formation of DNS for the TiO_2 films deposited by glancing-angle sputtering. A pure Ti plate was used as a target, Ar as the sputtering gas, and O_2 as the reaction gas. The RF power and the deposition pressure were kept constant at 200 W and 3 Pa, respectively. The deposition temperature was controlled at RT, 240°C, and 340°C with a lamp heater. The substrate angle was set to 85° relative to the target normal for glancing-angle deposition. SEM and XRD were used to characterize the microstructure and crystallinity of the films, respectively. SEM observation revealed that deep gaps among the nanocolumns were formed in the sample deposited at 240°C. It was found that improving crystallinity can be achieved by heating the substrate during film formation, which provides the potential for achieving DNS formation. On the other hand, excessive heating increases the surface migration distance, which is disadvantageous for the fabrication of DNS.

Keywords : Photocatalytic、Crystallinity、Discrete Nanocolumnar Structures 、Surface Migration Distance

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Abstract No. : **PO-S09-0245**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Effect of Substrate Temperature on Microstructure of TiO_2 Films Deposited by Glancing-angle Sputtering

CHEN YUCONG[*1], INOUE YASUSHI[1], OSAMU TAKAI[2]

[1]Chiba Institute of Technology, [2]Kanto-gakuin University

Titanium dioxide (TiO_2) has been known as one of the photocatalytically active materials. Since the photocatalytic reactions occur on the surface, it is expected that high photocatalytic properties can be achieved if TiO_2 thin films with discrete nanocolumnar structures (DNS) are fabricated by a glancing-angle deposition method. The purpose of this study is to confirm that increasing the substrate temperature is useful for the formation of DNS for the TiO_2 films deposited by glancing-angle sputtering. A pure Ti plate was used as a target, Ar as the sputtering gas, and O_2 as the reaction gas. The RF power and the deposition pressure were kept constant at 200 W and 3 Pa, respectively. The deposition temperature was controlled at RT, 240°C, and 340°C with a lamp heater. The substrate angle was set to 85° relative to the target normal for glancing-angle deposition. SEM and XRD were used to characterize the microstructure and crystallinity of the films, respectively. SEM observation revealed that deep gaps among the nanocolumns were formed in the sample deposited at 240°C. It was found that improving crystallinity can be achieved by heating the substrate during film formation, which provides the potential for achieving DNS formation. On the other hand, excessive heating increases the surface migration distance, which is disadvantageous for the fabrication of DNS.

Keywords : Photocatalytic、Crystallinity、Discrete Nanocolumnar Structures 、Surface Migration Distance

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Abstract No. : **PO-S09-0244**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

視角スパッタリングによって堆積されたTiO$_2$膜の微細構造に対する基板温度の影響

CHEN YUCONG*[1], INOUE YASUSHI[1], OSAMU TAKAI[1]

[1]*Chiba Institute of Technology*

二酸化チタン（ＴｉＯ$_2$）は、光触媒活性物質の１つとして知られている。光触媒反応は表面で起こるため、視角蒸着法により離散的なナノ柱状構造（DNS）を有するTiO$_2$薄膜を作製すれば、高い光触媒特性が得られることが期待されます。この研究の目的は、基板温度の上昇が視角スパッタリングによって堆積されたTiO$_2$膜のDNSの形成に有用であることを確認することです。ターゲットとして純Ｔｉ板、スパッタリングガスとしてＡｒ、反応ガスとしてＯ$_2$を使用した。ＲＦ電力および堆積圧力は、それぞれ２００Ｗおよび３Ｐａで一定に保たれた。蒸着温度はランプヒーターを用いて室温、２４０℃、３４０℃に制御した。基板角度は、視角蒸着のターゲット法線に対して85°に設定されました。SEMとXRDをそれぞれ膜の微細構造と結晶化度の特性評価に使用しました。SEM観察により、240℃で蒸着したサンプルではナノコラム間に深い隙間が形成されていることが分かりました。膜形成中に基板を加熱することで結晶性を向上させることができることが判明し、これによりDNS形成を達成できる可能性が得られる。一方、過剰な加熱は表面移動距離を増加させ、DNSの作製には不利になります。

Keywords : Photocatalytic、Crystallinity、Discrete Nanocolumnar Structures 、Surface Migration Distance

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Abstract No. : **PO-S13-0243**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Temperature Dependent Carrier-Resolved Photo-Hall Study in High Performance Perovskite Solar Absorber

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[1]Korea Advanced Institute of Science and Technology, [2]Ulsan National Institute of Science and Technology, [3]Korea Institute of Energy Research, [4]IBM Thomas J. Watson Research Center

In the field of photovoltaics, understanding the electrical and transport characteristics of carriers is important for improving the performance. However, Hall measurement, a fundamental method in the semiconductor characterization, has limitations as it only provides information about the majority carrier. We previously introduced a technique called "carrier-resolved photo-Hall" that can extract critical parameters for both majority and minority carriers in electronic materials, such as carrier density, mobility, recombination lifetime, and diffusion length. [1] This technique relies on a new photo-Hall equation and a highly sensitive AC Hall system based on parallel dipole line magnets. Furthermore, since the temperature can significantly affect carrier transport and recombination processes in solar cells, studying the temperature-dependent behavior of charge carrier transport is crucial for understanding solar cell performance and operation. Here we report our recent advancements in the “carrier-resolved photo-Hall” technique, enabling measurements in the temperature range of 20-340K. A temperature-dependent photo-Hall analysis was successfully conducted on a perovskite exhibiting a solar cell efficiency of 25.7%. The behavior of various transport properties with temperature and important information, such as the mobility scattering mechanism and dopant energy levels, were investigated. In the high-performance perovskite sample, electron and hole mobility increased with temperature up to room temperature and then decreased with the further increase of temperature, indicating impurity scattering and phonon scattering are dominant below and above room temperature, respectively. Also, the lifetime and carrier density of photo-generated charges increased with temperature, and this lifetime increase can be advantageous in situations where solar cells heat up during operation. This advance provides detailed insights into carrier transport properties of electronic materials and contributes to further development in various applications, including solar cells.

[1] O. Gunawan, B. Shin et. al., Nature 575, 151 (2019).

Keywords : Photo-Hall measurement, Temperature-dependent photo-Hall, Perovskite, Solar Cell

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Abstract No. : **PO-S09-0242**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Adatom migration enhanced sputter deposition of aluminum nitride on glass substrate

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Aluminum nitride (AlN) stands as a pivotal material in optoelectronic devices, surface acoustic wave (SAW) devices, and microelectromechanical systems (MEMS) owing to its exceptional characteristics such as high mechanical strength, high electrical resistivity, chemical stability, and large energy band gap. Among various deposition techniques, sputtering offers advantages in low deposition temperature, high uniformity, and scalability. This study investigates the structural properties of AlN films deposited under different process conditions including sputtering type (radio frequency (RF) and pulsed direct current (DC), substrate temperature, sputtering power, and gas ratio. The research extends to applying ion beam assistance in a pulsed DC sputtering system to enhance the adatom migration in the low-temperature sputtering process. As a result, by optimizing the process conditions, smooth (root mean square roughness < 0.5nm) and c-axis oriented AlN films were successfully deposited on an amorphous glass substrate. The structural quality and surface morphology of the film are confirmed through X-ray diffraction (XRD), scanning electron microscope (SEM), and atomic force microscope (AFM). Notably, ion beam assistance in pulsed DC sputtering demonstrates an enhancement in the crystallinity of the AlN films. Findings in this work can show the potential of ion beam-assisted deposition for high-quality AlN films. Also, as a buffer layer, smooth and highly oriented AlN films deposited on glass substrates hold promise as a fundamental element for the deposition of other III-V semiconductor materials on glass substrates. While this work establishes a foundation, further investigations are required to clarify the effect of ion beam irradiation on the quality of the deposited film.

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (RS-2023-00208574)

Keywords : Aluminum nitride(AlN), sputter, ion beam, adatom migration, thin film, glass substrate

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Abstract No. : **PO-S02-0241**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Boosting performance of vacuum-evaporated perovskite light-emitting diode with CsPbBr3/Cs4PbBr6 double layer

Nakyung Kim[1], Byungha Shin[*1]

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Halide perovskite has achieved a remarkable progress in its application to light-emitting diodes (LEDs) by taking advantages of high color purity with an extremely narrow spectral width (< 20 nm) and tunable band gap by adjusting the composition of halide anions. Most of the state-of-the-art perovskite light-emitting films were fabricated by a solution process, namely, spin-coating. This has the intrinsic limitation in the fine control of the emitter thickness and in mass production, necessary for commercialization. Here, we fabricate highly efficient vacuum-evaporated $CsPbBr_3$ perovskite LEDs with Cs_4PbBr_6 passivation layer. Both of the perovskite film, $CsPbBr_3$ and Cs_4PbBr_6 were deposited via thermal evaporation. The photoluminescence quantum yield (PLQY) of perovskite film improved from 7.4% without Cs_4PbBr_6 layer to 28.8% with a ultra-thin layer (~5 nm) of Cs_4PbBr_6. Although a thicker Cs4PbBr6 layer (~ 20 nm) can also improve PLQY up to 20%, the large bandgap of Cs_4PbBr_6 could lead to the high resistivity problem during device operation. The appropriate thickness of Cs_4PbBr_6 led to luminance of 260 cd m^{-2} and a external quantum efficiency of 2.5 % for vacuum-deposited perovskite LEDs. Details of the results and analysis will be discussed.

Keywords : Perovskite, Light emitting diodes

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Abstract No. : **PO-S08-0240**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Large-Scale Perovskite Single Crystals with Defined Thickness for Enhanced X-Ray Imaging Applications

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In recent research, metal halide perovskite (MHP) has gained significant attention for its exceptional optical characteristics, making it a prominent material in the fields of solar cells, light-emitting diodes, and X-ray detectors. Particularly in direct X-ray detector applications, MHP stands out due to its impressive diffusion length, high resistivity, substantial attenuation coefficients, and adjustable band gap, positioning it as an ideal photon absorber. Notably, MHP's single crystal form is increasingly favored over its thin film counterparts because of its reduced defect density and enhanced mobility-lifetime product, drawing considerable interest.

Despite these advantages, transitioning MHP single crystals to commercial X-ray detector usage faces challenges, particularly in fabricating large-area single crystals with millimeter-scale thickness. Optimal thickness is crucial: too thin, and the crystal inadequately absorbs X-rays; too thick, and it hampers the efficiency of charge collection. Traditional methods for cultivating MHP single crystals often result in simultaneous lateral and thickness growth, which is problematic for brittle MHP single crystals that require thinning, a process fraught with risks of damage and material loss.

This research introduces an innovative growth mechanism that facilitates the cultivation of large (up to 50 mm by 50 mm) MHP single crystals with a maintained thickness of just 1 mm, thereby obviating the need for risky thinning procedures in X-ray detection applications. We demonstrate that these large, thin single crystals can significantly enhance X-ray detectors, achieving an exceptional sensitivity of 3.0×10^4 C $\mathrm{Gy^{-1}_{air}}$ $\mathrm{cm^{-2}}$.

Keywords : Perovskite, X-ray detector

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Abstract No. : **PO-S15-0239**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Evaluation of OER catalytic activity of $Bi_2Sr_2CaCu_2O_{8+x}$

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$Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) is one of the copper oxide superconductors and is known to have a perovskite structure. In this research, we synthesize more single-phase Bi-2212 using the sol-gel method. And since Bi-2212 is known to function as an OER(Oxygen Evolution Reaction) catalyst, its performance will be evaluated for each synthesis process. The synthesis using the Sol-gel method is doped with Co in the process and the OER catalytic ability by Co doping is also shown as a result of this research.

The results of this research can be divided into two main categories: First, the main phase of the product is Bi-2212 even when the precursor used in the sol-gel method is partially replaced with Co. Second, not only regular Bi-2212 but also Co-doped Bi-2212 has OER catalytic activity. Among them, Bi or Cu among the metal elements constituting Bi-2212 was replaced by Co, and the results showed that the most catalytic activity was observed when Bi was replaced by Co.

Keywords : Superconductivity, Bi-2212, Sol-gel method, Cobalt dope, Oxygen reaction catalysis

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Abstract No. : **OR-S02-0238**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

AlGaInP red nanohole-structure LED with shaped Au/SiO_2 nanoparticles for localized surface plasmon

Sangbum KIM[1], Pil-kyu Jang[1], In-hwan Lee[*1]

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Due to its self-emission characteristics similar to OLED and the inherent advantages of inorganic LEDs such as high stability and fast response time, inorganic-based micro-LEDs are attracting attention as a technology to be applied to next-generation displays such as VR and AR. However, the high refractive index of AlGaInP LEDs and active layer defects generated during the process are major causes of LED efficiency degradation and must be improved for the commercialization of micro-LEDs.
In this study, as a method for improving the efficiency of red AlGaInP LEDs, we introduced the nanohole-structure and shaped Au/SiO_2 that enhance the internal quantum efficiency. We applied nanohole-structure and Au/SiO_2 nanoparticles (NPs) on the AlGaInP LEDs for LSP coupling between the metal NPs and the multiple quantum well layer. In these experiments, we created nanohole-structure with a diameter of 1 μm using electron beam lithography. Then, synthesized star and shaped Au/SiO_2 were coated on the AlGaInP LEDs by spin coating. The nanohole-structure AlGaInP LED chip achieve a higher PL intensity of ~109% compared to the reference.

Keywords : micro-LEDs, nanohole-structure, shaped Au/SiO2

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Abstract No. : **PO-S06-0237**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Improvement of Mechanical Properties in PBF Inconel 718 through Homogenization, Solution and Aging Treatment

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In this study, the effects of layer orientation, homogenization treatment, solution treatment, and aging treatment on the mechanical properties of Ni-based superalloy Inconel 718 manufactured using powder bed fusion (PBF) were analyzed before and after heat treatment. Inconel 718, when used in turbine disks, experiences a shortened service life because of stress concentration and fatigue in high-temperature, high-pressure environments. To improve these mechanical properties, three different heat treatments were applied, incorporating double aging by adding a homogenizing treatment and utilizing various combinations of solution treatment temperatures. As turbine discs are used in high-temperature and high-pressure environments, high-temperature tensile tests were conducted at 650°C. Four specimens were heat-treated using three different methods, and four specimens were tested in the as-built state for wear resistance at room temperature. OM, SEM, and EBSD were employed to analyze the microstructure of the fracture surface and wear track. Additionally, residual stress and precipitation phases were examined to establish correlations between mechanical properties and microstructure.

Keywords : IN718 superalloys, Powder bed fusion, Heat treatment, Microstructure, Mechanical properties

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Abstract No. : **OR-S05-0236**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Oral**

Synthesis and Characterization of 2D based heterostructures with TMD MOCVD system

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Two-dimensional transition metal dichalcogenides (TMDs) based heterostructures exhibit unique inter-material interactions, rendering them applicable in various fields such as electronic and optoelectronic devices. However, the exfoliation method employed for the synthesis of 2D material heterostructures has challenges in controlling size, position, and the number of layers. In this study, we have successfully formed large-area uniform 2D heterostructures by directly growing TMDs using the MOCVD method. We have analyzed the structural characteristics, junction properties, and inter-material interaction features of various graphene/TMDs and TMD/TMD heterostructures, confirming the formation of 2D heterostructures with unique properties. Using SEM, TEM, Raman, and PL analysis, we verified the uniform large-area growth of the heterostructures produced by the direct growth method. Specifically, we examined the optical properties at the interfaces of heterostructures using a micro Raman and PL mapping system. Also, The transition metal dichalcogenide heterostructure, developed selectively on defect sites in graphene, incorporates ion channels consisting of (i) van der Waals interlayer spaces tailored for effective Li+ ion retrieval and (ii) negatively charged vertical passages engineered to attract cations.

Keywords : 2D material, TMD, Graphene, Heterostructure

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Abstract No. : **OR-S02-0235**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Nanoscale 3D Printing Monitored by Near-field Interaction of Waveguided Light

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Nanoscale 3D printing is a promising option for display manufacturing because of its simplicity, low cost, and precise material delivery. However, nozzle-based nanoscale 3D printing methods, which employ a glass microcapillary as a nozzle, face the colossal challenge of tip breakage due to over-contact or carelessness. Here, we present a method for visualizing the microcapillary tip, enabling the precise and instant determination of its contact with other objects. Illumination directed to the back aperture of the microcapillary induces waveguiding of the light through the glass wall to the tip, enabling visualization of the tip by scattering. We discovered that the tip scattering is sensitive to contact with an adjacent object owing to the near-field interaction of the waveguided light, providing a clear distinction between the contact and non-contact states. The key advantages of our method include its minimal influence, irrespective of the conductivity, and applicability to nanoscale systems. Its applicability was demonstrated through nanoscale 3D printing, electrodeposition, and cell biology. Furthermore, our method exhibits versatility over a wide range of tip diameters, substrates, and in-filling materials. We expect that our method will contribute to the advancement of next-generation display development by offering a wide range of material options for display fabrication.

Keywords : 3D printing, Microcapillary, Waveguiding, Contact, Near-field interaction

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Abstract No. : **OR-S02-0234**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Structural Coloration via 3D Nanoprinting of Diffraction Gratings

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Structural colors are coloration by the diffraction of light from microstructures. Compared to pigmented colors, structural colors offer several advantages, including color permanence, biocompatibility, and low toxicity. To artificially implement structural coloration, a nanofabrication method capable of precisely controlling microstructures at the level of the light wavelength is necessary. A collective arrangement of substructures, represented by colloidal self-assembly or block copolymer self-assembly, offers a simple and cost-effective approach to structural coloration. With advancements in nanofabrication technology such as photolithography or two-photon polymerization, it is now feasible to directly fabricate individual nanostructures with the precision required for structural coloration. However, the direct integration of desired structural colors remains challenging because of the limited resolution, material specificity, or process complexity. Herein, we present the three-dimensional printing of structural colors through the direct writing of nanowire gratings using a femtoliter meniscus of a polymer ink. This method enabled us to achieve precise and flexible structural coloration by printing the nanowire diffraction grating with desired pitch and shape. In addition, alignment-resolved selective coloration is shown for the dynamic control of the image and the color synthesis. Notably, the printed diffraction grating is essentially a transparent polystyrene structure that allows backlight to pass through. We expect that our method will contribute to transparent reflective displays for advanced applications such as automobile head-up displays, smart windows, and augmented or virtual reality devices.

Keywords : 3D printing, Structural color, Diffraction grating, Nanowire

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Abstract No. : **PO-S02-0232**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Nondestructive Direct Optical Patterning of Perovskite Nanocrystals with Carbene-Based Ligand Cross-Linkers

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Microscale patterning of colloidal perovskite nanocrystals (NCs) is essential for their integration in advanced device platforms such as high-definition displays. However, perovskite NCs usually show degraded optical and/or electrical properties after patterning with existing approaches, posing a critical challenge for their optoelectronic applications. Here we achieve nondestructive, direct optical patterning of perovskite NCs with rationally designed carbene-based cross-linkers and demonstrate their applications in high-performance light-emitting diodes. We reveal that both photochemical properties and electronic structures of cross-linkers need to be carefully tailored to the material properties of perovskite NCs. This method produces high-resolution (~4000 ppi) NC patterns with preserved photoluminescent quantum efficiencies and charge transport properties. Prototype light-emitting diodes with patterned/cross-linked NC layers show a maximum luminance of over 60000 cd m^{-2} and a peak external quantum efficiency of 16%, outperforming those reported for patterned perovskite electroluminescent devices. Such material-adapted patterning method enabled by designs from a photochemistry perspective could foster the applications of perovskite NCs in system-level electronic and optoelectronic devices.

Keywords : perovskites, nanocrystals, nondestructive, patterning, LED

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Abstract No. : **IN-S15-0231**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Phase Control of Organometal Halide Perovskite for Development of Next-Generation Photovoltaic Devices

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Organometal halide perovskite (OHP) has attracted great attention as a leader among the next-generation photovoltaic materials since the first organometal halide perovskite solar cell (PSC) was reported. Recently, PSCs has shown the certified power conversion efficiency (PCE) of around 26% and the record surpasses the results of some conventional solar cells.

The increase of the OHP grain size is a well-known technique to develop high efficiency PSCs, because the increased OHP grain size will decrease grain boundaries inducing problems in charge carrier movement and, thus, enhance the performance of the PSCs. Various attempts for the improvements of the grains and its interface condition of the OHP light absorber are still actively being conducted.

In this study, it was confirmed that large physical gaps exist at the boundaries of the OHP ($MAPbI_3$) grains using transmission electron microscopy (TEM) analysis and revealed that the physical gaps interrupt flow of charge carriers in the PSCs. To overcome the negative influences of the large physical gap, we enlarged the grain size of the $MAPbI_3$ light absorber by increasing ratio of the cubic phases with microstructural phase control using liquid nitrogen (LN_2). By adopting the microstructural phase control, we could achieve decrease of the large physical gap at the boundaries of the $MAPbI_3$ light absorber and, consequently, obtain 20.23% PCE with a single cation $MAPbI_3$ PSC.

Keywords : perovskite solar cell, phase control, transmission electron microscopy

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Abstract No. : **KN-S01-0230**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Keynote**

Advancing high-energy and cost-efficient Ni- and Co-free Li-ion batteries through disordered rock-salt cathode materials

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The global transition towards electric vehicles and large-scale energy storage systems demands cost-effective and abundant alternatives to conventional Co/Ni-based cathodes, exemplified by materials like $LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$, for lithium-ion batteries (LIBs). Disordered rock-salt (DRX) cathode materials, such as $Li_{1.2}Mn_{0.4}Ti_{0.4}O_2$ and $Li_2Mn_{0.5}Ti_{0.5}O_2F$, have emerged as promising candidates due to their potential to utilize earth-abundant metals like Mn, Fe, and Ti, alongside their impressive energy density exceeding 900 Wh/kg. However, significant challenges persist before these materials can be practically integrated into LIBs. In this presentation, I will explore the current understanding, obstacles, and opportunities associated with developing Ni- and Co-free LIBs using DRX cathode materials.

Keywords : Li-ion battery, cathode material, disordered rock-salt, Ni- and Co-free Li-ion battery

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Abstract No. : **IN-S01-0229**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

Electrowritten Fiber-Enhanced Copper Current Collectors for Anode-Free Batteries

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We have developed an electrospinning-based manufacturing process tailored for battery systems that involve metallic lithium. In this presentation, we will present how to achieve precise three-dimensional (3D) geometrical control of fiber construction through an enhanced electrospinning method aiming at obtaining manufacturing precision comparable to 3D printing at a micro-scale. Unlike traditional techniques, our approach employs a mobile stage enabling fiber alignment. The resulting fibrous structures will be utilized in fabricating the anode current collectors for an innovative anode-free battery, a promising alternative to conventional Li-ion batteries. While integrating Li metal has historically posed challenges due to uncontrolled dendrite growth during Li plating and stripping, our research reveals that the 3D fibrous structure reinforced current collector enhances Li storage efficiency over numerous cycles compared to planar counterparts. We will discuss the effect of fiber compositions and controlled geometrical configurations on stabilizing Li plating and stripping morphologies to suppress dendrite growth. Additionally, we will propose a cell design principle to fundamentally extend the cycle life of anode-free batteries. Significantly, we believe that the advancement in battery manufacturing demonstrated in this work offers a systematic approach to developing next-generation energy storage systems, contributing to a sustainable energy future.

Keywords : Batteries, Li metal, 3D manufacturing, Electrospinning

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Abstract No. : **PO-S01-0228**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Mechano-thermal milling to eliminate the native passivation layer, rejuvenating lithium metal anodes

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Ensuring the stable and reliable functioning of high-energy lithium (Li) metal batteries (LMBs) is vital for both research and practical uses. Nonetheless, commercial Li metal anodes (LMAs) often face issues with inconsistent pre-passivation due to manufacturing processes unique to each vendor. This inconsistency can degrade the LMA's surface quality and hinder the consistent evaluation of innovative post-treatments and electrolytes. To counteract the initial degradation caused by the LMA itself, this study introduces a mechanothermal-milling (MTM) technique that employs heated blades to efficiently remove the native passivation layer (NPL), revealing unoxidized Li. The MTM-processed LMA (MTM-Li) outperforms conventional LMA in kinetics and interfacial resistance, leading to evenly distributed Li deposition and smooth Li removal. Furthermore, the MTM process levels the LMA surface, allowing for a precise assessment of SEI properties induced by electrolytes, which is critical for finding electrolytes that are truly compatible with the newly exposed Li. When used with highly stable electrolytes, MTM-Li helps control LMA's structural changes, thereby enhancing the cycling stability of LMBs, even under harsh conditions.

Keywords : Lithium metal anode, Surface treatment, Native passivation layer, Metallic Li, Initial interfacial state

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Abstract No. : **PO-S04-0227**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Drosophila ganglion cell inspired, in-sensor motion sensing

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Nowadays, rapid advancement of machine vision technology has led to extensive research on energy-efficient vision sensor system. In-sensor computing has emerged as a promising approach to enhance the time and power efficiency of conventional image processing systems. Various studies have developed sensors that can extract important features, such as edge detection, contrast enhancement, and noise reduction, to effectively reduce redundant data transfer between sensing and processing units.

However, recognizing the direction of a moving object in real-time is still challenging for in-sensor devices due to complexity in calculation between two consecutive frames in the sensor-level. Meanwhile, Drosophila ganglion cells accurately distinguish the direction of an object by identifying relative activation levels of neighboring photoreceptors. Here, inspired by the Drosophila eye, we report a real-time, in-sensor directional motion detector compatible with typical Si electronics.

The sensor comprises a pair of one photodiode and a phototransistor, in which the open circuit voltage of an illuminated Si photodiode amplifies the photocurrent of a neighboring phototransistor by tuning the gating voltage.

By arranging these sensing units in a hexagonal array, the direction of a moving object can be extracted in real time by comparing the relative photocurrent in six directions. Integrated into a conventional Si-based imager, the total processing time is greatly reduced by narrowing the monitoring range based on the directional information acquired.

Keywords : Energy-Efficient Vision Sensor Systems, In-Sensor Computing, Directional Motion Detection, Si Electronics, Sensor-Level Processing

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Abstract No. : **PO-S15-0226**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Improved Performance of Perovskite Solar Cell by Passivating TiO_2 Electron Transporting Layer with Organic Functional Material

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Recently, organic-inorganic perovskite solar cells (PSCs) have attracted great interest and achieved a certified power conversion efficiency (PCE) of around 26%.

High-efficiency PSCs are typically based on n-i-p structure, where an electron transport layer (ETL) is deposited on a transparent conductive oxide and a hole transport layer is formed on the perovskite layer.

TiO_2 has been widely used as an ETL for high-efficiency perovskite solar cells. In the case of the solution-process TiO_2 ETL, it contains plenty of oxygen vacancies.

Because the oxygen vacancies would serve as trap states to capture photo-generated electrons at the TiO_2 ETL/perovskite interface, the solution-process TiO_2 ETL possibly degrade the stability and efficiency of the PSCs. To develop highly efficient PSCs, thus, the oxygen vacancies of the TiO_2 ETL should be treated via proper method.

In this study, we report an effective way to reduce the density of oxygen vacancy using organic functional materials, which can be a passivation layer at the TiO_2 ETL/perovskite interface.

We applied the N-(2-Acetamido)-2-aminoethanesulfonic Acid (ACES) as the passivation layer and fabricated PSCs composed of FTO/TiO_2/ACES/perovskite/Spiro-OMeTAD/Au. With the PSCs including the ACES passivation layer, we achieved power conversion efficiency (PCE) of 24.50% and open-circuit voltage (Voc) of 1.13 V.

In addition, it was confirmed that the ACES treated PSC maintains 95% of its initial PCE after 1800h in the ambient condition (RH 10%). From the results, we confirmed that the introducing passivation layer in the PSCs is a useful method to reduce defects at the TiO_2 ETL/perovskite interface and improve the performance of the PSCs.

Keywords : perovskite solar cells

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Abstract No. : **PO-S01-0225**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Reversibility of Lithium Plating on Lithium-Ion Battery Anode

Seong-Yoon Kim[1], Heon-Cheol Shin[*1]

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In this study, we analyze the tendency of lithium plating on the anode surface and its reversibility under different charging conditions of Li-ion batteries, and propose an optimal charging method for minimizing irreversible lithium plating. First, the lithium electrodeposit morphology and its electrochemical reversibility were analyzed under different charging parameters (rate, state of charge, etc.). For this purpose, the plated lithium geometry was analyzed stereologically, and at the same time, the interfacial capacitance, open circuit voltage, and reversible/irreversible capacity of the lithium plated anode were analyzed to investigate their correlation. The analysis showed that the time period of plated lithium shrinkage in the open circuit state immediately after charging closely coincided with the time period of rapid capacitance reduction, and that the irreversible capacity at discharge was linearly related to the amount of capacitance decrease. This suggests that irreversible lithium plating can be detected through capacitance changes at rest immediately after charging. This relationship between plated lithium morphology-capacitance-reversibility also showed satisfactory accuracy in interpreting anode electrodes subjected to different charging protocols (constant current, multiple currents, pulsed current, etc.). In this presentation, the causes of the correlation between capacitance and irreversible capacity will be discussed in depth, and the optimal charging protocol for minimizing irreversible lithium plating will be presented by evaluating the irreversibility of lithium plating at different charging protocols.

Keywords : graphite, lithium electrodeposit, morphology, interfacial capacitance, reversibility

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Abstract No. : **PO-S11-0224**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Poster**

Energy storage application of Pb[$Zr_{0.48}Ti_{0.52}$]O_3 film with artificially modulated nano-grains via aerosol deposition method

yeji Son[1], seung-wook Kim[1], dae-yong Jeong[*1]

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As the renewable energy market expands, the ability to store the energy reliably and efficiently is becoming an important factor. Dielectric capacitors which have a dielectric between the two electrode plates are able to charge and discharge quickly through polarization changes. However, compared to batteries, dielectric capacitors have a extremely lower energy density. In order to overcome this disadvantage, this study aims to improve the performance of the capacitor by controlling the dipole of the dielectric to increase the energy density. Pb[$Zr_{0.48}Ti_{0.52}$]O_3 (PZT) is selected as the dielectric. PZT has excellent dielectric properties in the morphotropic phase boundary (MPB) region. A good composition to utilize the MPB region is 0.48:0.52. If PZT of this composition is synthesized through a sintering process to increase the grain size, secondary phases can be introduced. This can lead to a decrease in performance. Therefore, we plan to utilize the aerosol deposition (AD) method to change grain size of nanoparticles and create a relaxor ferroelectric. AD is a method of spraying powders onto a substrate at high speed through an aerosol system and it has the advantage of maintaining the nano-size at room temperature, which can increase the energy density accordingly. By mixing PZ and PT in the MPB region, it is possible to grow more random domains than they were synthesized, which means that you can maximize the number of dipoles in a small unit and increase the energy density. Therefore, the compositions of $PbZrO_3$ (PZ) and $PbTiO_3$ (PT) in the MPB region were attached to the substrate by AD. To compare the permittivity values, several PZT samples were fabricated with different compositions of PZ and PT, After the measurement, the data values of each sample are compared to determine the PZT composition with the highest storage capacity and efficiency. These results can lead to the improvement of dielectric capacitor.

Keywords : Aerosol deposition, dielectric capacitor, polarization change, Morphotropic phase, nano-size

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Abstract No. : **PO-S01-0223**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Electrochemical Properties of Lithium-Indium Alloys in All-Solid-State Batteries

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The electric vehicle and energy storage system markets are rapidly growing, leading to a strong demand for next-generation batteries that exceed the performance of conventional lithium-ion batteries. Among many alternatives, all-solid-state(ASS) batteries are receiving significant attention due to their high energy density and safety. Key to battery development is not only the advanced materials and cell design, but also the accurate electrochemical evaluation of materials. In general, their electrochemical properties are evaluated using half cells with lithium as the auxiliary electrode(AE). However, the use of lithium AE in ASS batteries suffers from problems such as lithium dendrite growth, physical deformation of lithium due to high internal pressure, and reaction products with electrolyte, which affect the overall electrochemical signal of the cell, reducing the reliability of the working electrode evaluation. Therefore, researchers have replaced lithium with lithium-indium alloy in ASS half cells. Lithium-indium alloy has constant voltage over a wide stoichiometric range, high chemical stability and is easy to fabricate. However, unlike lithium, it undergoes complicated reaction processes including alloying/dealloying and solid-state lithium transport. So, it is necessary to closely examine whether lithium-indium alloy can function reliably as AE under a wide range of operating conditions. In this study, the differences in electrochemical properties of lithium and lithium-indium alloy in ASS half-cells were analyzed under various operating conditions. The results showed that under typical conditions, the lithium-indium electrode had significant advantages over lithium in terms of non-polarizability. However, at lower temperatures and higher discharge rates, it exhibited non-ideal electrochemical signals that distorted the overall cell signal. A detailed overvoltage analysis confirmed that this was due to kinetic limitations under those conditions. In this presentation, the utilization of lithium-indium alloys as AEs for ASS batteries will be discussed. Moreover, a reliable electrochemical analysis from an AE perspective will be presented.

Keywords : All-solid-state batteries (ASSB), Lithium-indium alloy, Electrochemical analysis

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Abstract No. : **IN-S06-0222**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

An interpretation of deformation mechanism based on dislocation plasticity

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A challenge to tailor the properties of steels for structural applications requires a profound understanding of deformation mechanism in materials design and property enhancement. Among various deformation mechanisms, strain-induced martensitic transformation (SIMT) has received increasing attention owing to its favorable contributions to strength-elongation balance. Although several models for SIMT have been proposed and attempts have been made of providing experimental evidences to support the models, discrepancies remain about the essential parameters dictating nucleation of martensite and about the dislocation activities governing plasticity. To resolve the uncertainties underlying SIMT, we propose dislocation-based models to understand SIMT based on the systematic two-beam analyses on dislocations. Here, we propose a dislocation-based model for sequential fcc-hcp-bcc martensitic transformation. Apart from previous models for direct fcc-to-bcc MT, two-step transformation composed of fcc-to-hcp followed by hcp-to-bcc was a main transformation path. For the first stage, Frank partial dislocation played a decisive role in the formation of fcc-to-hcp MT. And, two invariant-plane strains are required to complete the hcp-to-bcc MT. By incorporating dislocation dissociation model into the concept of stacking fault energy, we suggest a synthesized concept of deformation scenario that can provide fundamental and predictive insight into plasticity and transformability.

Keywords : deformation mechanism, dislocation, martensitic transformation, TEM, steel

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Abstract No. : **IN-S15-0221**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Fabrication of Silicon Micro/nanostructures by Anodization and their Surface Analysis

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Micro/nanostructures such as wires, needles, walls, and rolls have been considered for a variety of functional and high-performance devices. In particular, rolls are useful because they can be applied to tubes, pipes, capsules, springs, etc. In this study, a silicon roll structure was formed on the surface of a silicon substrate via anodization using an extremely diluted hydrogen fluorine (HF) solution. Silicon oxide layers are known to form on the surfaces of silicon substrates during anodization. In addition, a circular depression is formed simultaneous with the roll. This study found that a roll was formed by circular peeling of the surface during anodization, and then a circular depression was formed at the same location. The length and width of the formed rolls were approximately 10 μm and 1 μm, respectively. The diameter of the depression was approximately the same as the length of the roll. In this report, elemental mapping of the surface of a micro/nano structure was investigated. The starting material was a p-type (100) single-crystalline silicon substrate. The HF concentration was in the range of 10^{-4}–10^{-2} vol%. A vertical Teflon cell was used for anodization. Elemental mapping was performed using an electron probe microanalyzer (EPMA, JXA–8230, JEOL). The peaks of the spectra of Si–Kα, O–Kα, and F–Kα were observed for our samples. In addition, EPMA elemental mapping images revealed that oxygen and fluorine were present in the roll and circular depression, respectively. Besides, fluorine atoms were abundant in the layer slightly below the surface. These results agreed with those of the XPS depth profile.

Keywords : silicon oxide, anodization, rolls, fine bubbles

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Abstract No. : **PO-S01-0220**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

A Novel Strategy for Dendrite-Free Zn Anodes: In-Situ Application of Metal Fluoride/Polymer Protection Layers

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In the quest for safer and more sustainable energy storage solutions, aqueous Zn metal batteries (AZBs) stand out for their inherent non-flammability and cost-effectiveness. However, the commercial viability of AZBs is hampered by challenges such as Zn dendrite formation and the parasitic hydrogen evolution reaction (HER) within Zn metal anodes (ZMAs). To address these critical issues, our study introduces a novel bi-layer-structured approach to enhance ZMA stability. This method involves a one-step in-situ coating process that combines a hydrophilic polymeric outer layer with a zincophilic Ag-decorated inner layer (Ag^0/ZnF_2), facilitated by a displacement reaction using a silver fluoride (AgF) additive. This innovative AgF-guided bi-layered Zn protective layer (BSPL@Zn) effectively mitigates Zn dendrite growth and HER, while promoting uniform Zn deposition. The outcome is a notable improvement in battery safety and longevity, evidenced by a threefold reduction in hydrogen gas evolution and prolonged short-circuiting times. Our findings demonstrate that BSPL@Zn enables robust cycling performance in a Zn||Zn cell, sustaining over 1800 hours of operation at a plating capacity of 5 mAh cm^{-2}. Moreover, when applied to a Zn||$NH_4V_4O_{10}$ cell, BSPL@Zn showcases exceptional cycling stability over 1000 cycles with 80% capacity retention. This study not only elucidates the mechanisms behind dendrite and HER suppression but also offers a scalable strategy for the practical application of ZMAs in AZBs, representing a significant advancement in the development of reliable and sustainable energy storage technologies.

Keywords : Aqueous Zn battery, Zn metal, Zn metal modification, bi-strucutred protection layer

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Abstract No. : **PO-S01-0219**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Electrochemical Characterization of Overdischarged Li-Ion Batteries

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Batteries in electric vehicles and energy storage devices are made up of multiple unit cells connected to form modules and packs for high voltage and high capacity. Even though the health of those batteries is managed by a battery management system, there are still reports of battery abuse such as overcharging and overdischarging. While many researchers focus primarily on overcharging mainly due to fire hazard, the internal changes that occur during overdischarging should not be overlooked in terms of battery stability and safety. In particular, dissolution of the Cu substrate and precipitation of Cu in an overdischarged cell can cause internal short circuits in severe cases, which can lead to cell degradation and safety issues. It is therefore important to study in detail the behaviors of cells subjected to overdischarges, especially the phenomena associated with internal short-circuits. In this presentation, we report on the behavior of internal short-circuit and degradation of cells subjected to over-discharge under subsequent charging conditions. First, we investigated the relationship between charging conditions, Cu morphology, and self-discharge after overdischarge by charging the cells at different rates after overdischarge and comparing the Cu electrode morphology formed and the cell leakage current. The results showed that there was a clear relationship between them, especially dendritic Cu deposits formed at high charging rates greatly accelerated the self-discharge of the cell. In addition to the self-discharge behaviors, the initial reaction resistance and degradation tendency of the charged cells after overdischarge also showed differences depending on the charging conditions. In this presentation we will analyze in depth the internal short-circuit behaviors and its causes under different charging conditions after overdischarge. We will also propose a subsequent charging method for the safe use of overdischarged cells.

Keywords : Overdischarge, Internal short-circuit, Cell degradation

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Abstract No. : **IN-S01-0218**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

Understanding the Complicated nature of Residual Lithium in High-Nickel Lithium-Ion Battery Cathodes

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The adoption of lithium-ion batteries (LIBs) by the electric vehicle (EV) industry highlights the necessity for advancements in high-energy density and cost-efficiency. Cathode materials with high nickel content, also known as high-Ni materials, are notable for their capacity to enhance energy storage. However, they encounter difficulties due to the presence of residual lithium compounds such as LiOH and Li_2CO_3. These substances not only induce the release of gas, thereby posing a potential threat to the integrity of the battery, but also interfere with the slurry coating procedure by forming gel-like aggregates as a result of interactions with the polyvinylidene fluoride (PVdF) binder. Although the advantages of dry coating for high-Ni cathodes are acknowledged, there is still limited research on the processes of lithium compound formation/removal, Li^+/H^+ exchanges, and the influence of lithium source impurities.

This study looks into the issues raised above by using a new titration method and studying the structure of the material before and after cobalt hydroxide was added. The objective is to elucidate the behavior of lithium residues on cathodes with high nickel content. Our research aims to address the challenges posed by high-Ni oxide by focusing on the development of cathode materials to improve the performance of LIBs in EVs. This study not only identifies key factors that influence the presence of lithium compounds but also provides valuable insights into strategies for mitigating their negative effects. This research represents a significant advancement towards the development of optimized cathode materials with high nickel content for potential commercial applications in the future.

Keywords : high-nickel cathode, residual lithium, gelation, titration

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Abstract No. : **PO-S12-0217**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Enhanced Photocatalytic Performance for TiO_2/g-C_3N_4 Catalysts by Coupling with Gd-doped $CaAl_2O_4$:Eu^{2+}, Nd^{3+} Phosphor

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Triply doped $CaAl_2O_4$:Eu^{2+}, Nd^{3+}, and Gd^{3+} phosphors were synthesized using a solid-state method at 1300 °C and coupled with TiO_2/g-C_3N_4. The effects of the Gd^{3+} concentration as a codopant on the emission intensity and afterglow performance of the phosphors were investigated. The characterization of $CaAl_2O_4$:Eu^{2+}, Nd^{3+}, and Gd^{3+} was performed via X-ray diffraction, scanning electron microscopy, UV-Vis absorption spectroscopy, and energy-dispersive spectroscopy. Fluorescence spectroscopy was performed to evaluate the excitation, emission, and afterglow-decay properties of the synthesized phosphor. The Gd^{3+}-co-doped $CaAl_2O_4$:Eu^{2+}, Nd^{3+} phosphor exhibited enhanced luminescence properties in relation to a commercial $CaAl_2O_4$:Eu^{2+}, Nd^{3+} phosphor. In addition, outstanding photocatalytic efficiencies were observed for the Gd^{3+}-co-doped $CaAl_2O_4$:Eu^{2+}, Nd^{3+} phosphor/TiO_2/g-C_3N_4 composite in relation to those for the non-Gd^{3+} samples under UV-light illumination. Alternatively, Gd^{3+}-doped and undoped $CaAl_2O_4$:Eu^{2+}, Nd^{3+}/TiO_2/g-C_3N_4 exhibited similar photocatalytic efficiencies under visible-light illumination

Keywords : CaAl2O4:(Eu,Nd), long lasting phosphor, TiO2/g-C3N4, photocatalyst, heterojunction

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Abstract No. : **PO-S11-0216**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Nylon 66 Composite Nanofibers based High-Performance Triboelectric Nanogenerators for Wearable Devices Applications

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A triboelectric nanogenerator (TENG) is an energy-harvesting technology that can be used in wearable devices with a simple structure and flexible form. Over the last decade, most research has been conducted on improving TENG performance using various materials and forms. In addition, research has been undertaken to improve mechanical durability due to the nature of friction on TENG. However, when TENG is used in a wearable device, temperature and humidity environments must be considered. Due to the nature of wearable devices, TENG performance may be reduced due to human body temperature and sweat. TENG performance changes rapidly depending on the TENG temperature and surrounding humidity. TENGs that generate physical friction also generate frictional heat from the surrounding environment. Heat generation in TENG is a factor that can reduce performance depending on the material. Moisture in the air is the factor that most significantly deteriorates TENG performance. As relative humidity increases, performance decreases rapidly, reaching levels that make it difficult to use it as an energy harvesting device. To solve these problems, studies have been conducted to increase resistance to moisture using super-hydrophobic materials or to prevent discharge by absorbing water molecules using hydrogen bonding.

In this study, a TENG with high resistance to heat and moisture was manufactured using Nylon 66-based composite nanofibers. Nylon 66 is a tribo-positive material with high wear resistance. However, Nylon 66 shows significant performance changes even with temperature changes of several K near room temperature. Additionally, it is not resistant to moisture, so its performance drops sharply as humidity increases. It was fabricated as Nylon 66/Ceramic nano-powder composite nanofiber using electrospinning to compensate for this. Low dissipation factor and high thermal conductivity minimize heat generation and speed up heat dissipation, significantly lowering the temperature change of the device. Lastly, performance reduction at high humidity was reduced through hydrogen bonding and removing anions. We attempted to apply a TENG with these properties as a wearable device.

Acknowledgment

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Keywords : Triboelectric nanogenerator, Nanofiber, Nylon 66, Wearable

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Abstract No. : **OR-S04-0215**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Oral**

Enhanced Energy Storage in Dielectric Polymer Nanocomposites via Quantum-Confinement of Nano Metal Particles

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The quest to improve the electrical energy storage capacity of dielectric polymer nanocomposites has led to the exploration of incorporating high dielectric constant (high-k) ceramic fillers into dielectric polymers. While this strategy has shown promise, it often results in a compromised dielectric breakdown strength and elevated dielectric losses due to the electrical property disparities between the ceramic fillers and the polymer matrices. Addressing these critical limitations, our study introduces a novel fabrication approach for polymer nanocomposites that exhibit significantly enhanced breakdown strength and minimized dielectric loss. The key innovation lies in leveraging the quantum-confinement effect of nano metal particles, specifically through the use of core-satellite-structured, ultra-small palladium or gold-decorated TiO_2@PDA@Pd and Au nanowires (NWs) as nanofillers. These fillers integrate the moderate-k properties of TiO_2 nanowires and capitalize on the unique electrical characteristics conferred by the quantum-confinement effect. Our findings demonstrate that the TiO_2@PDA@Pd NWs 6 vol% nanocomposites, in particular, show a remarkable increase in discharged energy density - approximately 535 % higher than that of pure P(VDF-HFP) and TiO_2@PDA@Pd NWs nanocomposites. This substantial improvement is attributed to the synergistic effects of the nanometal particles and TiO_2 nanowires, which facilitate a more efficient charge storage mechanism within the polymer matrix. This research provides a deeper understanding of the quantum-confinement effect in enhancing the energy storage capabilities of dielectric polymer nanocomposites. It opens up new avenues for developing high-performance energy storage materials.

Keywords : Quantum-Confinement, Nano Metal Particles, high dielectric constant, ceramic fillers, coulomb-blockade effect

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Abstract No. : **PO-S15-0214**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Evaluation of the Cross-sectional Shape of Silicon Wire fabricated by Anodization

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Silicon wires are expected to be useful in optical integrated circuits and other applications. We developed a new method for fabricating silicon wires. In our method, silicon wires were fabricated by anodizing a single-crystal silicon substrate with dislocations in a hydrogen fluorine (HF) solution. Structural control is critical when wires are used in optical devices. The cross-sectional shape of the wire is similar to an inverted triangle. In particular, all surrounding surface structures such as the top and lower surfaces are important. In general, a thick silicon oxide layer forms on and around these surfaces. If the thickness of the layer closes to light wavelength, the layer should be reconstructed for devices. In this study, we evaluated the cross-sectional shape and discussed strategies for controlling it. A silicon substrate with a p-type (100) plane was used as the starting material. Grooves were formed on the surface of this substrate, which resulted in the formation of dislocations. The wires were then fabricated through anodization in an HF solution. The surface of the wire was observed by scanning electron microscopy and energy dispersive spectroscopy. As the results, the oxide layer was formed around surface of the wire. The thickness of the oxide layer is approximately 0.1–0.3 μm. Finally, it was confirmed that the oxide layer was removed by HF solution. As the same time, the surface morphology might be changed.

Keywords : silicon, dislocation, anodization, wire

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Abstract No. : **PO-S04-0213**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Liquid metal based wireless and stretchable receiver device for implantable bioelectronics

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Wirelessly powered implantable bioelectronics are indispensable for future digital healthcare services owing to their direct therapeutic capabilities. However, current wireless power transfer (WPT) systems and bioelectronic devices are sensitive to mere condition changes (e.g. distance and alignment between transceivers, deformation of the implantable device), thereby limiting operational area, stable power supply and electromechanical property. Our device presents solutions to these challenges in both material selection and WPT system design. Instead of device composed of copper or nanocomposite which possess either high conductivity or stretchability, respectively, our device utilizes liquid metal to achieve both the properties. To address the sensitivity of WPT systems to bio-environmental changes, we employ Parity-Time symmetric (PT-S) WPT, which adjusts the operational frequency between transceivers to ensure nearly constant power transmission to implantable device. The effectiveness of our approach is demonstrated by the significantly reduced power transmission fluctuations imposed by displacement, misalignment between transceivers and deformation of the implantable device. As a proof of concept, our system is implemented as an implantable cardiac pacemaker *in vivo*. The anticipated outcome is a stable performance of our system an account of the consistent power supply and deformation-insensitive property despite the bio-dynamic movements by a rabbit. We expect our platform to serve as a bridge, facilitating the active integration of WPT into the biological industry.

Keywords : Implantable bioelectronics, Stretchable device, Liquid metal, Robust wireless power transfer

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Abstract No. : **OR-S05-0212**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Weighted mobility ratio engineering for high-performance thermoelectric materials

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Thermoelectrics, which can generate electricity from a temperature difference, or vice versa, is a key technology for solid-state cooling and energy harvesting; however, its applications are constrained owing to low efficiency. Since the conversion efficiency of thermoelectric devices is directly obtained via a figure of merit of materials, zT, which is related to the electronic and thermal transport characteristics, the aim here is to elucidate physical parameters that should be considered to understand transport phenomena in semiconducting materials. It is found that the weighted mobility ratio of the majority and minority carrier bands is an important parameter that determines zT. For nanograined Bi–Sb–Te alloy, the unremarked role of this parameter on temperature-dependent electronic transport properties is demonstrated. This analysis shows that the control of the weighted mobility ratio is a promising way to enhance zT of narrow bandgap thermoelectric materials.

Keywords : thermoelectric, weighted mobility ratio, bipolar conduction, nanostructuring

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Abstract No. : **PO-S03-0211**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Enhancing Gas Sensor Sensitivity with Nanoporous Copper Oxide Prepared via High-Pressure Thermal Evaporation

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Safety accidents related to gas, such as leaks and explosions incidents due to gas usage in industry and daily life, continue to occur. Therefore, as one of the preventive measures for such accidents, the demand for gas sensors is increasing. Nanoporous structural materials are receiving a lot of attention across various fields, including catalysts, sensors, and fuel cells, owing to their high reactivity stemming from a high specific surface area. In particular, when these materials are applied to gas sensors, they can significantly enhance sensor sensitivity.

In this study, copper oxide, prized for its high availability and excellent electrical properties, was fabricated into a nanoporous structure and applied to a semiconductor gas sensor. The nanoporous structure was fabricated through controlled nucleation and growth via high-pressure thermal evaporation. Copper oxide, which maintained its porosity, was prepared through air annealing in a furnace.

The prepared samples were characterized through XRD analysis to confirm the presence of the copper oxide phase. SEM images were also obtained to verify the nanoporous structure. The prepared copper oxide was applied to a gas sensor, and gas sensing test was conducted targeting reducing gases (H_2S, CO, SO_2, H_2) to test the gas response ability.

The results demonstrate that the nanoporous copper oxide gas sensor prepared in this study exhibits p-type characteristics. Additionally, it shows a superior response compared to the existing copper oxide sensor.

Keywords : gas sensor, copper oxide, nanoporous

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Abstract No. : **OR-S04-0210**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Oral**

Bionic artificial skin for skin regeneration and tactile function restoration

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Tactile function is essential for human life as it enables us to recognize texture and respond to external stimuli, including potential threats with sharp objects that may result in punctures or lacerations. Severe skin damage caused by severe burns, skin cancer, chemical accidents, and industrial accidents damage the structure of the skin tissue as well as the nerve system, resulting in permanent tactile sensory dysfunction, which significantly impacts an individual's daily life. Here, we introduce a fully-implantable wireless powered tactile sensory system embedded artificial skin (WTSA), with stable operation, to restore permanently damaged tactile function and promote wound healing for regenerating severely damaged skin. The fabricated WTSA facilitates (i) replacement of severely damaged tactile sensory with broad biocompatibility, (ii) promoting of skin wound healing and regeneration through collagen and fibrin-based artificial skin (CFAS), and (iii) minimization of foreign body reaction via hydrogel coating on neural interface electrodes. Furthermore, the WTSA shows a stable operation as a sensory system as evidenced by the quantitative analysis of leg movement angle and electromyogram (EMG) signals in response to varying intensities of applied pressures.

Keywords : Artificial skin, Tactile function restoration, Skin regeneration

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Abstract No. : **PO-S15-0209**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Application of Structural Isomer Additive with Carbonyl and Amine Groups for Development of High Efficiency Perovskite Solar Cell

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Organic-inorganic hybrid perovskite (OIHP) has attracted considerable attention as a next-generation photovoltaic materials due to its excellent optoelectronic properties and low cost. Recently certified power conversion efficiency (PCE) of the organic-inorganic hybrid perovskite solar cell (PSC) has exceeded 26%. To develop the highly efficient PSCs, it is essential to fabricate a high quality OIHP light absorber and, thus, unintended defects in the OIHP layer are critical problems causing a huge deterioration in performance of the PSCs. For this reason, many studies have been conducted to improve the performance of PSCs by removing defects in the OIHP light absorber. Among them, the additive engineering has shown remarkable results in defect healing and stability of the OIHP light absorber, and its potential still sufficient.

In this report, L-alanine methyl ester hydrochloride (L-AMECl) and β-alanine methyl ester hydrochloride (β-AMECl) which have structural isomer structures and have a carbonyl group and an amine group as functional groups were applied to the OIHP light absorber as additives. The PSC used in this study is composed of FTO/TiO_2/modified OIHP light absorber/spiro-OMeTAD/Au layers, and the modified OIHP light absorber was formed by adding the additives (L-AMECl and β-AMECl) to the OIHP solution. As a result, we identified that the additives with carbonyl and amine groups passivate defects by interacting with uncoordinated Pb^{2+} in the OIHP light absorber and, finally, a PCE of over 24% was achieved. Based on the above results, we believe that considering the functional group position of structural isomer materials is possibly very useful approach for the enhancement of the OIHP light absorber.

Keywords : Perovskite solar cell, Alanine, Additive Engineering, Perovskite Passivation

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Abstract No. : **OR-S12-0208**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Joule-heating electrospun reduced-graphene oxide nanoribbon-coated polymeric sorbent with an excellent sorption/desorption of high-viscosity oil

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Reusable oil sorbents for oil/water separation have been extensively researched due to their environmentally friendly applications. However, they still exhibited some weaknesses for heavy or high viscous oil: oil desorption and reusable capacity because oil tightly adheres to the sorbent, unlike light oil. An increase in oil temperature leads to lower oil viscosity so oil fluidity on the surface of the sorbent increases. Consequently, it can improve the oil desorption capability and reusability of the oil sorbent. This study applied the Joule-heating technique that converts electric current into thermal energy because it can significantly decrease oil viscosity and efficiently desorb oil on the sorbent. To enhance the desorption of high-viscous oils, this study developed the Joule-heated reduced graphene oxide nanoribbon (r-GONR)-coated polyvinylidene fluoride (PVDF) oil sorbent with hydrophobicity/oleophilicity.

r-GONR was coated onto PVDF with different concentrations (3, 5, and 7%) to improve the Joule-heating effect of the oil sorbent. Joule-heating performance was observed using a direct current power supply from 10 to 30 V to confirm the increased temperature of the surface. The surface temperature of PVDF did not change at any voltage due to not being conductive, but the r-GONR-coated oil sorbents exhibited an increasing temperature up to 160 ℃. Oil sorption and desorption performance were tested using the Joule-heating technique to confirm the reusability using high-viscous oil. The r-GONR-coated oil sorbent showed over 4 times higher oil desorption efficiency than the PVDF sorbent with a Joule-heating effect. In addition, it could be used up to the 5th sorption/desorption cycle, with a recovery efficiency of approximately 50%. Therefore, the Joule-heated r-GONR-coated PVDF oil sorbent will significantly contribute to tackling oil spills as well as economic reuse of the oil sorbent and recovery of oil.

Keywords : Oil desorption, Joule-heating, reusable oil sorbent, reusability

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Abstract No. : **OR-S04-0206**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Residual Stress-based Hole Expansion process optimization and investigation of residual stress effect on fatigue crack growth

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Residual stress induced plastic deformation during the fabrication of aircraft components significantly influences their fatigue life and crack propagation characteristics. Hole expansion process has been widely used to generate residual stress in these components By expanding the hole around a designated area, this process generates compressive residual stress, effectively mitigating crack growth. The surface compressive residual stress augments the fatigue limit and enhances mechanical properties, particularly by suppressing stress corrosion cracking (SCC). Achieving the desired magnitude of residual stress necessitates the design of an optimal hole expansion process. Conducting repetitive experimental designs for this purpose proves to be prohibitively costly and time-consuming. Thus, it is necessary to efficiently analyze the relation between the process variables and the primary outputs through finite element analysis. In this study, the optimized hole expansion process has been designed by analyzing the relation between design variables of hole expansion process such as Insert Angle, Mandrel Diameter, and Plate Hole Diameter and the primary outputs of the process such as residual stress magnitude and distribution, and stress of mandrel. By utilizing the resultant optimal process, we have compared and assessed the residual stress induced in the material during the hole expansion process using three different typts of measurement methods, namely X-ray diffraction (XRD), hole drilling, and contour analysis. Subsequently, we have analyzed the implications of these findings on fatigue crack growth.

Keywords : Residual stress, Hole expansion, Fatigue, FEM

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Abstract No. : **IN-S09-0205**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Invited**

Design of Interface Formation Process of Ferroelectric-$Hf_xZr_{1-x}O_2$/TiN Interface for Metal–Ferroelectric–Metal Capacitors with High Fatigue Resistance

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Ferroelectric $Hf_xZr_{1-x}O_2$ (HZO) is attractive for future non-volatile memory devices due to its scalability and excellent CMOS compatibility. The fatigue is one of the most serious issues in practical applications. The oxygen vacancies (V_O) in HZO films formed during field cycling are thought to cause domain pinning, resulted in fatigue [1]. However, it has been unclear why V_O increases in HZO films. In this work, we studied reaction at HZO/TiN interfaces of TiN/HZO/TiN metal–ferroelectric–metal (MFM) capacitors during field cycling to clarify the origin of V_O formation. We also demonstrated superior fatigue properties by designing HZO/TiN interface formation processes.

HZO/TiN interfaces were characterized using synchrotron hard X-ray photoelectron spectroscopy after applying switching cycles. The Ti-O peak intensity of Ti 1s spectra increased during fatigue field cycling while no difference of Ti 1s spectra was observed between the pristine and wake-up states. Therefore, the surface oxidation of TiN electrodes occurred in the fatigue state, indicating that oxygen atoms were supplied from the HZO film to TiN electrodes. Thus, we concluded that one of the origins of additional V_O formation in HZO films should be reaction at HZO/TiN interfaces during field cycling.

Based on these results, we focused on controlling oxygen atom movement at HZO/TiN interfaces during field cycling to obtain superior fatigue properties. We will discuss demonstration of MFM capacitors with high fatigue resistance by introducing a surface-oxidized TiN bottom-electrode [2] and inserting ZrO_2 nucleation layers between the HZO film and TiN electrodes [3,4] to prevent the unwanted reaction at HZO/TiN interfaces.

[1] M. Pešić et al., *Adv. Funct. Mater.* 26, 4601 (2016).
[2] T. Onaya et al., *Solid-State Electron.* 210, 108801 (2023).
[3] T. Onaya et al., *APL Mater.* 7, 061107 (2019).
[4] T. Onaya, *ECS Trans.* 112, 75 (2023).

Keywords : ferroelectric HfxZr1−xO2, metal–ferroelectric–metal capacitor, ZrO2 nucleation layer, interface reaction, fatigue

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Abstract No. : **OR-S14-0203**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Study of $CuFeO_2$ for photoelectrochemical CO_2 conversion

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An effective approach to mitigate increasing levels of greenhouse gas emissions, involves converting harmful CO_2 from the atmosphere into valuable chemical building blocks through photoelectrochemistry (PEC). For this application, semiconductor photoelectrodes with the right characteristics are required, made of earth-abundant, non-toxic and cheap materials. Given copper's proven activity as a reaction site for CO_2 conversion, this study focusses on copper delafossites as photocathode materials. The delafossite structure consists of a ternary oxide characterized by formula ABO_2, where A represents a monovalent metal cation and B a trivalent metal cation.[1] Due to their structure, delafossites can offer improved hole mobility, photostability and electrochemical stability, rendering them specifically interesting for PEC applications. In particular, $CuFeO_2$ is a suitable photocathode, due its stability, conductivity and bandgap of 1.5 eV to absorb the greater part of the solar spectrum.[2] Therefore, the synthesis and materials properties of $CuFeO_2$ were investigated. A hydrothermal route was employed to synthesize powders, starting from different Fe/Cu ratios. Furthermore, an aqueous solution-gel route was optimized, starting from metal citrate precursors. The powders were characterized with X-ray diffraction, Raman mapping, SEM-EDX and UV-vis spectroscopy to study phase formation, surface, composition and bandgap. The solution-gel method can also be employed to produce thin films, starting from the same precursors. These were also characterized by Raman and UV-vis spectroscopy. Furthermore, the samples were tested in a photoelectrochemical setup. The hydrothermal samples were tested to observe the effects of the copper and iron composition on the photocurrent, determined by LSV. These results are compared to the solution-gel samples with a more porous structure. Finally, the photocurrent of the $CuFeO_2$ thin films was also determined in the PEC setup.

1 Marquardt, et al., Thin solid films 496(2006), 146-156
2 Prévot et al., ChemSusChem 8(2015), 159-1367

Keywords : Photoelectrochemistry, CO2 reduction, delafossite, CuFeO2

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Abstract No. : **PO-S06-0202**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of Thermal stability Test on Precipitation Behavior and Mechanical Properties of Extruded Al-Mg-Si-Cu-Mn alloy

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Age hardenable Al-Mg-Si (6xxx series) alloys are widely used in the automotive, transportation, and aerospace industries due to their excellent strength-to-weight ratio, formability, and corrosion resistance. In these industrial fields, safety and durability are important, thus it is essential to enhance the strength of the alloys. A number of studies have been reported on additional alloying elements, heat treatment process, forming process to improve the strength of alloys. In this study, we aimed to obtain optimal multi-step aging treatment conditions with a combination of temperature and time for extruded Al-1.1Mg-0.5Si-0.5Cu-0.4Mn alloy. The alloy was prepared through casting, homogenization, and extrusion process. The extruded alloy was solutionized at 540 °C, naturally aged, and then artificially aged at 180 °C. Subsequently, the alloy was further aged at either 150 °C or 170 °C for 5 days. To analyzing the precipitation behavior, we carried out Transmission Electron Microscopy (TEM) and Differential Scanning Calorimetric (DSC) analysis. Hardness tests and tensile tests were conducted to measure the corresponding mechanical properties.

Keywords : Al-Mg-Si alloy, Multi-step aging, Precipitation behavior, Mechanical property, Heat treatment

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Abstract No. : **IN-S15-0201**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Development of High-entropy-type superconductors and thermoelectric materials

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High-entropy alloys (HEAs) are typically defined as alloys containing at least five elements with concentrations between 5 and 35%, resulting in high configurational mixing entropy. HEAs have recently attracted much attention in the fields of materials science and engineering because of their tunable properties as structural materials, such as excellent mechanical performance under extreme conditions. Thus far, we have extended the concept of HEA to compounds, wherein one of the crystallographic sites is high-entropy alloyed.

In a *RE*123-type cuprate (*RE*BCO) superconcudtors, high superconducting transition temperature T_c was remained even in the HE-type sampels [2], and local (intra-grain) J_c (J_c^{local}) showed a trend to be improved in the HE-type samples [3]. Based on these results, we fabricated thin film of HE-type *RE*123 by pulsed laser deposition method as a first example [4]. We investigated pinning mechanism in HE-type *RE*BCO thin films. Moreover, we investigated He-ion irradiation for the films to reveal the HEA effect.

In some HE-type thermoelectric materials, we found the successful reduction of lattice thermal conductivity.

Moreover, we successfully stabilized the cubic high temprerature phase of AgBiSe2, which shows complicated crystal structural transition from hexagonal to rhombohedral and finally to cubic with temperature, by utilizing the high-entropy concept through a simultaneous substitution of the Se site with S and Te. Ultra-low k_{lat} and a high peak ZT value of 0.89 (T = 750 K) was achieved. The present work demonstrates the stabilization of the cubic structure using the HE concept, together with achieving a high thermoelectric performance owing to the synergy between an ultra-low k_{lat} by effective point defect scattering and better transport properties by suppression of the bipolar effect. The perspective of HE-type functional materials will be disccused in the talk.

Keywords : High-entropy-alloy, High-entropy, Superconductor, Thermoelctric material

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Abstract Preference : **Invited**

Development of High-entropy-type superconductors and thermoelectric materials

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High-entropy alloys (HEAs) are typically defined as alloys containing at least five elements with concentrations between 5 and 35%, resulting in high configurational mixing entropy. HEAs have recently attracted much attention in the fields of materials science and engineering because of their tunable properties as structural materials, such as excellent mechanical performance under extreme conditions. Thus far, we have extended the concept of HEA to compounds, wherein one of the crystallographic sites is high-entropy alloyed.

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In some HE-type thermoelectric materials, we found the successful reduction of lattice thermal conductivity.

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Keywords : High-entropy-alloy, High-entropy, Superconductor, Thermoelctric material

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Abstract No. : **IN-S08-0199**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Flexoelectricity-driven mechanical ferroelectric polarization switching in metastable ferroelectrics

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Recently, an intriguing new concept based on flexoelectricity has emerged, ultilizing mechanical forces to switch ferroelectric polarization. This so-called mechanical switching of polarization could be technologically advantageous over conventional switching of polarization via an external electrical bias. First of all, it offers the potential to mitigate side effects induced by electric bias, such as charge injection, Joule heating, and dielectric breakdown. In addition, it might potentially enable much higher-density data writing, compared to conventional electrical bias-driven polarization switching. In this presentation, we present a breakthrough finding of hyper-efficient mechanical polarization switching in metastable ferroelectrics, marking a significant advancement in overcoming prior challenges. Through a combination of density functional theory, phenomenological modeling, and comprehensive electrical and mechanical characterizations, we unveil the remarkably superior mechanical switching of polarization exhibited by an artificial metastable ferroelectric $CaTiO_3$ film, compared to other conventional ferroelectrics.

Keywords : ferroelectrics, flexoelectricity

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Abstract No. : **PO-S06-0198**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Impact of Aging Temperature on the Microstructure, Mechanical and Wear Properties of 17-4PH Stainless Steel Fabricated by Selective Laser Melting

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Additive manufacturing technologies for metallic materials based on powder layer fusion are currently under active research. In aerospace, where parts are in short supply, additive technology is essential. 17-4PH steel is a precipitation-hardening stainless steel and is a highly functional material used in the aerospace and launch vehicle industries. In this study, 17-4PH steel was prepared using the powder bed fusion (PBF) process. The effects of aging temperatures (420°C, 480°C, 540°C, and 600°C) for 4 hours on microstructure, tensile fracture mechanism, and wear properties were compared with the as-built material. After heat treatment, the specimen exhibited enhanced mechanical properties attributed to precipitates compared to its as-built state. Specimens with optimal heat treatment showed improved tensile strength, yield strength, and elongation compared to as-built. The wear properties also exhibited strong wear resistance attributed to the precipitation of Cu and Nb.

Keywords : 17-4PH, PBF, wear properties, Microstructure, Mechanical properties

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Abstract No. : **PO-S06-0197**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Impact of Aging Temperature on Mechanical Properties of M300 Alloy Fabricated via Powder Bed Fusion

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18Ni-300 maraging steel parts are primarily manufactured using casting, forging, and welding processes, which have drawbacks such as extended production time and challenges in creating parts with intricate shapes. Maraging steel powder is suitable for the Powder Bed Fusion (PBF) process due to its low reflectivity and high weldability. The specimen was prepared using the PBF process, which is the most commonly used additive manufacturing (AM) technology in the industry. This study examined the effect of aging treatment temperatures (430°C, 490°C, 550°C/3h) on M300, prepared using powder bed fusion (PBF), on the mechanical properties, microstructure, and austenite fraction. When the optimal heat treatment set was at 430°C, austenite precipitated in the crystal granular system. This led to an increase in cell thickness and irregular microstructure, resulting in the highest hardness of 593.9 HV. The analysis of the austenite phase fraction using the Rietveld method confirmed that the mechanical properties were enhanced by the moderate amount of austenite at 430°C.

Keywords : 18Ni-300 maraging steel, powder bed fusion, aging treatment, microstructure

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Abstract No. : **PO-S10-0196**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

iRGD와 형광염료의 세포 투과성 펩타이드 접합을 이용한 항암치료제 개발

Doori Kang[1], Jinhui Ser[1], Geonwoo Jeong[1], YuJin Lim[1], Woohyung Jang[1], Hoonsung Cho[*1]

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Keywords : iRGD, Bioconjugation, Cell-penetrating peptide, Fluorescent dye, Cancer therapy

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Abstract No. : **PO-S08-0195**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

Phase transition of heterogeneous ice

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Ice presents an intriguing case of polymorphism, exhibiting diverse forms, most notably hexagonal ice (Ih), cubic ice (Ic) and stacking-disordered ice (Isd). These phases are central to advances in fields such as cloud science, climate modelling and cryogenics, yet the molecular mechanisms driving their formation and transformation remain largely unexplored. In this study, we use cryogenic transmission electron microscopy (TEM) to investigate the formation of heterogeneous ice on graphene under varying temperature and vapour conditions. Our analysis is supported by observations of size distributions in dark-field micrographs and thickness measurements by electron energy loss spectroscopy (EELS), which indicate transitions from Ic to Isd at thicknesses of 40-50 nm. High-resolution TEM studies of Isd highlight the role of dislocation movement in the phase shift from the metastable cubic to the hexagonal phase, suggesting that defect-induced phase transformations are possible under irradiation. Conversely, defect-free single crystalline Ic phases do not transition to Ih upon irradiation, highlighting the critical role of defects in the polymorphic phase transition. These findings provide a more nuanced understanding of ice phase formation and the mechanisms of cubic to hexagonal phase transitions, enriching our knowledge at the nanoscale.

Keywords : crystalline ice, phase transition, stacking disorder, heterogeneous nucleation

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Abstract No. : **PO-S01-0194**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Enhancing Aqueous Zn-Metal Battery Performance with Hydrophilic Nanocarbon-Functionalized Janus-Faced Separators

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In pursuing next-generation energy storage, aqueous zinc (Zn) metal batteries (AZBs) emerge as a promising alternative to lithium-ion systems, offering cost-effectiveness and safety for large-scale applications. However, the performance and longevity of AZBs are compromised by Zn metal anode (ZMA) irreversibility, attributed to dendrite growth and the emergence of "dead Zn." To counter these challenges, we introduce a novel Janus-faced separator with an acid-treated carbon supportive layer (aCSL), enhancing hydrophilicity and providing additional sites for uniform Zn2+ ion distribution and deposition. Our approach addresses the critical issues of dendrite formation and dead Zn, significantly improving Zn Coulombic efficiency (CE). We present optimized current density and Zn plating protocols that reduce hydrogen evolution reaction (HER) side effects, achieving a notable initial CE of 99.6% at 1 mA cm^2 over 900 cycles and maintaining stable performance for over 1200 hours. The enhanced separator notably contributes to the Zn||α-MnO2/CNT full cell's stable cycling performance, with a capacity retention of 61.3% after 2000 cycles. This study highlights the efficacy of hydrophilic nanocarbon-functionalized separators in advancing AZBs, marking a significant step toward reliable and efficient energy storage solutions.

Keywords : Acid-treated carbon supporting layers, Aqueous Zn-metal batteries, Zn dendrite, Janus-faced separators, Zn-metal anodes

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Abstract No. : **PO-S06-0193**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Characterization of Thermal and Mechanical Properties of Fiber Reinforced Plastic using Polyimide

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Polyimides(PIs), basically, have been exhibited exceptioanal performance of thermal stability, good chemical resistance, and excellent mechanical properties. Also, the excellent dielectric properties and inherently low coefficient of thermal expansion are essential chracteristics of PIs as an utilization in the military applications.
In this study, we improved thermal stability of PIs, which synthesized using diamine and dianhydride monomers with different chemical structure, by tailoring inter-molecular interactions between PI chains. The resultant PIs were characterized for chemical architecture, rheological characteristics, and cure behavior. In order to apply high thermal resistant PI to structural fileds, glass fiber reinforcements were mixed with PI. PIs had good mechanical elongation and tensile strength, which also helped the adhesion between the polyimide layer or between heterogeneous materials. The fiber-reinforced plastic (FRP) exhibited excellent tensile strength and modulus, and these properties were maintained even during continuous use up to 400 °C

Keywords : fiber-reinforced plastic (FRP), Polyimide (PI)

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Abstract No. : **PO-S01-0192**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Maintaining Lithiophilic Properties of Slim Li-Alloy Coating on Current Collectors for Lithium Metal Batteries with No Excess Lithium

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This research introduces the use of very thin (~50 nm) multi-metallic coatings composed of six metals (Cu, Ag, Au, Pt, W, and Fe) on copper (Cu) bases, aimed at enhancing the design of current collectors for Li-metal batteries without excess lithium (ZE-LMBs), which are known for their exceptionally high energy density. Due to the lack of lithium-hosting materials in these batteries, lithium tends to deposit in an uncontrolled, dendritic form on the Cu current collector. This leads to continuous lithium loss and significant decomposition of the electrolyte, preventing the battery's full potential from being reached during cycling. The study found that, unlike coatings made from non-alloy metals like Cu, W, and Fe, those made from Ag, Au, and Pt improve the surface's affinity for lithium. This helps to prevent the formation of lithium dendrites, thus enhancing the reversibility of lithium deposition. Specifically, coatings made of platinum (Pt) keep their lithium-attracting properties over multiple cycles of lithium deposition and removal, due to their ability to maintain the initial coating layer through the battery's cycling life. This leads to improved performance in ZE-LMBs by enabling controlled, dendrite-free lithium plating and enhancing the battery's electrochemical stability. The findings emphasize the necessity of selecting appropriate lithium-alloy metals that can maintain their attractiveness to lithium over time to optimize the operation of ZE-LMBs.

Keywords : Zero-excess Li metal batteries, Sputtering, Current collector, Lithiophilicity, Lithium deposition morphology

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Abstract No. : **PO-S01-0191**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Enhancing the Longevity of Lithium-Sulfur Batteries with Lean Electrolytes through a Two-Layer Protective Strategy for Lithium Metal Anodes

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Developing lithium-sulfur (Li-S) batteries with a minimal amount of electrolyte is crucial for significantly surpassing the energy storage capacity of current lithium-ion batteries. However, premature depletion of the electrolyte, due to reactions with lithium metal anodes (LMAs), hampers the efficiency of Li-S battery chemistry and sulfur utilization, leading to reduced battery life. To effectively mitigate the loss of electrolyte, it is imperative to provide durable protection for LMAs against the evolving interface between the anode and protective layers (PLs). This research identifies two essential factors for maintaining an adaptable interface with PLs in response to localized lithium degradation: surface free energy (SFE) and Young's modulus. These were analyzed through mechanical simulations and practical tests on three varied PL designs. To prevent early delamination of PLs, a novel, dual-layer adaptive protective layer (APL) has been developed. This APL is designed to evolve with the changing structure of the PL|LMA interface caused by lithium pitting. It consists of a high-SFE polymer inner layer that lowers interfacial energy against the LMA surface, and a highly elastic polymer outer layer that acts as a barrier against electrolyte and lithium polysulfides. The application of APL on LMA resulted in a Li-S battery with a doubled lifespan in cycling tests compared to batteries with unprotected LMAs, showing even better performance than those with single-layer PLs.

Keywords : Li metal battery, Li-sulfur battery, Protection layer

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Abstract No. : **PO-S10-0190**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Development and optimization of nanoemulsion containing ceramide C2 to repair skin damage caused by lotion

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Environmental changes and improper skincare can compromise normal skin, leading to disorders like dermatitis and reduced barrier function [Su et al, 2017]. For skin repair and care, topical transdermal delivery of skincare actives is an effective method. Ceramides support renewal of the skin's natural protective layer and form an effective barrier against moisture loss. Therefore, the molecule, identical to human skin, is particularly suitable for long-term protection and repair of sensitive and dry skin [Li et al, 2020]. However, its application in cosmetics and pharmaceuticals is difficult, owing to its low solubility and poor penetrability. Research on transdermal ceramide delivery is exploring methods to enhance skin penetration. Microneedles, for example, create microchannels that bypass the cuticle, allowing direct access to deeper skin layers. However, they damage the skin.

We aim to use safer and more effective nanoemulsions to improve the solubility of ceramides and facilitate their transport to better perform their functions. In this study, the transdermal transport of oil-in-water ceramide nanoemulsion is realized by adding a safe transdermal accelerator (glycerin) to the formula of nano-emulsion and controlling the particle size of nano-carrier (~100 nm). At the same time, it can be applied to mice model of skin damage induced by lotion, and it is expected to reduce the inflammatory response of skin and repair the skin barrier.

At present, the optimized nanoemulsion had been verified to inhibit the crystallization of ceramide C2, and *in vitro* experiments have verified the transdermal ability and safety of nanoemulsion. Nanoemulsion is expected to be an effective carrier for transcutaneous delivery of ceramide. Moreover, model of skin damage caused by sodium dodecyl sulfate was established to simulate the cumulative damage of daily life lotion. Future work is to verify its effectiveness in animal models.

Keywords : nanoemulsion, ceramide C2, transdermal delivery, repair skin damage

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Abstract No. : **PO-S15-0189**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Immobilization of Amicyanin into 3 Types of Biochar Derived from Wood

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Amicyanin, a type 1 copper protein, plays a crucial role in energy production in *Paracoccus denitrificans* by facilitating electron transfer between methylamine dehydrogenase (MADH) and cytochrome c-$_{55i}$. Serving as the redox center for the ET, amicyanin has a type 1 copper site that coordinates copper with a Cys, two His, and a Met. This property enables capturing heavy metals from aqueous environments. Traditional methods of heavy metal removal like chemical precipitation and electrochemical techniques pose ecological risks and cost concerns. Therefore, biological treatment processes using biomass or enzymes including metalloproteins show great promise as eco-friendly alternatives for removing heavy metals from contaminated aquatic environments. However, the protein's function is highly sensitive to alterations in its environment, such as variations in temperature, pH levels, and salt concentration. Immobilization into biochar can be a possible solution for this challenge. Biochar is carbonaceous material produced by biomass pyrolysis and has great potential in various areas including immobilization, because of its moderate surface area and porosity. In this study, biochar derived from various types of wood which is Eucalyptus, Larch and Oak was activated with citric acid for surface modification and used as support materials. Our findings demonstrate successful immobilization of amicyanin within all biochar types, confirmed through FE-SEM analysis and absorbance measurements. Notably, Oak biochar exhibited the highest binding capacity (57.51 mg/g-BC) when using 100 μM of amicyanin.

Keywords : Biochar, Amicyanin, Immobilization, Bioremediation

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Abstract No. : **IN-S02-0188**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Invited**

Interface Engineering for High-Performance Quantum Dot Light-Emitting Diodes

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Colloidal quantum dot (QD) nanocrystals are well-known for their unique optical and electronic properties based on quantum confinement effects. These properties can be precisely tuned through solution-based synthesis by adjusting the size, shape, and chemical composition of the QDs. Due to their adaptability and tunability, QDs have attracted considerable interest in various optoelectronic applications, including QD-based light-emitting diodes (QLEDs), solar cells, photodetectors, and lasers. Among these applications, QLEDs have been of great interest for their potential in the next generation of display devices, as they exhibit exceptional optoelectronic properties. However, to expedite commercialization, it is essential to continuously improve the performance and stability of the devices. Achieving these improvements requires a comprehensive consideration of various factors, ranging from material properties to device architectures. This presentation outlines our recent strategies to improve QLED performance through interface engineering in both QDs and QLEDs. By focusing on these critical aspects, we aim to improve the functionality and efficiency of QLED technology.

Keywords : QLED, quantum dot, display, interface

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Abstract No. : **PO-S14-0187**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Tailoring Charge Transfer In $NiMoO_4$ Via Mn-Doping For Electrocatalytic Hydrogen Production

Dhanaji Malavekar[1], Jin Hyeok Kim[*1]

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The quest for efficient electrocatalysts that can drive the exploration of materials for hydrogen evolution reaction (HER) to achieve energy efficient hydrogen production is rising. Herein, by employing a doping strategy, we report the synthesis of self-supported Mn-doped $NiMoO_4$ as an advanced HER electrocatalyst. Benefiting from the superior charge transfer enabled by the formation of rode like structure, as well as electronic modulation due to Mn insertion, $Ni_{0.8}Mn_{0.2}MoO_4$ electrocatalyst exhibits remarkable electrocatalytic activity and stability. The HER overpotential of 108 mV to achieve a current density of 10 mA cm^{-2}, and consistent electrocatalytic performance over 100 hours. This work demonstrates the synthesis of earth abundant elements-based electrocatalysts and their capability for sustainable and selective electrochemical Hydrogen production.

Keywords : Electrocatalysis; Doping; Water splitting

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Abstract No. : **OR-S02-0186**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Oral**

All-printed Light Emitting Devices using Robotic Arm

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Electrochemiluminescence (ECL) is a fascinating light emitting technology owing to its simple configuration and solution processability. Typically, light emitting devices are fabricated in a sandwiched structure with a transparent electrode on top, which restricts their form factor. Here, we demonstrate all-printed electrically driven lighting via direct ink writing method using a robotic arm. The ECL emitting layer and electrodes were directly printed in a side-by-side lateral configuration, which enables a form-factor-free manufacturing with complex designs even on curved surfaces. In addition, the direct printing nature allows seamless implementation on diverse substrates, including polyimide film for flexible operation.

Keywords : 3D printing, Robotic Arm, Electrochemiluminescence, Light emitting devices

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Abstract No. : **PO-S10-0185**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

MXene-loaded nanoparticles for enhanced chemo-photothermal therapy of tumors

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Photothermal therapy (PTT) is an invasive and effective technique that converts light into heat energy to treat cancer. MXene, due to its absorptivity in the NIR region, has gained considerable attention in the field of PTT. However, MXene is unstable in aqueous environments, as its functional groups are susceptible to oxidation. To resolve these issues, in this study, we prepared Hyaluronic acid - Poly(lactide-co-glycolide) (HA-PLGA) nanoparticles (NPs), which encapsulated MXene and paclitaxel (PTX), enabling the dual delivery of heat and therapeutic agents to tumor sites. The spherical NPs synthesized through a water-in-oil-in-water (W/O/W) emulsion technique were evaluated through dynamic light scattering (DLS) and transmission electron microscopy (TEM). The temperature of NPs was also confirmed to be suitable for PTT when they were exposed to NIR laser. Moreover, in vitro release test indicated that the NPs stably released the drug. Cellular uptake and cell viability tests were performed, demonstrating that the NPs have excellent intracellular absorption and can reduce cancer cell viability. Finally, by in vivo anti-tumor experiments, our NPs shown the successful cancer treatment. Taken together, this work presents a promising approach for the treatment of cancer using PTT and drug delivery systems.

Keywords : MXene, Photothermal therapy, Nanoparticles, Hyaluronic acid

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Abstract No. : **OR-S10-0184**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Oral**

Magnetron sputter-deposited refractory high-entropy thin film with a tailored compositions for metallic biomedical applications

GEONWOO JEONG[1], WOOHYUNG JANG[1], DOORI KANG[1], YUJIN LIM[1], HOONSUNG CHO*[1]

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In this study, we synthesized a high-entropy alloy (HEA) tailored for biomaterial applications, comprised of TiMoVWCr, utilizing radio-frequency (RF) magnetron sputtering. Conventional implant materials, such as commercially pure titanium (CP-Ti) and stainless steel, exhibit significant limitations for prolonged use, including inferior wear resistance and potential toxicity. To overcome these challenges, high-entropy alloys, and high-entropy metallic glasses (HEMG), which consist of five or more constituent elements, have been proposed as an effective solution owing to their improved phase stability, and superior mechanical and electrochemical properties. Accordingly, the deposition of thin films comprising refractory metal elements—Ti, Mo, V, W, and Cr—is anticipated to markedly enhance the hardness, wear resistance, and biocompatibility of implant materials. Our research presents a thorough analysis that begins with an examination of the crystal structure, followed by assessments of mechanical properties, electrochemical behavior, surface characteristics, and cytotoxicity. Microstructural investigations and elemental composition analyses of the TiMoVWCr thin films demonstrated uniformity and the absence of segregation, affirming the efficacy of the sputtering process in synthesizing high-quality films. X-ray diffraction (XRD) and valence electron concentration (VEC) data indicated a body-centered cubic (BCC) structure, with a major peak orientation at (110). Electrochemical analysis and X-ray photoelectron spectroscopy (XPS) data elucidated that the passive oxide layers on the TiMoVWCr thin films are instrumental in providing exceptional corrosion resistance. Moreover, the alloy exhibited remarkable hardness (29.2 ± 1.5 GPa), elastic modulus (321 ± 8.9 GPa), smooth surface morphology, and good cell viability, outperforming CP-Ti. This study's findings and further research in this direction could lead to innovative, long-lasting, and biocompatible medical implants.

Keywords : High-entropy alloys, RF magnetron sputter, hardness, biocompatibility, corrosion resistance

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Abstract No. : **PO-S03-0183**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Design and Fabrication of Ultrathin Silicon-Based Strain Gauges for Piezoresistive Pressure Sensor

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Ultra-thin (20 um) silicon strain gauges were fabricated with silicon-on-insulator (SOI) wafer by a wet etching process. Buffered oxide etchant (BOE, NH_4F: HF =6:1) solution was used for wet etching process in which the operating temperature was 50°C. Photoresist as a passivation layer was deposited on the upper side of SOI wafer to minimize strain gauge damage by chemical etchants. Small amount of octylamine and octanol were added to BOE solution to improve surface wettability and SiO_2/Si selectivity. The fabricated strain gauges were attached to the pressure diaphragm and the performance of strain gauge was investigated by measuring with the hydraulic pressure system. The resistance changed linearly with tensile and compressive strains. Maximum values of non-linearity, hysteresis, thermal coefficient of resistance (TCR) and sensitivity were -0.341%, 0.909%, 4,128 ppm/°C and 34.22 mV/V, respectively. The fabricated strain gauges might be well applicable to the hydrogen pressure sensor which is detectable on a high pressure range.

Keywords : gauge releasing, SOI, surfactant, BOE, strain gauge, pressure response

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Abstract No. : **PO-S12-0182**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Immobilization of Amicyanin into Various Wood Based Biochar

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Amicyanin, a type 1 copper protein, plays a crucial role in energy production in *Paracoccus denitrificans* by facilitating electron transfer between methylamine dehydrogenase (MADH) and cytochrome c-$_{55i}$. As the redox center for the ET, amicyanin has a type 1 copper site that coordinates copper with a Cys, two His, and a Met. To this end, Amicyanin can be used for capturing heavy metals in the aqueous environment. However, the protein's function is highly sensitive to alterations in its environment, such as variations in temperature, pH levels, and salt concentration. Immobilization into biochar can be a possible solution for this challenge. Biochar is carbonaceous material produced by biomass pyrolysis and has great potential in various areas including immobilization, because of its moderate surface area and porosity. In this study, biochar derived from various types of wood which is Eucalyptus, Larch and Oak was activated with citric acid for surface modification and used as immobilization support material. As a result, we successfully confirmed the immobilization of amicyanin into all types of biochar through FE-SEM and measurement of changes in absorbance. Among them, Oak biochar showed the highest binding capacity (57.51mg/g-BC) when 100uM of amicyanin was used.

Keywords : Biochar, Amicyanin, Immobilization, Bioremediation

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Abstract No. : **PO-S12-0181**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Evaluating the Antibacterial Activity of Silver Nanoparticles obtained from two different synthesis methods

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Metal-based nanoparticles make it challenging for pathogens to develop resistance due to their non-specific bacterial toxicity mechanisms. Metal-based nanoparticles are also gaining attention as antibacterial agents due to their ability to broaden the spectrum of antibacterial activity. Silver nanoparticles (AgNPs) are commonly utilized in the fields of biology and medicine because of the antibacterial properties of silver. Despite these advantages of AgNPs, conventional chemically synthesized AgNPs can cause environmental and human health problems. Instead, the green synthesis method utilizes plant biomass as a capping and reducing agent for nanoparticle formation. The green synthesis method has several advantages such as simplicity, lower toxicity, and eco-friendly nature. In this study, the antibacterial activity of silver nanoparticles was measured according to two types of synthesis methods; chemical synthesis and green synthesis using green tea extracts. Qualitative indicators were confirmed through agar well diffusion assay, and quantitative indicators, such as minimum bactericidal concentration (MBC) and IC50, were obtained via cell growth curve analysis. As a result, when comparing the indicators, AgNPs derived from green synthesis showed an excellent antibacterial effect at a much lower concentration than those from chemically synthesized method. It suggests the potential utilization of AgNPs derived from the green synthesis method using green tea extract in the biomedical field.

Keywords : Silver nanoparticles (AgNPs), Antibacterial activity, Green synthesis

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Abstract No. : **PO-S10-0180**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Enhancing Hemoglobin Stability through Encapsulation within Elastin-Like Polypeptide Nanoparticles to Address Blood Shortages

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Currently, blood supply shortage has been a worldwide issue, and various kinds of hemoglobin-based artificial blood have been researched to address this problem. However, when hemoglobin stands alone in the bloodstream, it can readily dissociate, leading to various side effects, such as ROS and cytotoxic heme production, renal failure, and vasoconstriction. In this study, hemoglobin was encapsulated within elastin-like polypeptide (ELP) nanoparticles to enhance its stability in the bloodstream. ELP block copolymers, E50A40E50 was constructed in an *E. coli* expression system and purified by invert transition cycling(ITC). ELPs, with their unique phase transition properties and biocompatibility, offer a viable platform for nanoparticle formation. Specifically, amphiphilic triblock copolymer E50A40E50 demonstrates the ability to form vesicular nanoparticles, providing an ideal environment for hemoglobin encapsulation. Hemoglobin-encapsulated ELP nanoparticles (Hb-ELP NPs) were characterized and investigated for their oxygen binding and releasing functions. This study suggests the potential of ELP encapsulation as a promising approach or stabilizing hemoglobin and developing hemoglobin-based artificial blood.

Keywords : artificial blood, encapsulation, ELP, nanoparticle

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Abstract No. : **PO-S14-0178**
Symposia : **Water splitting, CO2 reduction**
Abstract Preference : **Poster**

DFT Study Of Possible S Doping Sites On Beta-FeOOH

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Sulfur doping into iron (oxy) hydroxide (S-FeOOH) electrocatalysts is a helpful method to enhance oxygen evolution reaction (OER) in the water splitting. However, although several studies have been discussed, there is still a lack of understanding regarding the exact role of S in enhancing the electrochemical properties of FeOOH. In our knowledge, it is due to unknown doping location of S caused by the complicated surface structure of FeOOH. Therefore, in this study, we discuss possible doping locations of S on the FeOOH electrocatalysts to reveal the mechanism behind enhanced OER via S doping. First, it is discussed possible doping locations of S on the (100) plane of beta-FeOOH. And then, density functional theory (DFT) + hamiltonia (Hubbard Hamiltonian) method is employed to calculate adsorption energy of S at possible doping sites. The calculations were performed using PWscf package as implemented in Quantum ESPRESSO 7.2. As a result of this study, it was confirmed that sulfur is more strongly adsorbed to the FeOOH catalyst than oxygen. The adsorption energy of sulfur on the catalyst surface was calculated to be 30.44 eV at the oxygen site and 28.41 eV at the iron site, whereas the adsorption energy of oxygen was calculated to be 6.14 eV at the oxygen site and 3.36 eV at the iron site. These results indicate that sulfur doping reduces the available sites for hydroxide ion adsorption on the catalyst, explaining recent findings that excessive sulfur doping leads to a decrease in OER activity.

Keywords : water splitting

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Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Thermal Transport Properties of Ni-containing High-Entropy Alloys at Elevated Temperatures (<850 K)

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High-entropy alloys (HEAs) refer to the alloys comprising five or more principle elements, each in relatively high concentration (5-35 at.%), and have drawn great attention due to their unique properties: sluggish mass diffusion, solid-solution hardening, and irradiation resistance. Especially, nickel-based HEAs are of great industrial importance for extreme environments, such as aerospace or radiation environment, which in part is attributed to effective defect recombination due to their low thermal conductivity. Although understanding thermal transport behavior at high temperatures is crucial for managing heat flow in materials and designing effective thermal management systems, reports on thermal conductivity of nickel-based HEAs at elevated temperatures are still limited compared to their mechanical properties. Furthermore, previous studies have reported a notable contribution of phonons to the thermal conductivity in solid solutions containing nickel, whereas the phonon thermal conductivity of most metals is significantly suppressed due to the electron-phonon scattering. In this study, we prepare pure nickel and three nickel-based alloys: NiFe, NiFeCr, and NiCoFeCrMn. In the temperature range of 300 K – 850 K, the electrical resistivity and thermal conductivity are determined by using the four-point technique and time-domain thermoreflectance (TDTR), respectively. We investigate the contribution of each heat carrier type in thermal conductivity, i.e., electrons and phonons, using the Wiedemann-Franz law as well as the temperature dependence of the thermal conductivity. We expect this study to contribute a better understanding of thermal transport properties of nickel-based HEAs at elevated temperatures.

Keywords : Thermal tranport properties, Thermal conductivity, High-entropy alloys, Ni-based alloys

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Abstract No. : **PO-S01-0176**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Atomic Force Microscopy Studies of Chemically Synthesized Pure Crystalline C60 Nanorods

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Atomic Force Microscopy (AFM) can create images with atomic resolution along with height information at the angstrom scale using very small amounts of samples, making it an excellent microscope. Therefore, AFM is suitable for analyzing the surface morphology of pure crystalline fullerene C_{60} nanorods. In this study, C_{60} nanorods were synthesized using the liquid-liquid interface precipitation (LLIP) method and annealing process. The annealing temperature conditions for C_{60} nanorods were varied as a variable, with each being manufactured at four different conditions: 60 °C for 12 hours, 300 °C for 2 hours, 500 °C for 2 hours, and 700 °C for 2 hours. The surface morphology of differently annealed C_{60} nanorods was investigated using AFM, and 2D and 3D images were generated and compared to those of the SEM results. Additionally, roughness was measured and calculated for each sample. Through the surface morphology and roughness measured by atomic force microscopy, we found that the sample annealed at 300 °C for 2 hours exhibited the best visibility of nanorod morphology and the most favorable roughness. In contrast, the sample annealed at 700 °C for 2 hours showed a significant deviation from the nanorod morphology, likely due to excessive evaporation resulting from the high annealing temperature, and it displayed the least favorable roughness.

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1.Yin, L. et al. "Abnormally High-Lithium Storage in Pure Crystalline C60 Nanoparticles." *Advanced Materials* 33(43), 2021, 2104763

Keywords : C60 nanorods, liquid-liquid interface precipitation(LLIP), phase transition, lithium-ion batteries(LIBs)

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Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Chemical Bonding States of Fullerene Nanostructure According to the Annealing Temperature for Lithium-ion Battery Anodes

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Recent advancements have highlighted the potential of nanocarbon materials like fullerene (C_{60}) for energy applications, owing to their distinctive physicochemical characteristics, expansive surface area, and superior conductivity. In this study, C_{60} nanorods were synthesized through liquid-liquid interfacial precipitation using m-xylene and 2-propanol. The samples were vacuum-dried at 60°C for 12 hours (C_{60} NRs-6012h) and subsequently annealed at 300°C for 2 hours under an N2 flow (C_{60} NRs-603002h), successfully achieving a phase transition from hexagonal close-packed (h.c.p.) to face-centered cubic (f.c.c.) structure. The surface morphology and diameter of the synthesized C_{60} nanorods were characterized using scanning electron microscopy, and X-ray diffraction analysis confirmed the presence of the f.c.c. structure. And the C60 NRs-603002h samples were then soaked in electrolytes of LiPF6 in EC/DEC 1:1 + FEC 10wt% and LiTFSI in EC/DEC 1:1 + FEC 10wt%. The composition and chemical structure of the SEI layer formed during the first discharge and first charge cycles were compared. Our findings indicate that the C60 nanorods exhibit superior electrochemical performance, and the analysis of SEI layer composition provides insights into their potential application as anode materials in lithium-ion batteries.

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Keywords : : C60 nanorods, liquid-liquid interface precipitation (LLIP), phase transition, lithium-ion batteries (LIBs)

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Abstract No. : **PO-S01-0174**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Poster**

Non-fluorinated Ether Solvents as Electrolytes for Crystalline C_{60} Potassium-ion Battery Anodes

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C_{60} nanomaterials, as a promising material, show great potential in battery applications. They can improve the energy density and cycle performance of lithium-ion batteries, enhance the performance indicators of supercapacitors, improve the cycle life and stability of lithium-sulfur batteries, and serve as electron acceptor materials in photovoltaic cells to enhance photoelectric conversion efficiency. However, there are currently few studies on C_{60} nanomaterials in the field of potassium-ion batteries, and there is a lack of relevant research on the electrochemical processes and mechanisms. In comparison to lithium-ion batteries, potassium-ion batteries offer abundant sources of potassium metal, higher electrolyte conductivity, elevated voltage platforms, and increased energy density. Hence, applying C_{60} nanomaterials to potassium-ion batteries presents a promising choice.

In this study, C_{60} nanorods were synthesized as anode materials for potassium-ion batteries. Recognizing the significant impact of the electrolyte on battery electrochemical performance, including cation intercalation behavior, operating voltage, cycling stability, and solid electrolyte interphase (SEI) formation, three non-fluorinated electrolytes (THF, 2-THF, and 2,5-THF) were selected to prepare weak cation-solvent interaction electrolytes for potassium-ion batteries. Weakening the cation-solvent interaction facilitates the formation of anion-derived SEI under low salt concentrations, aiming to achieve low cost, high energy density, and superior cycle stability in potassium-ion batteries.

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Keywords : C60 nanomaterials，potassium-ion batteries，non-fluorinated electrolytes

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Abstract No. : **PO-S01-0173**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Material Characteristics and Electrochemical Performance of Waste Onion-derived sodium-ion battery anodes

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Biomass-derived carbon materials are regarded as promising anode materials for sodium-ion batteries (SIBs) owing to high electronic conductivity, stability, and low cost. However, their commercial application is restricted because of their low capacities and poor cycling stabilities. Heteroatom doping and increasing the active specific surface area of carbon materials have proven to be key to solving these problems. In this study, a facile activation and annealing process combined with freeze drying and KOH treatment was used to successfully prepare nitrogen-doped onion-derived carbon materials (dried onion (DO) and freeze-dried onion (FDO)) with high specific surface areas. Structural and morphological study of the samples are performed using XRD and TEM/EDS. The chemical bonding states of the samples were investigated using XPS. The obtained carbon materials exhibited excellent electrochemical performances as anodes for SIBs, delivering high discharge reversible capacities of 140.5 (DO) and 151.4 (FDO) mAh g^{-1} at a current density of 0.05 A g^{-1} after 30 cycles. The capacities reached 45 (DO) and 66 (FDO) mAh g^{-1} at 30 A g^{-1}. Specifically, FDO//$Na_3V_2(PO_4)_3$@C full cells achieved a reversible capacity of 43.9 mAh g^{-1} with a specific energy of 91.5 Wh kg^{-1} at 5 C after 1,000 cycles, indicating that it provides broad prospects for the energy storage system of SIBs.

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Keywords : soduim, nitrogen, onion, carbon

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Abstract No. : **PO-S01-0172**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Low-temperature Behavior of Crystalline Pure fullerene Nanostructure for Lithium-ion Battery Anodes

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In this study, we synthesized pure crystalline fullerene (C60) in nanorod form to explore its potential as an anode material in lithium-ion batteries (LIBs). The synthesis process involved several steps, and we evaluated the performance of the C60 nanorods as LIB anodes through various tests. Our electrochemical analysis revealed that the battery electrodes containing C60 nanorods displayed high capacity and stability, as evidenced by long-term cycling tests. These findings suggest that C60 nanorods could be a promising material for battery electrodes with applications across various fields.

However, there is still a gap in research regarding the low-temperature characteristics of the synthesized samples, particularly in relation to the duration of synthesis and heat treatment temperature. To address this gap, we investigated and compared the low-temperature characteristics and basic electrochemical properties of samples synthesized under different heat treatment conditions and duration times (60-12h, 300-5h, 500-5h, 700-5h). Additionally, we analyzed the structure of each C60 nanorod sample using X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques.

This research was supported by the National Research Foundation of Korea (NRF) funded by the MSIT and MEST (grant numbers NRF-2021R1A4A1022198, NRF-2022R1A2B5B01001943, and NRF-2018R1A5A1025594).

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Keywords : C60 nanorods, low-temperature

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Abstract No. : **PO-S03-0171**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Plasma polymerization in pyrrole solution for PPy-Cu film for gas sensing layer

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The in-solution plasma (iSP) method, which induces electrical discharges within solution materials, offers an alternative to chemical activation reactions such as reduction, oxidation, and fragmentation. This approach inherently avoids the influence of ambient air, including the unintentional generation of reactive oxygen and nitrogen species through chemical interactions between plasma and ambient air. Recently, the iSP process was employed for the first synthesis of polypyrrole (PPy) films, marking a novel application of this technique. Key to the formation of PPy films using the iSP process is the generation of negative streamers and the provision of an anodic substrate during the process in liquid pyrrole.

This study investigates the PPy coating method based on the mechanism of the in-solution plasma (iSP) film formation for a gas sensor application. The proposed method offers a significant advantage by requiring only a single liquid monomer and electricity to form the PPy film on the desired electrode in a one-step process. A proposed iSP reactor having an additional electrode serving as both an anodic substrate and a biased electrode is developed for inducing negative streamers, and PPy films are successfully deposited on Cu substrate immersed in pyrrole solution during the process. Besides, the Cu substrate supplies Cu ions during the process, resulting in the creation of PPy-Cu film. The morphology, chemical and electrical properties of these films are investigated in detail. Finally, the PPy-Cu film is coated on the IDE substrate to investigate its properties as a gas sensor.

Keywords : plasma process, solution plasma, PPy-Cu film

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Abstract No. : **PO-S01-0170**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Electrochemical Performance of Na(Ni,Fe,Mn)O_2 Synthesized by Solid-State Reaction for Sodium-ion Battery Cathodes

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As the environmental impact of fossil fuel consumption worsens, there's been a surge in demand for efficient energy storage technologies. While lithium-ion batteries are predominant, theie limitations, such as the scarcity and high cost of lithium, have led to the emergence of sodium-ion batteries as a promising alternative. Sodium-ion batteries utilize abundant and evenly distributed sodium resources and share similar electrochemical behaviors with lithium-ion batteries, allowing for the application of existing lithium-based electrode material technology. However, sodium-ion batteries typically offer lower energy capacities compared to lithium-ion batteries. To address this issue, we have synthesized and analyzed three novel cathode materials: $NaNiO_2$, $NaNi_{0.9}Fe_{0.05}Mn_{0.05}O_2$, and $NaNi_{0.8}Fe_{0.1}Mn_{0.1}O_2$ using a solid-state reaction method. Starting materials Na_2O_2, NiO, Fe_2O_3, and Mn_2O_3 were mixed in stoichiometric proportions, with an additional 15% Na_2O_2 to compensate for high-temperature decomposition.

These compounds underwent structural characterization via X-ray diffraction (XRD) and Raman spectroscopy. Coin half-cells fabricated with these materials were evaluated through a series of electrochemical tests, including cycle tests, long-cycle stability, rate capability, galvanostatic intermittent titration technique, and electrochemical impedance spectroscopy. In-situ XRD analysis was also conducted to observe structural changes during the charging and discharging cycles. This study compares the structural and electrochemical properties of the synthesized cathode materials, demonstrating their potential in advancing sodium-ion battery technology. These findings contribute to the development of sodium-ion batteries as a viable and sustainable energy storage solution, offering an alternative to conventional lithium-ion batteries.

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Keywords : soduim, batteries, solid state reaction

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Abstract No. : **PO-S06-0169**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Influence of Sr Content on the Microstructure, Mechanical Properties, and Electrical Conductivity of Al-Si-Mg Alloy

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This study explores the effect of strontium (Sr) addition on the microstructural, mechanical, and electrical characteristics of Al-Si-Mg alloys, which are critically acclaimed in the automotive and aerospace sectors for their superior strength-to-weight ratio, excellent thermal conductivity, and as potential replacements for copper in electronic applications. Employing high-frequency induction followed by extrusion, solution treatment, and rolling, alloys were processed with thickness variations from 4 mm to 0.6 mm. Microstructural examinations revealed a significant influence of Sr concentration on phase formation, with alloys containing up to 0.25 wt.% Sr displaying spherical Al_2Si_2Sr phases, whereas concentrations above this threshold promoted the formation of needle-shaped Al_4Sr intermetallics. Tensile testing illustrated a clear correlation between Sr content and mechanical properties; extruded specimens achieved maximal strength at 0.25 wt.% Sr, contrastingly, rolled specimens exhibited diminished strength at the same concentration, highlighting the impact of processing techniques on microstructural integrity. Electrical conductivity assessments showed minimal variation with Sr content in extruded specimens, which exhibited over 20% enhanced conductivity over their cast counterparts, attributed to a more homogeneous microstructure. Conversely, rolled specimens showed decreased conductivity, likely due to the induction of residual stresses. Collectively, these findings underscore the critical role of Sr in tailoring the microstructural, mechanical, and electrical properties of Al-Si-Mg alloys, with significant implications for their application in various industrial domains.

Keywords : Al, Microstructure, Mechanical Properties, Electrical Conductivity

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Abstract No. : **PO-S10-0168**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Enhancing plant physiology monitoring with hydrogel microneedle-based electrodes

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In the horticultural industry and crop management, accurate diagnosis and prediction of plant diseases and health conditions are crucial for estimating the product yield. Recently, electrochemical impedance spectroscopy (EIS) has emerged as a promising avenue for monitoring plant physiology within smart farm system. However, the rough and stiff epidermal tissue of plants can interfere with the impedance signal when using only electrodes, causing the EIS data for plants unreliable. To collect precise impedance signals, the connection between the electrodes and the plant's vascular tissue must be fulfilled. Hydrogel microneedles can be utilized as bridge from vascular tissue to the electrode by penetrating the sap-rich tissue, swelling, and transporting sap to the plant's outer surface with minimal invasiveness. However, research on enhancing the precision of plant impedance monitoring has been limited. In this context, we used gelatin methacryloyl (GelMA), a biocompatible hydrogel widely used in tissue engineering, known for its high swelling ratio, making it ideal for sap conveyance. We fabricated a microneedle array using GelMA, demolded with polydimethylsiloxane (PDMS) thin film as an adhesive layer to apply on the plant tissue. Additionally, a barbed microstructure was adopted to increase attachment force of hydrogel microneedles, and the substrate-less manufacturing method minimizes strain on the stem and leaves, ensuring unrestrained plant growth and enabling long-term monitoring. Our studies demonstrated that the GelMA microneedle array significantly reduced impedance levels compared to the control group and allowed for precise, real-time monitoring of water stress level. This finding suggests a novel approach for direct observation of the physiology status of plants through minimal invasion, offering a new strategy for long-term crop management and environmental control based on impedance measurements.

Keywords : Hydrogel microneedle, Plant physiology, Impedance monitoring, Fluid extraction

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Abstract No. : **PO-S13-0167**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Band Offset Optimization of Sb2Se3/ZnMgO Interface Using SCAPS-1D

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Sb_2Se_3 is a promising material for solar cells due to its non-toxicity, abundant resourse, and optimal band gap (1~1.2eV) as an absorber layer material. Although CdS is commonly used as a buffer layer in Sb_2Se_3 solar cells, the Sb_2Se_3/CdS interface is expected to have a cliff-like structure, potentially increasing interface recombination and causing a decrease in the open-circuit voltage (V_{oc}). This study proposes a method to transform the interface between the light-absorbing layer and the buffer layer from a cliff structure to a spike structure using $Zn_{1-x}Mg_xO$ as the buffer layer to optimize the band-offset. The $Zn_{1-x}Mg_xO$ as the buffer layer can adjust the delta conduction band offset (ΔCBO) according to the Mg content, allowing for the formation of a spike-like structure at the interface. SCAPS-1D was used for band-offset optimization, simulating the band structure and I-V characteristics of the Sb_2Se_3/ $Zn_{1-x}Mg_xO$ interface under various Mg contents. When the Mg content reached ~0.145, CBO became positive value, transitioning from a cliff-like to a spike-like structure, and the V_{oc} improved with increasing Mg content until after 0.3, where it showed a decreasing trend. The maximum conversion efficiency was observed at Mg/(Zn+Mg) = 0.3, reaching 13.69%.

Keywords : Sb2Se3, ZnMgO, Voc, spike, cliff, delta conduction band offset, SCAPS-1D

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Abstract No. : **PO-S10-0166**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Nanoporous Gold Surface-Enhanced Raman Spectroscopy (SERS) substrates for Detecting Peanut Allergen, Ara h1

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Food allergens could cause urticaria, asthma, and also serious anaphylaxis. Among food allergens, especially peanuts are representative food that easily causes allergies. Unfortunately, there is no known specific cure for peanut allergy, the best management of food allergy is only prevention. Thus, we focused on the detection of Ara h1, one of the peanut allergens responsible for allergic reactions in 35% to 95% of peanut allergy patients, using nanoporous gold Surface-Enhanced Raman Spectroscopy (SERS) substrates.

Nanoporous structures are fabricated by using a high-pressure thermal evaporation. They are formed due to the relatively short mean-free path under high pressures. The high pressure causes homogeneous nucleation and growth, with repetitive collisions between gas molecules and metal particles due to the reduced surface mobility of the adatoms. By this process, leading to the formation of nanogaps and 'hot-spots' that enhance the Raman signal through Localized Surface Plasmon Resonance (LSPR). Therefore, these metals are particularly used in constructing surface-enhanced Raman spectroscopy (SERS) substrates due to their peculiar characteristic of amplifying Raman signals. SERS substrates are crucial in biosensors, given their ability to detect minute quantities of target materials owing to their ultrahigh sensitivity.

In this research, nanoporous gold was deposited using a high-pressure thermal evaporator at 2.0 torr and varying thicknesses of deposited gold. We explored the characteristic peak of Ara h1 by analyzing Raman spectra at every step of bioconjugation, and the limit of detection (LOD) of Ara h1 by varying concentrations with the gold SERS substrates.

Through this research, we propose the broader applicability of our approach in detecting various allergens and aim to contribute to the development of a portable peanut allergen detection sensor.

Keywords : Surface-Enhanced Raman Spectroscopy, Peanut allergy, Food allergy, Nanoporous

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Abstract No. : **PO-S03-0165**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Poster**

One-step Synthesis of Conductive Polypyrrole Film by Halogen-doped Atmospheric Pressure Plasma Process

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Unlike general organic polymers, conductive polymers have electrical properties similar to metals or semiconductors due to dopants. In order to use changes in electrical properties in response to specific gases as chemical sensors, conductive polymers are developed by doping halogen elements such as iodine into conjugated polymers. Since polymerization using atmospheric pressure (AP) plasma is attracting attention as a very simple, cost-effective, and environmentally friendly method, here we propose a new iodine-doped AP plasma polymerization method to improve the electrical properties while maintaining a stable plasma for polymer film deposition.

We fabricated a new AP plasma reactor having two metal injection needles as electrodes to simultaneously conduct plasma polymerization and iodine doping inside the reactor. The vaporized pyrrole monomers are introduced into the AP plasma reactor through one injection needle along with argon and converted into radicals by the plasma energy. At the same time, the sublimated iodine molecules are also introduced into the reactor through the other injection needle by the argon flow and activated by the plasma. Therefore, pyrrole radicals are cross-linked to deposit a polypyrrole (PPy) film and iodine is doped during this plasma polymerization, resulting in a conductive PPy film. In this AP argon plasma polymerization, the effects of electrode configuration, applied voltage, and amount of argon flowing to monomer and iodine on the morphological, chemical, and electrical properties of the PPy film were examined. In particular, this PPy film maintained stable electrical conductivity in air for more than a month, demonstrating promise for utilizing this film as a activated layer in gas sensors.

Keywords : Conductive polymer, Pyrrole polymerization, Atmospheric plasma, Halogen doping, Gas sensors

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Abstract No. : **PO-S09-0164**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Effect of Ag coating with austenite volume fraction on the electrochemical properties of super duplex stainless steel SAF2507: Advanced Li-ion battery case materials

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The demand for Li-ion batteries has significantly increased due to the growing demand for electric vehicles and portable electronic devices. Although new products are introduced and functionalities are continuously improved each year, incidents of battery explosions, caused by internal temperatures reaching up to 700 ^{o}C, persist. Traditional battery materials, primarily aluminum, have a melting temperature below 670 ^{o}C and that cannot prevent the loss of lithium during combustion. To address this issue, SAE304 has been used as a substitute. However, with a high-temperature strength of only 170 MPa at 700 ^{o}C and high thermal expansion rate, SAE304 is not an ideal material. Nevertheless, it remains widely used due to its well-established reputation. Therefore, this study aims to enhance safety by replacing SAE304 with SAF2507. SAF2507 maintains a strength of over 300 MPa at 700 ^{o}C and has a thermal expansion rate 60 % lower than SAE304. Additionally, SAF2507 is a duplex stainless steel composed of austenite and ferrite, providing excellent strength and high corrosion resistance. The dual phase structure can be altered with heat treatment, and this study controlled the austenite fraction by heat treating from 1100 (50 %) to 1300 ^{o}C (under 30 %) followed by rapid cooling at a rate of 50 ^{o}C/s. The microstructure after heat treatment was analyzed using field emission scanning electron microscopy and X-ray diffraction. Subsequently, Ag coating was applied, and the electrochemical properties were evaluated to open circuit potential, electrochemical impedance spectroscopy, and potentiodynamic polarization tests. The potentiodynamic polarization test in tests confirmed uniform corrosion at passivation range with Ag loss during galvanic corrosion, followed by verification of the pitting potential (E_{pit}) through galvanic corrosion of austenite and ferrite.

Keywords : Li-ion battery case, Ag coating, super duplex stainless steel, volume fraction, electrochemical behavior

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Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Dynamically tunable multicolor emissions from zero-dimensional Cs3EuCl6 and Cs3TbCl6 nanocrystals with wide color gamut

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This study demonstrates dynamically tunable multicolor emissions from a single component, zero-dimensional (0-D) cesium europium chloride (Cs_3EuCl_6) and cesium terbium chloride (Cs_3TbCl_6) nanocrystals. Highly uniform colloidal Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals are synthesized *via* the heating-up method. Excitation-wavelength-dependent multicolor emissions from Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals are observed. Under excitation of 330–400 nm, both NCs exhibit blue photoluminescence (PL). Under wavelengths shorter than 330 nm, characteristic red and green emissions are observed from Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals, respectively, owing to the atomic emissions from the f-orbitals in trivalent europium (Eu^{3+}) and terbium (Tb^{3+}) ions. Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals exhibit broadband excitation spectra and enhanced absorption properties. Particularly, Cs_3EuCl_6 nanocrystals exhibit a very narrow full-width at half-maximum in both blue and red PL and no overlap between the two spectra. The photophysical properties of these nanocrystals are further investigated to understand the multicolor PL origins by time-resolved and temperature-dependent PL measurements. Finally, the potential applications of Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals as anti-counterfeiting inks for high-level security are demonstrated. Given their broadband excitation with enhanced absorption properties and dynamically tunable colors with a wide color gamut, Cs_3EuCl_6 and Cs_3TbCl_6 nanocrystals have great potential as novel multicolor nanocrystal emitters for many emerging applications.

Keywords : Nanoparticle, zero-dimensional nanocrystal, lanthanide ion, dual luminescence

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Abstract No. : **PO-S13-0162**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Impact of CdS Electron Transport Layer on SbSeI Solar Cells via a Two-Step Solution Process

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Antimony chalcoiodides (SbChI, Ch = S, Se) are attracting significant interest for next-generation solar cells due to their tunable bandgap, high absorption coefficient, high chemical stability, earth abundant, low-cost, and low toxicity constituents [1,2].

This presentation investigates the impact of CdS used as the electron transport layer (ETL) on the growth of SbSeI films fabricated through a two-step solution process. This process involves first forming Sb_2Se_3, followed by its conversion to SbSeI [3,4]. A thiol-amine solution containing Sb_2O_3 and Se precursors was used to fabricate the Sb_2Se_3 film. The film was then transformed into SbSeI by reacting the pre-formed Sb_2Se_3 with SbI_3. The fabricated SbSeI solar cells with CdS ETL exhibited a higher power conversion efficiency (PCE), compared to devices fabricated with TiO_2 ETL. As a result, the solar cells achieved the best PCE of 3.6% with a short-circuit current density of 22.0 $mAcm^{-2}$, an open-circuit voltage of 367.0 mV, and a fill factor of 0.449. This research paves the way for developing low-cost, environmentally friendly, and stable solar cells.

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Keywords : SbSeI, Solar Cell

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Abstract No. : **OR-S14-0161**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Environmentally benign synthesis of Nd-Doped TiO_2 Quantum Dots for next-generation H_2 fuel

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Sol-gel and hydrothermal synthesis are efficient chemical techniques used to create TiO2 and Nd-doped TiO2. Techniques including zeta potential, FTIR, TEML, HRTEM, X-ray-EXD, XRD, XPS, BET, and XPS are employed to examine the attributes. Using an aqueous solution of methylene blue, the photocatalytic efficiency of the generated sample under sunlight and UV (ʎ= 365) was evaluated. Photoelectrochemical processes transform light energy into chemical energy through electrochemical reactions that occur at the interface of a semiconductor electrode immersed in an electrolyte solution. Doping quantum dots improves the performance of TiO2. The goal of the research is to maximize the photocatalytic activity of Nd-doped TiO2 by achieving the best results at low concentrations of Nd when it is uniformly doped in TiO2 quantum dots.

Keywords : Photocatalysis, Nd-Doped TiO2 Quantum Dots, Photoelectrochemical processes

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Abstract No. : **PO-S14-0160**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Synthesis of Nd-Doped TiO_2 Quantum Dots: A Sustainable Approach for Enhanced Photocatalytic Hydrogen Production

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TiO_2 and Nd-doped TiO_2 are synthesized utilizing effective chemical processes such as sol-gel or hydrothermal. Zeta potential, FTIR, TEM, HR-TEM, X-ray-EXD, XRD, XPS, BET, and XPS are some of the techniques used to study the characteristics. The photocatalytic efficiency of the produced sample under solar light and UV (ʎ = 365) was measured using an aqueous solution of methylene blue. Through electrochemical reactions that take place at the interface of a semiconductor electrode submerged in an electrolyte solution, photoelectrochemical processes convert light energy into chemical energy. The performance of TiO_2 is enhanced by the doping of Nd quantum dots. When Nd is uniformly doped in TiO_2 quantum dots, the research aims to maximize the photocatalytic activity of Nd-doped TiO_2 by obtaining the best results at low concentrations of Nd. Doping Nd with titanium dioxide lowers the band gap from 3.23 eV to 3.16 eV. Various factors were used to investigate the photoreactor (PR) effectiveness of Nd-doped TiO_2. The factors include light source type and quantity, pH, and Nd concentration. When exposed to UV and solar light, Nd-doped TiO_2 exhibited a high photodegradation efficiency because of its smaller size, which improved the photocatalyst's degradation effectiveness by giving the photocatalytic activity a large surface area.

Keywords : TiO2, Nd-doped TiO2, Photocatalytic efficiency, Quantum dots, Photoreactor.

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Abstract No. : **PO-S10-0159**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Cyclic mechanical stimulus regulates mechanotransduction of smooth- and skeletal-muscle cells

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Understanding the complex and dynamic microenvironment of muscle cells is crucial for mimicking their physiology, considering both biochemical and mechanical aspects. Previous studies have highlighted the crucial role of mechanical stimuli in shaping cell morphology, proliferation, growth, and phenotype shift. However, insights into how periodic mechanical stimulation affects the maturation of muscle cells remain incomplete. Our platform facilitates the observation of cellular responses to mechanical stimuli by exposing cells seeded on thin PDMS membranes to various frequencies and strains. Key mechanotransduction markers, such as yes-associated protein 1 (YAP) and megakaryoblastic leukemia 1 (MKL1), translocate from the cytoplasm to the nucleus and activate in response to mechanical stress. Smooth muscle cells (SMCs) exhibit increased YAP expression in the nucleus, whereas skeletal muscle cells (SkMCs) show elevated MKL1 expression in the nucleus after six hours of cyclic mechanical stress at 0.5Hz and 5% to 15% strain. After five days of culture under these mechanical stimuli, SMCs show elevated expression levels of calponin and α-SMA, indicating enhanced maturation. Similarly, SkMCs exhibit increased intensity levels of Actinin and MyoD, signifying enhanced maturation due to mechanical stimulation. This platform, closely mimicking muscle cell physiology, possesses potential for developing sophisticated microphysiological models for precision medicine.

Keywords : Mechanotransduction, Muscle cell, Cell maturation, Cyclic mechanical stress

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Abstract No. : **IN-S08-0158**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Nanoscale Study on Lithium-Ion Battery Electrodes Using Scanning Probe Microscopy Techniques

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The demand for high-performance lithium-ion batteries (LIBs) is significant in various energy-related fields, including electric vehicles and energy storage systems (ESSs). To develop high-performance LIBs, it is essential to understand the degradation phenomena of LIB electrodes. Recently, several scanning probe microscopy (SPM) techniques have been introduced to study LIB electrode materials. The application of these new analysis tools to the LIB research field enables us to observe what happens inside the LIB electrode materials at the nanoscale.
In this talk, I will present research results based on SPM techniques such as scanning spreading resistance microscopy (SSRM) and Kelvin probe force microscopy (KPFM) used to investigate the degradation of LIB cathode and anode materials. [1-5].

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Keywords : lithium-ion battery, degradation, SSRM, KPFM

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Abstract No. : **PO-S01-0157**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Structural Evolution According to the Annealing Treatment of Chemically Synthesized C_{60} Nanorods

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In this study, we synthesized one-dimensional C_{60} nanorods utilizing the liquid-liquid interface precipitation method, followed by an annealing process at various temperatures: 60 °C for 12 hours (designated as C_{60} NRs-6012h), 300 °C for 2 hours (C_{60} NRs-603002h), 500 °C for 2 hours (C_{60} NRs-605002h), and 700 °C for 2 hours (C_{60} NRs-607002h). Initially, we analyzed the surface morphology and mean diameter of each sample using SEM and relevant software. Furthermore, X-ray diffraction technique and Raman spectroscopy were employed to investigate the crystal structure and Raman active modes. The as-prepared C_{60} NRs underwent a structural phase transition from h.c.p. to f.c.c. owing to the evaporation of solvent molecules during subsequent drying and annealing processes. Notably, all samples exhibited reversible Li^+ storage capacity as an anode active material in lithium-ion batteries. Particularly noteworthy was the enhanced rate performance and long cycle stability observed in the f.c.c. structured C_{60} NRs-603002h electrode compared to other conditions.

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Keywords : C60 nanorods, liquid-liquid interface precipitation (LLIP), phase transition, lithium-ion batteries (LIBs), electrochemical performance

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Abstract No. : **IN-S12-0156**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Eco-friendly construction materials incorporating marine wastes and bacteria

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This study explores eco-friendly construction materials by incorporating marine wastes and bacteria into cement-based composites, addressing both environmental concerns and enhancing material properties. The accumulation of waste shells and fishing nets presents significant environmental challenges, including soil pollution and odor issues. Moreover, the construction field faces scrutiny for its substantial energy consumption and CO_2 emissions during aggregate production. Our research investigates the potential of recycling various marine wastes, such as cockle, oyster, and murex shells, along with waste fishing nets, by integrating them as partial substitutes for fine aggregates and fibers in cementitious materials. These materials were cleaned using an ultrasonic device or washed, then crushed or ground before incorporation into cement mortar specimens to examine their effects on the material's microstructural characteristics and flexural performance. The results demonstrate that cockle shell powder, when properly processed, serves as a viable alternative to traditional aggregates, and ground waste fishing nets can effectively reinforce cement mortar, improving its flexural properties. Additionally, the utilization of bacterial concrete as a self-healing material, capable of autonomously repairing damages through microbially induced calcium carbonate precipitation (MICP) can be considered a sustainable and environmental approach. The precipitated calcium carbonate, in phases such as calcite and vaterite, significantly enhances the durability and mechanical properties of cement mortar, depending on the curing solutions used. This research not only offers a solution to managing marine waste but also introduces innovative methods to produce more sustainable and durable construction materials, contributing to the reduction of environmental impact in the construction industry.

Keywords : concrete, microstructure, marine wastes, bacteria, mineralization

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Abstract No. : **PO-S02-0155**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Shape-controlled synthesis and self-assembly of highly uniform upconverting calcium fluoride nanocrystals

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Herein, the size- and shape-controlled synthesis of nearly-monodisperse, lanthanide-doped calcium fluoride (CaF_2) nanocrystals (NCs) is reported. The sizes and shapes of CaF_2 NCs are controlled by tailoring the reaction conditions, such as the concentration of lithium fluoride precursors, reaction time and temperature, and the procedure for adding the calcium trifluoroacetate precursors in the reaction mixture. Highly uniform CaF_2 NCs are synthesized with several morphologies, such as nanospheres, truncated octahedra, nanoplates, and nanowires. The shape-controlled CaF_2 NCs self-assemble into NC superlattices with long-range orientational and positional order forming crystalline and liquid crystalline structures. The near-infrared-to-visible upconversion luminescence properties are investigated by varying the types of dopants as well as the sizes and shapes of the CaF_2 NCs.

Keywords : nanoparticles, nanoparticle shape, self-assembly, luminescence

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Abstract No. : **PO-S15-0154**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Electrical resistance and optical properties of boron-doped diamond fabricated by mode conversion-type microwave plasma CVD

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Boron-doped diamond (BDD) has been applied to electrochemical applications because of its conductivity, chemical stability, wide potential window, and low background current. In this study, we investigated the relationship between the optical properties and resistance of BDD.
BDD was prepared using mode conversion-type MWPCVD apparatus. Substrate was SiO_2 of □10, t2. The evaluations of samples were conducted by visual observation, SEM observation, and Raman spectroscopy.
From the SEM observation, crystal shape was not clear such as amorphous at a boric acid concentration of 0.01 g/ml and a carrier gas flow rate of 3 sccm. However well-defined crystals were observed in the SEM images under the other conditions. Obtained Raman spectrum was similar to BDD except for the boric acid concentration of 0.01 g/ml carrier gas flow rate of 3 sccm. Transmittance was very low at a boric acid concentration of 0.02 g/mL carrier gas flow rate of 3 sccm, and the resistance was 245.3 Ω. At a boric acid concentration of 0.02 g/mL carrier gas flow rate of 5 sccm, transmittance was about 1.5% in the UV region, however transmittance decreased in the visible region, and transmittance was very low in the IR region, and the resistance was 404.2 Ω. At a boric acid concentration of 0.01 g/mL carrier gas flow rate of 1 sccm, transmission was confirmed in the UV, visible, and IR regions, transmittance was decreased in the IR region especially, and the resistance was 724.3 Ω. At a boric acid concentration of 0.03 g/mL and a carrier gas flow rate of 1 sccm, transmission was confirmed in the UV, visible, and IR regions, and the resistance was 5.947 kΩ.
The relationship between the optical properties and resistance of BDD synthesized by mode conversion-type MWPCVD was related to increase of the transmittance in the IR region.

Keywords : diamond, CVD, microwave, plasma, optical property

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Abstract No. : **PO-S15-0153**
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Abstract Preference : **Poster**

Effects of sulfuric acid concentration and bath temperature on anodic oxidation of aluminum in electrolyzed sulfuric acid bath

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Anodic oxidation is the process of passing an electric current through the anode metal in an electrolytic solution to grow an oxide layer on the surface. Wear resistance of aluminum was improved by anodic oxidation. On the other hand, Electrolyzed sulfuric acid with a high redox potential can be obtained by electrolyzing sulfuric acid.
It is thought that the dissolution rate and oxidation rate of anodic oxidation using electrolytic sulfuric acid are different from using those sulfuric acid.
In this study, the effects of sulfuric acid concentration and bath temperature on anodic oxidation using electrolytic sulfuric acid were investigated.
Sulfuric acid and electrolyzed sulfuric acid were used as the electrolyte. The weight, thickness, and hardness of sample were evaluated. The surface was observed by FE-SEM and chemical bonding state of the surface was analyzed using XPS.
Mass was increased only in the 9 wt% electrolyzed sulfuric acid bath.
The film thickness were 32.0μm for 9wt%/293K, 30.5μm for 18wt%/293K, 35.7μm for 9wt%/278K, 33.5μm for 18wt%/278K. and the film thickness of 9wt% was thicker than that of 18wt%.
The film hardness were 328Hv for 9wt%/293K, 290Hv for 18wt%/293K, 413Hv for 9wt%/278K, 353Hv for 18wt%/278K. and the film hardness of 9wt% was harder than that of 18wt%
Micropores of 10-20 nm in diameter were observed in FE-SEM image for each sample,
anodic oxidation layer can be obtained even without pretreatment.
Peak height of AlOOH, Al_2O_3, and $Al_2(SO_4)_3$ in XPS spectra were higher 278 K than 293 K for the temperature and 9 wt% than 18 wt% for concentration.
As a result of investigation, the thickness and hardness of the film 9wt% were better than those of 18wt%. even at low concentrations, properties were better.

Keywords : aluminum, anodic oxidation, electrolyzed sulfuric acid, concentration, bath temperature

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Abstract No. : **PO-S12-0152**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Electrochemical Denitrification for Simultaneous NH_3-N Oxidation and H_2 Production from Landfill Leachate: Towards Sustainable Waste Management and Green Energy Generation

EUN KYEONG BYEON[1], Juwon Lee[1], Hyoung-il Kim*[1]

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Landfill leachate presents a complex mixture containing diverse components, including organic compounds, heavy metal ions, and notably high concentrations of ammonia. With NH_3-N concentrations ranging from 1,000 to 3,000 mg/L due to anaerobic decomposition, landfill leachate holds significant potential within the context of the hydrogen economy. Utilizing electrolysis to generate hydrogen from T-N(NH_3-N) in leachate presents an appealing opportunity for sustainable waste management practices, alongside the provision of clean energy resources.

Herein, we introduce an electrochemical denitrification approach designed to achieve simultaneous NH_3-N oxidation and hydrogen production utilizing a Ni-based multi-metal catalyst. Our approach entails the synthesis of the catalyst via a facile and cost-effective method tailored for NH_3 oxidation. The surface composition and properties of the electrodes were characterized using SEM, XPS, XRD, and analyzed for electrochemical properties using LSV, CA, and EIS under the presence and absence of ammonia. Furthermore, hydrogen production efficiency was assessed via gas chromatography in both the presence and absence of ammonia. Sustained hydrogen production exceeding 2400 μL within a 30 minute duration was confirmed specifically when employing a Ni-based multi-metal catalyst in the presence of ammonia.

Through comprehensive experimentation and analysis, this study illuminates the feasibility and implications of leveraging landfill leachate for green energy production via hydrogen generation. Our findings represent a significant, guided exploration contributing to effective waste product management practices.

Keywords : electrochemical, ammonia, ammonia oxidation, hydrogen, H2 production

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Abstract No. : **OR-S12-0151**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Facile one-pot synthesis of porous N-doped carbon nanosheet coupled with Co/CoO nanoparticles for efficient peroxymonosulfate activation

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Increasing water pollution caused by organic contaminants remains a serious environmental issue, especially those that are difficult to remove via conventional methods. In recent years, advanced oxidation processes (AOPs) have received significant attention as efficient water treatment technologies. In-situ generated reactive oxygen species (ROS) from both radical and non-radical pathways can degrade organic pollutants into CO_2 and H_2O or less toxic molecules. Transition metals (e.g. Mn, Co, Ni, Fe) with different chemical valence states can act as activators for PMS activation. Among them, Co-based materials are considered to be the most effective activators due to their eco-friendly and high redox potential (Co^{3+}/Co^{2+}, 1.82 V).

Herein, a composite porous catalyst N-doped carbon nanosheet coupled with Co/CoO (Co/CoO-NC) was constructed using a facile one-pot thermal reduction approach. Attributing to the interaction between Co/CoO and NC, Co/CoO-NC exhibits excellent PMS activation capacity, as 4-CP was completely removed with 30 min with low catalyst dosage. Furthermore, Co/CoO-NC could maintain good degradation performance in a broad pH range, and the excellent magnetic properties of the catalysts facilitate easy recovery from the water while exhibiting high stability in reusability experiments. Further exploration via electron paramagnetic resonance (EPR) analysis and radical quenching experiments demonstrate that the reactive species generated during the 4-CP removal process were sulfate radical ($SO_4^{\bullet -}$) and hydroxyl radical ($^{\bullet}OH$), in which $SO_4^{\bullet -}$ played the dominant role.

This study provides a facile method for synthesizing high-performance and environmentally friendly cobalt-based catalysts and offers a strategy for removing emerging organic pollutants.

Keywords : PMS activation; 4-cp; cobalt-based catalyst

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Abstract No. : **IN-S04-0150**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

Bio-Integrated Soft Electronics Based on Biomimetic 3D Nanofiber Networks

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Nanofiber networks are essential structures in natural biological tissues, which exhibit a combination of mechanical flexibility, fracture resistance, and mass permeability to enable many important physiological functions. Inspired by natural soft tissues, we exploit biomimetic nanofiber networks as building blocks for the construction of a variety of bio-integrated soft devices. A key component in these materials and devices is aramid nanofiber (ANF). With appropriate solvent-based processing steps, the ANFs self-organize into hyperconnective networks, which capture some of the key features of load-bearing soft tissues. They also exhibit tissue-mimetic physical properties and microstructural reconfigurability, which are beneficial for device applications. The composites can be functionalized with bioactive molecules or soft electronic components for interfacing with cells and tissues. In this presentation, I will introduce some of our recent works ranging from electroconductive hydrogels and wearable devices to theoretical modeling and meso-structural designs. These works address the fundamental physical mismatches between biomedical devices and biological soft tissues, paving the way for the development of advanced wearable human-machine interfaces, implantable electronics, tissue engineering platforms, and other biomedical systems.

Keywords : biomimetic materials, nanofibers, soft electronics, hydrogels, nanocomposites

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Abstract No. : **OR-S12-0149**
Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Oral**

Synthesis of ethylene urea from CO_2 by Zr-doped Mg-Al layered double hydroxide

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Carbon Capture and Utilization technology, which involves separating and recovering CO_2 and converting it into other compounds for beneficial use, has been gaining attention in recent years. The reaction of CO_2 and Ethylenediamine in the presence of a catalyst produces Ethylene Urea (EU), which is used as a raw material for chemicals. However, a major challenge is the requirement for high-pressure and high-purity CO_2, which involves energy-intensive compression and purification processes. To overcome this, the use of inorganic materials capable of adsorbing CO_2 to capture and then reacting the adsorbed CO_2 with an amine eliminates the need for high-pressure CO_2. Therefore, attention has been given to Mg-Al Layered Double Hydroxide (Mg-Al LDH) as a CO_2 adsorbent. Mg-Al LDH has the ability to adsorb CO_2 and shows potential for application in CCU technology. Additionally, research on CO_2 capture and EU synthesis using $Ti_xZr_{(1-x)}O_2$ has confirmed that an increase in the Zr content leads to an increase in EU production. In this study, Zr-doped Mg-Al LDH was synthesized and utilized as a source of CO_2 and a reaction promoter to explore the synthesis of EU without the need for high-pressure and high-purity CO_2. Mg-Al LDH and Mg-Al-Zr were synthesized using the sol-gel method. The crystal properties were evaluated using X-ray diffraction. After CO_2 adsorption, LDH, Ethylenediamine, and 2-propanol were placed in an autoclave and heated at 160 °C for 24 hours. After the reaction, the amount of EU produced was analyzed. Mg-Al-Zr LDH was identified as a material comprising LDH and $Zr(OH)_4$. Notably, while the use of Mg-Al LDH yielded 0.0172 mmol of EU, employing Mg-Al-Zr LDH resulted in a significant increase, with 0.0624 mmol of EU generated.

Keywords : Layered double hydroxide, Carbon Capture and Utilization, Ethylene Urea

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Abstract No. : **OR-S12-0148**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Investigation of the properties of Mg-Al layered double hydroxide intercalated with CO_3^{2-} on HCl gas removal

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In Japan, about 80% of waste is incinerated to reduce its volume and then disposed of in landfills. The exhaust contains acid gases such as HCl, SO_x, and NO_x, which needs to be treated properly. In the dry method, a common acid gas treatment method in Japan, HCl is neutralized with slaked lime. It generates neutralization products that cause the environmental burden. Therefore, a novel acid gas treatment material that does not generate neutralization products is required. Mg-Al layered double hydroxide intercalated with CO_3^{2-} (CO_3・Mg-Al LDH) can remove acid gas and regenerate its structure through anion exchange. It is expected to be applied as an acid gas treatment material to replace slaked lime. This study aims to control the chemical properties of CO_3・Mg-Al LDH and achieve advanced acid gas treatment, and investigates the characteristics of CO_3・Mg-Al LDH with high HCl removal capacity. Four types of LDH with different synthesis methods were prepared. The HCl adsorption capacity of each sample was measured by gas distribution experiments. Composition was determined by ion chromatography and particle size distribution was evaluated by laser scattering method. The sample with the lowest HCl removal capacity had a SO_4^{2-} weight composition of 2.76 (wt%), while the sample with good removal capacity had a SO_4^{2-} weight composition of less than 1.0 (wt%). On the other hand, the particle size range of the sample with good adsorption capacity was relatively broad, suggesting that SO_4^{2-} weight composition and particle size of CO_3・Mg-Al LDH are related to HCl removal and that controlling them improves the removal capacity of LDH.

Keywords : Layered double hydroxide, gas adsorption

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Abstract No. : **PO-S12-0147**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Investigating Sample Preparation and Measurement Conditions for Microplastics Analysis Using Pyrolysis Gas Chromatography Mass Spectrometry

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The widespread environmental challenge posed by microplastics demands the development of sophisticated analytical methods for their collection and detection. This study aims to optimize sample preparation and pyrolysis gas chromatography/mass spectrometry (py-GC/MS) measurement conditions for microplastics, particularly polytetrafluoroethylene (PTFE) and polystyrene (PS). It is determined that 600-630 ℃ is the optimal pyrolysis temperature for PTFE to produce distinct tetrafluoroethylene peaks without overlap, crucial for accurate microplastic identification. PTFE in powder form significantly reduces peak overlaps compared to ethanol solutions, improving analysis precision. Regarding PS sample preparation, this study reveals that oven-drying water solutions containing PS substantially increase peak intensities compared to those not oven-dried, highlighting the influence of solvent presence on the pyrolysis process. Moreover, it is noteworthy that commercial-grade and laboratory-grade PS demonstrate significant differences in solubility within organic solvents, potentially affecting microplastic quantification in environmental samples. In addition, when tetramethylammonium hydroxide (TMAH), commonly used to enhance the pyrolysis process of hydrolysable oligomers, is added to the stainless-steel sample cups provided with the py-GC/MS equipment to optimize pyrolysis products, leakage of the sample cups often occurs, illuminating the instrumental and methodological considerations for microplastic analysis. Through meticulous investigation, this study elucidates critical factors affecting the reliability of microplastics identification via py-GC/MS, establishing a foundation for the development of standardized analytical methodologies in environmental monitoring.

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Keywords : Microplastic; Py-CG/MS; Measurement

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Abstract No. : **OR-S06-0146**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Design of Extrusion Process of Al-Mg-Si-Cu-Mn alloy by Simulated Variable Optimization

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In the automobile industry, the need for lightweighting car bodies is emerging due to increasing sales of electric vehicles and issues with their battery weight. Extruded aluminum alloys with excellent specific strength and formability have been widely used as automobile parts. Al-Mg-Si alloys, the most widely used aluminum alloys in extrusion applications, are being utilized in automobile structural components because of their excellent corrosion resistance and weldability. The strength of heat-treatable Al-Mg-Si alloys can be enhanced by forming finely dispersed precipitates through the heat treatment process. By utilizing this aspect, there are many studies on the precipitation behavior and relevant mechanical properties of Al-Mg-Si alloys. However, most of them concentrate on optimizing heat treatment process and alloy composition in laboratory settings. There is a lack of systematic research considering variables in the actual manufacturing process. In this study, we aimed to evaluate the microstructure and mechanical properties of an extruded Al-Mg-Si-Cu-Mn alloy influenced by process variables that may occur during the extrusion process. To simulate the extrusion process variables, we set the solution temperature and quench delay time as the main process variables. Hardness measurement and tensile tests were performed to evaluate mechanical properties. Transmission Electron Microscopy (TEM) observation and Differential Scanning Calorimetric (DSC) analysis were also carried out to understand the microstructure differences induced by process variables.

Keywords : Al-Mg-Si alloy, Extrusion, Microstructure, Mechanical property, Quenched-in vacancies

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Abstract No. : **OR-S03-0145**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Oral**

A Breathable and Stretchable Temperature Sensor Using Partially Reduced Graphene Oxide and Mesh-Shaped Textile

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The digital healthcare market is expanding globally due to population growth, aging, and infectious diseases such as COVID-19, thus the interest in healthcare monitoring through wearable devices is increasing. In addition, body temperature is the most basic signal that determines our body's condition, and both hypothermia and high fever can cause serious diseases. To this end, the development of a system that can monitor body temperature in real-time is required. However, commercial thermometers are rigid and heavy, making it difficult to measure body temperature on the human skin in real time over a long period. On the other hand, the silicone-based flexible sensors commonly used to address this have very low breathability, which can cause sweating and discomfort when attached to the skin for a long time. Accordingly, a temperature monitoring device which is soft, lightweight, and highly breathable is demanded. In this study, we developed a PrGO on mesh-shaped textile temperature sensor that allows long-term monitoring of body temperature in real-time by taking advantage of the breathability and stretchability of textiles. The prepared temperature sensor showed outstanding breathability, washability, excellent stretchability, decent sensitivity, high linearity, and fast response time. Additionally, it could be attached to the human skin making it possible to use it for a variety of applications.

Keywords : Meshed textile, Partially reduced graphene oxide, Breathability, Temperature monitoring

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Abstract No. : **PO-S12-0144**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Development of synthesis of zeolites from coal fly ash and application of ammonia gas adsorption

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Coal fly ash (CFA), a byproduct of fossil fuel combustion, is one of the representative waste that negatively affect to environment and human health. Prior studies suggest that CFA converts into valuable mineral called zeolite. Zeolite has basic structure of SiO_4 and AlO_4 tetrahedra. Since CFA contains abundant Si and Al, research has been conducted to synthesize CFA into zeolite based on this premise. Zeolite is applied diverse fields as adsorbent, catalysis and support of catalysis. In this study, zeolite was used as an adsorbent for ammonia gas.

For higher purity zeolite, CFA was magnetically separated to remove impurities, such as iron (Fe). Through the magnetic separation, non-magnetic fly ash (NMFA) was obtained. CFA and NMFA were mixed in appropriate ratio with sodium hydroxide (NaOH) and potassium hydroxide (KOH). The mixtures were calcined in a furnace and the calcined solid were mixed with deionized water (DIW). After synthesis, zeolite was obtained we named zeolites made from CFA with NaOH as ZF-X and with KOH as ZF-CHA, respectively. Similarly, zeolite made from NMFA with NaOH was named ZNF-X and with KOH was named as ZNF-CHA, respectively. To characterize materials, various analysis such as X-ray diffraction (XRD), X-ray fluorescence (XRF), Fourier transform infrared spectroscopy (FT-IR) and scanning electron microscopy (SEM), etc. were conducted. This work demonstrates that ammonia gas can be stored an environmentally friendly way and serves as the basic study for utilizing ammonia, which has the potential to replacement fossil fuel.

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Keywords : Coal fly ash, Zeolite, alkali-fusion method, Ammonia gas adsorption

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Abstract No. : **PO-S12-0143**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Synthesis of nZVI supported by alkali pre-treated natural zeolite as an effective engineered material of in-situ remediation systems: investigation of iron nanoparticles encapsulation phenomenon

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In recent decades, nanoscale zero-valent iron (nZVI) has emerged as a promising material for the in-situ remediation of contaminated soil and groundwater. However, its practical application in subsurface environments still faces technical challenges, primarily due to rapid aggregation. This aggregation results in blockages around injection well and limits transport performance within porous media. To address this issue, various supporting materials have been explored to stabilize nZVI against aggregation. Among these materials, natural zeolite (NZ) sourced from the mining industry stands out as a valuable resources due to its abundant availability, eco-friendliness and low cost. However, effective utilization of NZ often necessitates appropriate pre-treatment. In this study, we applied an alkaline solution to pre-treat NZ, aiming to enhance its quality by modifying its physicochemical characteristics. The synthesized nZVI-Zeolites exhibited dramatically enhanced transportability in 3D porous media compared to typical nZVI. Our findings unraveled that the significant improvement in nZVI stabilization stems from the encapsulation of iron nanoparticles within the structure of alkali-treated zeolite. We investigated the nZVI encapsulation mechanism under various alkali pre-treatment conditions, identifying two main factors: structural defect formation via Si extraction from the zeolite framework and enhanced cation-exchange ability. Particularly noteworthy is the longevity of encapsulated nZVI, as evidenced by electrochemical corrosion tests. Therefore, encapsulated nZVI-Zeolites can be considered as an ideal engineered material for future application in filed scale in-situ remediation systems.

Acknowledgements
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Keywords : Nano material, natural zeolite, encapsulation, alkali treatment

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Abstract No. : **PO-S06-0142**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

The precipitation microstructure and hardening of stress-aged Al-Cu-Mg-Ag alloy polycrystal

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Al-Cu-Mg-Ag alloy exhibits high specific strength, good fracture toughness and fatigue properties due to the plate-like Ω precipitates formed on {111}Al habit planes. It is known that the nucleation and growth of precipitates can be promoted by external stress during aging. The stress-orienting effect on the formation of fine misfitting precipitate was firstly studied by GP zones on {001} habit planes in Al-Cu single crystal by Eto1), where anisotropic hardening behavior was found depending on the geometries of dislocation interactions of the stress-oriented GP-zones. However, anisotropic hardening behaviors of stress-oriented Ω precipitates on {111} habit planes is unknown. Therefore, the purpose of present study is to find deformation anisotropy caused by the stress-oriented Ω-phase in Al-Cu-Mg-Ag alloy.

Al-Cu-Mg-Ag polycrystalline was homogenized at 793 K for 4 days and hot rolled at 703 K with reduction rate of 60%. After solid solution treatment at 793K for 1hour, stress and stress-free aging were conducted at 450K. After each of the heat treatments, samples were water-quenched immediately. For stress-aging, external stress ranging from 50 to 150 MPa was applied by stress-aging machine. Stress-orienting effect of Ω-phase was clarified by TEM observation. In order to find the deformation anisotropy of stress-oriented Ω precipitates, micro-Vickers hardness test was conducted on the surfaces normal and parallel to the axis of stress-aging. Also, nano-indentation test was carried out on the surface of {111} crystalline orientation.

Anisotropic hardening behavior was found in the stress aged sample, where the hardness of the plane parallel to the stress axis was higher than that of perpendicular. For nano-indentation test, hardness curve of parallel plane shows smoother than that of perpendicular plane. Result of this tendency maybe related to the geometrical relationship between stress-oriented Ω-phase and dislocation slip system.

Keywords : Aluminum alloy, Ω-phase, stress-orienting effect, anisotropic hardening

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Abstract No. : **PO-S12-0141**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Synthesis of Al and Fe-based Metal-organic Frameworks Using Sequential Acid Leachate from Red Mud

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In this study, we developed synthesis method of aluminum and iron-based metal-organic frameworks (i.e., MIL-53(Al), MIL-96(Al), MIL-100(Al), and MIL-100(Fe)) by using Al and Fe sources extracted from red mud (RM). We utilized HNO_3 as the first lixiviant to obtain Al ions, followed by HCl as the second lixiviant to obtain Fe ions from RM. The HNO_3 solution containing various metal ions was thermos-treated to removal Si impurity, and then the Al-MOFs were finally synthesized by adding organic linker (i.e., terephthalic acid and trimesic acid). We found that various Al-MOFs could be successfully synthesized depending on the organic linker and hydrothermal reaction conditions. After the HNO_3 treatment, remaining solid residues were treated with a second acid leaching process and then used for MIL-100(Fe) synthesis. A variety of surface analysis such as X-ray diffraction and Scanning electron microscope, transmission electron microscope, and BET was carried out to characterize the synthesized MOFs. Finally, we applied the synthesized MOFs for adsorption removal of perfluorooctanoic acid (i.e., PFOA), and the results showed remarkable adsorption performance in MIL-100(Al) phase.

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Keywords : Red mud, Metal-Organic Framework, Perfluorooctanoic acid

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Abstract No. : **OR-S06-0140**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Oral**

Negative Strain Rate Sensitivity of Flow Stress Measured by Micropillar Compression Test for Additive Manufactured Al-Fe Alloy

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Laser powder bed fusion (L-PBF) is one of the most representative metal additive manufacturing techniques that can produce complex metallic components by using a scanning laser beam to selectively melt consecutive bedded powder layers. Al–Fe alloys are promising materials for heat exchanger applications owing to low raw material costs and a preferable combination of specific strength and thermal conductivity. However, the brittle needle-shaped Al13Fe4 phase, which is formed in equilibrium solidification conditions in the Al-Fe binary system, has caused processing difficulties. On the other hand, the fine metastable Al6Fe phase is formed in the L-PBF processed Al-Fe alloy due to the high cooling rate. Due to the unique solidification microstructure, the L-PBF processed Al-Fe alloy shows enhanced mechanical strength and ductility compared to the commercial cast Al-Fe alloys. Meanwhile, the L-PBF processed Al-Fe alloy has inhomogeneous solidification microstructure due to the melt-pool structure where the melt-pool boundary and melt-pool interior have different microstructures because the solidification rate is drastically increased from the melt-pool boundary toward the melt-pool interior. It is assumed that the superior mechanical properties would result from the melt-pool interior in the L-PBF processed Al-Fe alloy. This study investigated the mechanical properties of the melt-pool interior in the Al-2.5%Fe binary alloy manufactured by the L-PBF process using a single-crystal micropillar compression test. The L-PBF processed Al-2.5%Fe alloy showed negative strain-rate sensitivity, while subsequently annealed samples and the slowly solidified alloys showed positive strain-rate sensitivity. As a result of the microstructure analysis, we found that the negative strain-rate sensitivity of L-PBF processed specimens resulted from the dynamic precipitation during the deformation. The negative strain-rate sensitivity of L-PBF processed Al-Fe alloy resulting from the dynamic precipitation will be discussed with the microstructure analysis results.

Keywords : Al-Fe alloy, Additive Manufacturing, Strain Rate Sensitivity, Single Crystal Micropillar

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Abstract No. : **IN-S13-0139**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Invited**

High-Performance Solar Cells Based on Low Bandgap Organic Perovskite Quantum Dots

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In the last ten years, the field of solution-processed solar cells has advanced significantly. This improvement is mostly due to the search for new materials and the perfection of manufacturing techniques aimed at increasing the efficiency and market viability of solar cells. Currently, the focus of research has shifted towards not only enhancing efficiency but also expanding the variety of solar cell technologies and improving production methods. In this scenario, quantum dot technology stands out as a promising avenue for innovation. The unique properties of quantum dots present exceptional opportunities for groundbreaking work. This presentation will cover the progression of quantum dot solar cells, from foundational concepts to the latest technological achievements. We'll examine how quantum dots operate, highlighting their role in mitigating defects and stabilizing phases. Utilizing the quantum effects of these dots is a key tactic for improving stability and addressing challenges in defect management. This method paves the way for new directions in solar cell research and promises a future filled with innovative developments.

Keywords : quantum dot, solar cell, perovskite, organic cation, low bandgap

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Abstract No. : **OR-S15-0138**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Preparation of B-doped CVD diamond and its electrochemical applications

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The electrochemical properties of Boron doped diamond (BDD) are excellent. Electrical potential window is wide comparison with conventionally used electrode materials such as platinum, and it is possible to make electrochemical reactions difficult with conventional electrode materials. Control of electrical resistance in synthesis of BDD using microwave CVD and hot filament CVD and its application to chemical electrodes were investigated.

The influence of plasma state on volume resistivity of B-doped diamond (BDD) was investigated. The plasma during growth is measured by Optical Emission Spectroscopy (OES) and make clear relationship between emission species and resistance value. With increasing B containing emission species such as B and BH peaks in OES spectra, volume resistivity is decreased. It suggested that B system emission species in OES spectra influences volume resistivity of BDD.

On the other hand, the HFCVD apparatus with filaments and substrates set up vertically was used. By set up the filaments vertically and by introducing the reaction gas from the bottom, promoting the decomposition of reaction gas and deposition rate is increased. Measuring of the reaction gas states with Q-MS, no fragment of $B(OCH_3)_3$ (boron source) could be confirmed. In addition, the grain size of BDD increases as the CH_4 intensity decreases. From this, the possibility of feedback control of grain size.

For industrial applications of electrolyzed sulfuric acid, which is obtained by using of BDD electrodes, is mainly applied to surface treatments such as plating on plastic and anodic oxide coating. For industrial use, it is necessary to control the concentration of oxidizers in ESA. Also, the possibility of measuring the concentration of oxidizers in electrolytic sulfuric acid using Raman spectroscopy will be introduced.

Keywords : Boron doped diamond, CVD, Raman, electrolyzed sulfuric acid

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Abstract No. : **PO-S06-0137**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of fine precipitates on the electrical conductivity and mechanical properties of aluminum alloy with magnesium addition

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Aluminum alloys, featuring Si as a primary alloying element, stand out as crucial commercial casting alloys. These hypoeutectic cast alloys boast exceptional castability, weldability, pressure resistance, and corrosion resistance, making them prevalent in aircraft structures, automotive manufacturing, and various engineering applications.

It is well known that the addition of Mg influences the stacking-fault energy and thus the strength, the recovery and the recrystallization characteristics of aluminum. An increase of magnesium, within the alloy range, results in increased strength at the expense of ductility. Magnesium also has a beneficial effect on corrosion resistance. By including additional elements, it is possible to improve the mechanical properties of Al–Si–Mg alloys.

In this study, the effects of Mg additions on the microstructure and tensile properties of aluminum alloys were investigated. The aluminum alloy melt was held at 750°C and then poured into a mold at 200°C. The aluminum alloys were hot-extruded into a plate with a thickness of 4mm. The microstructures of the alloys were examined using a field emission scanning electron microscopy (FE-SEM) and electron backscatter diffraction (EBSD) system. The phase composition of the alloys was examined using a scanning electron microscope equipped with an energy-dispersive X-ray spectrometer (EDS). The electric conductivities of the alloys were measured using the eddy current method at room temperature. The mechanical properties of the as-extruded Al alloy specimens were measured by universal testing machine with ASTM E8M standard. Tensile tests were carried out at an initial strain rate of 1.0×10^{-3} s^{-1}.

Keywords : Aluminum, Magnesium, Extrusion, Electrical conductivity, Mechanical properties

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Abstract No. : **PO-S14-0136**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Innovative Approaches to PEM Water Electrolysis: Harnessing Surface-Engineered 1T′-Phase WS2 Nanosheets and Stabilized Ti3C2 MXene for Enhanced Efficiency and Economic Feasibility

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Electrochemical hydrogen evolution reactions (HER) are the most attractive for overall water splitting, and the use of Pt-based catalysts (PGMs) has traditionally driven this process. However, alternative low-cost, active, and stable non-PGM catalysts are highly desirable for replacing PGMs. In recent years, transition metal chalcogenides (TMDs) such as MoS_2 and WS_2 have received much attention as potential HER catalysts. These materials have demonstrated low hydrogen adsorption free energy (ΔG^*) and low overpotential, making them promising alternatives to PGMs. In this study, we have modified 1T′-WS2@C-Ti3C2 MXene with a stable form of C-Ti3C2 MXene was cationically modified to improve adhesion to the WS2 layer on carbon paper (CP) surface. The material exhibited a high number of electrochemically active sites, excellent structural stability, and superior electrocatalytic activity, making it a promising candidate for hydrogen evolution reaction (HER) catalysts. In the practical cell setup employed with a low catalyst loading of 0.25 mg cm^{-2} and a Nafion117 membrane, which generated a small voltage of 1.85 V at a current density of 630 mA cm^{-2}. Furthermore, the modified catalyst exhibited a mass activity that was 30 times higher than ionomer-containing 1T′-WS2@C-Ti_3C_2 MXene electrode, highlighting the importance of optimizing both the catalyst and the electrode fabrication process to improve the intrinsic catalytic activity, electrode conductivity, and stability for practical PEM water electrolysis. The findings suggest a promising direction for future research in this field.

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Keywords : Hydrogen evolution reaction, 1T′-WS2@C-Ti3C2MXene catalysts, DFT analysis, PEMWE, PEMWE stack system

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Abstract No. : **IN-S11-0135**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Invited**

Enhanced Performance of a Thermoelectric Generator by Cantilever Vibration and Piezoelectricity

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Hybrid energy harvesters, combinations of energy harvesters with different harvesting mechanisms, have been proposed to overcome limitations of single method energy harvester. Although the total power is reported to be larger than that of individual power output, most of works reported that the total power output is lower than the summation of individual energy harvesters. Moreover, to the best of our knowledge, no research has been reported that each harvesting method assists the other harvesting efficiency. Here, we present an effective hybrid energy harvester that combines piezoelectricity and thermoelectricity, resulting in a larger final power generation. The piezoelectric cantilever beam was adopted to leverage oscillation-induced cooling effect for the heat dissipation effect, a crucial factor for the thermoelectric power generation. The study also investigates heat dissipation effects with respect to cantilever designs, showing that the trapezoidal cantilever design exhibits the highest displacement and heat dissipation. Furthermore, finite-element analysis is conducted to validate the experimental findings, which are consistent with the measured heat dissipation trends. As a result, the hybrid energy harvesting method achieves a power output of 7.619 mW in the presence of 0.5g vibrational source, more than 50 % increase compared to a static condition. This improved performance demonstrates that one harvesting method can be supportive to the other so that the devised hybrid energy harvester is promising for diverse applications where thermal and vibrational energy sources exist.

Keywords : Energy Harvester, Thermoeletric, Piezoelectric, Cooling

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Abstract No. : **PO-S15-0134**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Synthesis and thermoelectric properties of high-entropy-type CoSb3 skutterudite

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$CoSb_3$-based skutterudites are among the most promising candidates for thermoelectric devices at intermediate temperatures due to their high carrier mobility, electrical conductivity, and relatively large Seebeck coefficient. Comparatively, having the high room temperature thermal conductivity ($10^{-15} Wm^{-1} K^{-1}$) of binary skutterudites results in a low ZT value which restricts its use in practical applications. The decrement in the lattice thermal conductivity (k_L) is an effective approach to improve the performance of thermoelectric materials for practical applications. In this regard, the high-entropy-alloy (HEA) is one of the best strategies to enhance the required phonons scattering by lattice disorder because of its high configurational entropy of mixing (S_{mix}). HEAs are developed with five or more principal elements in equimolar or near equimolar ratio, producing a random solid solution with a simple crystal structure like BCC or FCC. The resulting new crystal structure shows significant disturbances, strain, and severe lattice distortion which induces the necessary phonons scattering into the lattice. Thus, it is expected that the HEAs possess low k_L resulting from severe lattice distortion. To avail this strategy, we have synthesized HE-type $CoSb_3$ skutterudite compounds and found a large reduction in k_L value in HE-type compounds. Also, we have successfully synthesized the Indium filled HE-type skutterudites to take the rattling motion of indium into account for further decrease in k_L value. We will discuss the preparation and effect of HEA on the thermoelectric properties of $CoSb_3$ skutterudite in detail. Additionally, the effect of indium filling on the thermoelectric properties of the HE-type $CoSb_3$ compound will be discussed.

Keywords : thermoelectric, skutterudite, high-entropy-alloy, phonon scattering, lattice thermal conductivity

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Abstract No. : **OR-S02-0133**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Oral**

Integration of multiple blue InGaN/GaN microrod-LED alignment using dielectrophoresis with flexible substrate

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Here, we report a novel LED platform featuring horizontally aligned blue InGaN/GaN microrod-LEDs on a flexible substrate using the dielectrophoresis technique. The fabrication process involves manufacturing the microrod-LEDs with p-ohmic metal via top-down plasma dry etching. Following fabrication, the microrod-LED arrays are detached from the substrate and dispersed in acetone. Subsequently, a colloidal solution was drop-casted onto the interdigitated electrode pattern on the flexible substrate, with polarized microrod-LEDs aligned between the interdigitated electrode patterns through the application of high-frequency sinusoidal AC bias, where change in the electric field gradient was most severe. Optical microscopy image confirmed an alignment efficiency of approximately 82.9%. Following alignment, the flexible LED platform was encapsulated with a UV-curing agent and transferred to a carrier substrate. low-surface-energy polytetrafluoroethylene layer was introduced beneath the flexible polyimide substrate, enabling the physical peel-off of the flexible substrate from the rigid substrate. The transferred flexible LED platform exhibited consistent current-voltage (I-V) and electroluminescence (EL) characteristics, even under bending conditions with a radius as small as 4.5 mm. Furthermore, stable I-V and EL characteristics were maintained throughout a subsequent 1000-cycle bending test. We believe that this approach readily drives DEP technology from yielding the rigid, brittle electronics into manufacturing the next-generation flexible, wearable electronics.

Keywords : GaN LED, dielectrophoresis, alignment

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Abstract No. : **OR-S07-0132**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

Flexoelectricity for triboelectrification

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Keywords : Triboelectricity; Energy Harvesting; Flexoelectricity; DFT

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Abstract No. : **OR-S11-0131**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Evaluating the Synergy of Cobalt Doping and Fe/Ni Ratio Variation on the Thermoelectric and Magnetic Properties of $ZrFe_{0.5}Ni_{0.5}Sb$ Double Half-Heusler Materials

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A promising strategy to overcome the challenges of commercializing conventional thermoelectric (TE) materials is to improve the figure of merit (zT) of new TE materials and explore their potential for various niche applications. This research focuses on assessing the effectiveness of cobalt (Co) doping in enhancing the performance of $ZrFe_{0.4}Ni_{0.6}Sb$, which was recently optimized through variations in the Fe/Ni ratio, and investigating the resulting magnetic behavior. The synthesized $ZrFe_{0.4-y}Co_yNi_{0.6}Sb$ samples show phase separation and form coherent biphasic DhH and ZrNiSb phases. This leads to a significant improvement in electrical conductivity through simultaneous carrier donation and modulation doping effects, with the y=0.4 sample showing an increase to ~3886 S/cm compared to ~400 S/cm in the Co-free sample at room temperature. In addition, the thermal conductivity of the y = 0.1 sample decreases by ~18% compared to the y = 0 sample, which is due to increased phonon scattering. This decrease in thermal conductivity leads to an increase in peak zT from 0.33 to 0.37 at 973 K. However, higher Co doping concentrations have a negative effect on the Seebeck coefficient and significantly increase the electronic and lattice thermal conductivities, resulting in lower zTs for samples with $y \geq 0.1$. Analysis of $(ZrFe_{0.4}Ni_{0.6}NiSb)_{1-z} + (ZrNiSb)_z$ samples confirms that the ZrNiSb phases are responsible for the poor TE performance in samples with $y \geq 0.1$. Further investigation, utilizing the recently restructured single parabolic model, reveals that the $ZrFe_{0.4}Ni_{0.6}NiSb$ system was already overdoped before Co doping, which explains the decrease in power factor. Lastly, the measured magnetic properties reveal the ferromagnetic nature and tunable magnetism of the synthesized samples, potentially broadening their applications in spintronics.

Keywords : phonon scattering, magnetic semiconductors, modulation doping effect, phase separation

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Abstract No. : **IN-S01-0130**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Invited**

Guided phase transition in host formation reaction for designing cathode materials of Li-ion batteries

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Attempts to explore materials that store lithium ions and electrons separately open a new branch of cathode materials and design strategy through numerous combinations of lithium compounds and transition metal compounds. Among the combination, host formation reaction transforming the transition metal compounds to reversible host for lithium ion storage with incorporation of anion from electrochemical splitting of lithium compounds enables to excavate the new polymorph of cathode materials. Here, we introduce the guided phase transition mechanism of host formation reaction inducing the phase transformation of transition metal compounds to new metastable phase analogous to original crystal structure. In LiF-FeF_2 composite model system, the crystal structure of tetragonal FeF_2 successfully guide phase transition route to reach metastable tetragonal FeF_3 contrary to the formation of thermodynamically stable rhombohedral FeF_3. Resemblance of crystal structure between tetragonal FeF_2 and FeF_3 alleviates compositional inhomogeneity even in intercalation and conversion reaction resulting low voltage hysteresis and high reversibility. We believe that guiding the reaction pathway to minimize the change in crystal structure in intercalation and conversion reaction is essence to evade irreversible reaction pathway for conversion cathode materials.

Keywords : Host formation reaction, Metastable cathode, Iron fluoride, Conversion

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Abstract No. : **KN-S02-0129**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Keynote**

InGaN-based RGB Micro-LEDs and Future

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Micro-LED displays are energy-saving and fitting for AR and VR applications. InGaN-based RGB micro-LEDs for the pixel of the micro-LED displays will be the breakthrough of cost-competitive micro-LED displays.

InGaN-based blue and green LEDs are bright and very efficient. On the other hand, InGaN-based red LEDs are difficult compared to those LEDs. Therefore, the development of high-quality and high-In-content InGaN is a highly attractive topic for future displays. The difficulty of red emission in InGaN originates from the low-temperature growth of InGaN and strong strain in InGaN/GaN QW structures.

Our original MOVPE and strain-compensation technology are countermeasures for those issues, resulting in highly efficient InGaN-based red LEDs. The typical values of red LEDs are the peak wavelength 630 nm, FWHM 50 nm, EQE 6%, and WPE 3% at 20 mA (<3 V). Since InGaN red LEDs have large conduction offsets in the quantum wells, the characteristic temperature was as high as 400 K at the temperature range of 300-370 K. Also, red 5x5 um2 micro-LEDs have achieved the highest output power density of ca. 1000 mW/cm2 with a peak wavelength of 630 nm at around 100 A/cm2. This result implies the possibility of red and yellow VCSELs based on InGaN.

Recently, we have demonstrated InGaN-based integrated RGB micro-LEDs. Red, green, and blue LEDs are connected with GaN tunnel junctions. The RGB devices have covered 71% of Rec. 2020. The paper will present the recent progress of InGaN LED technologies including the above topics.

Keywords : InGaN, Micro-LED, Red LED, MOVPE, Micro-LED display

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Abstract No. : **PO-S17-0128**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Study of spin transport in Pt/YIG bilayer fabricated by metal-organic decomposition

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Spin transport in heterojunctions of magnetic insulators and heavy metals has drawn much attention due to its potential application in spintronics devices. In this research, we synthesized high-quality yttrium iron garnet (Y3Fe5O12, YIG) films on (111)-oriented gadolinium gallium iron garnet (Gd3Ga5O12, GGG) substrates using the metal-organic decomposition (MOD) approach. The crystallinity, surface morphology, and magnetic properties of the YIG films were characterized as a function of thickness variation. Our analysis revealed smooth surfaces with root-mean-square (RMS) roughness below 0.6 nm. Epitaxial growth was maintained up to a thickness of 116 nm, beyond which it began to degrade. The magnetic anisotropy exhibited an in-plane easy axis with low coercivity (4.8 ± 0.4 Oe). Spin Seebeck effect voltage measurements indicated the highest signal for a 366 nm thick film, diminishing with increasing thickness. Spin transport across the YIG/Pt interface was investigated via spin Hall magnetoresistance, from which the spin-mixing conductance (G_r) was determined to be 5.49± 1.66 ×1014 Ω-1m-1, consistent with literature values.

Keywords : Metal-organic decomposition; spin Seebeck effect; spin Hall magnetoresistance, yttrium iron garnet.

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Abstract No. : **OR-S14-0127**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

FeOOH-Inhanced CoMnP Nanowires for Efficient Water oxidationFeOOH-Inhanced CoMnP Nanowires for Efficient Water oxidation

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Oxidation evolution reaction (OER) has high active energy barrier due to complex proton-electron transfer process. Therefore, it's crucial to facilitate charge transfer and passivate active sites for solving the slow kinetic problem of OER. In this paper, cobalt nickel layered double hydroxide nanowires (CoMn-LDH) were prepared by hydrothermal method, then phosphatized (CoMnP) by heating under sodium dihydrogen phosphate atmosphere, and then Iron (III) oxide-hydroxide (FeOOH) coating were grafted onto CoMnP surface (labelled as FeOOH/CoMnP) by convenient and rapid chemical bath deposition at room temperature, which was used as OER electrocatalyst. The prepared graded FeOOH/CoMnP not only provided abundant exposure active site, but also generated sufficient oxygen vacancies. At the same time, FeOOH interface engineering has produced strong electronic interaction, which promotes Electron transfer and improves corrosion resistance. Therefore, the FeOOH/CoMnP catalyst achieved excellent OER performance with an ultralow overpotential of 256 mV at 20 mA cm^{-2} along with a Tafel slope of 65.21 mV dec^{-1} and remains stable during the durability test for 40 h. This work provides a method to increase the intrinsic OER activity of FeOOH/CoMnP-based catalysts derived from LDH. This work provides a typical example to improve the photocatalytic H_2 production performance by fabricating heterostructure using bimetallic phosphide to modify FeOOH.

Keywords : Oxidation evolution reaction; Cobalt manganese layered double hydroxides; iron oxy-hydroxide;

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Abstract No. : **IN-S12-0126**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Advancing the Oxidation of Aromatic and Plastic Contaminants with Direct Hole-Mediated Pathways in Photocatalytic and Photoelectrochemical Systems

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The increasing severity of environmental pollution, driven by the persistence of organic pollutants and the accumulation of plastic waste, underscores the critical demand for the formulation of effective and sustainable remediation methodologies. This presentation explores the progress in photocatalytic and photoelectrochemical technologies aimed at the oxidation of aromatic compounds and polymeric substances, highlighting essential studies that reveal the mechanisms and effectiveness of these innovative approaches. It will delve into the methodologies for the selective participation of photo-generated holes in the oxidation of target pollutants. The precise manipulation of reactive species plays a pivotal role in the efficient breakdown of organic contaminants, and a deeper insight into the characteristics of these pollutants, as well as their reactions with specific radical species, is vital for the creation of highly active materials tailored for environmental engineering applications. This cohesive strategy not only addresses the pressing issues of water pollution and waste management but also lays the groundwork for the advent of sustainable technologies capable of converting pollutants into valuable resources. The outcomes emphasize the significance of employing hole-mediated oxidation processes within a comprehensive framework to confront a variety of environmental challenges, thus establishing a novel standard for the efficiency and utility of photocatalytic and photoelectrochemical systems in the field of environmental remediation and resource recovery.

Keywords : photocatalysis, photoelectrochemical cell, photo-generated hole, advanced oxidation process

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Abstract No. : **PO-S06-0125**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Influence of Al content changes on mechanical properties and microstructure of ultralight Mg-Li alloy

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Magnesium is one of the lightest metals, weighing only 64% of aluminum and 22% of steel, with excellent specific strength and modulus of elasticity. Additionally, magnesium possesses outstanding vibration damping capabilities and electromagnetic shielding properties, making it widely used in various industries such as aerospace, automotive, medical devices, and electronics.

But pure Mg and most Mg alloys are hexagonal close-packed(hcp) crystal structure and commonly slip through basal plane component {0001}<11-20>or twin through pyramidal plane component {10-12}<10-11> due to the high axial ratio (c/a), which results in a poor plastic deformation ability at room temperature. The critical resolved shear stress (CRSS) for the basal plane of magnesium is approximately 0.5 MPa, whereas for non-basal planes, it is around 40 MPa. Adding Li to Mg alloys can reduce the axial ratio of Mg and the CRSS, which can activate additional slip systems and enhance the ductility. Depending on the Li content, Mg alloys exhibit different crystal structures. When the Li content is below 5.7 wt.%, all Li atoms are dissolved in the Mg matrix, forming a single-phase structure of α-Mg (HCP). When the Li content ranges from 5.7 to 10.3 wt.%, a dual-phase structure of α-Mg (HCP) + β-Li (BCC) is observed. Finally, when the Li content exceeds 10.7 wt.%, Mg atoms are dissolved in the Li matrix, resulting in a single-phase structure of β-Li (BCC). Mg-Li alloys with a single-phase structure of β-Li (BCC) exhibit excellent room-temperature formability but suffer from a significant reduction in strength. To address this issue, research is needed to enhance the strength of Mg-Li alloys by adding alloying elements. The addition of Al is expected to improve the strength and stiffness of magnesium-lithium alloys, thereby improving their overall characteristics.

Therefore, in this study, we investigated the microstructure and mechanical properties of Mg-8Li-0.5Zn alloys containing 4, 6, and 8wt.% aluminum. Each alloy was fabricated by gravity casting in an SF_6+CO_2 gas atmosphere using an electric furnace. Subsequently, plate-shaped extrudates with a 12mm thickness were produced through direct extrusion at an extrusion ratio of 7.4:1. We analyzed the changes in XRD, microstructure, and mechanical properties of Mg-8Li-0.5Zn alloys as a function of aluminum content.

Keywords : Magnesium, Lithium, Aluminum, Mechanical properties, Microstructure

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Abstract No. : **OR-S11-0124**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

High-Performing and Capacitive-Matched Triboelectric Implantable Devices Driven by Ultrasound

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The development of implantable bioelectronics, designed for semi-permanent application, necessitates the use of biocompatible energy sources and protective materials to safeguard the devices. Until now, efforts in research have tended towards paths where these crucial elements could not be integrated simultaneously. Here we discusses the development of a triboelectric implant powered by ultrasound at a safe intensity of less than 500 mW cm^2, which enables a battery-less, miniaturized, and wireless neurostimulator fully encased in titanium (Ti). The implant utilizes a high dielectric composite with extremely low output impedance, allowing for the efficient transmission of power to generate stimulation pulses without the need for a battery, even with the presence of ultrasound attenuation caused by the Ti packaging. This approach has achieved the highest energy transmission efficiency reported to date. In vivo experiments on rats have proven the effectiveness of this device system in alleviating urinary symptoms, marking a considerable advancement towards the goal of developing devices that can be permanently implanted to regulate human organs and address a variety of diseases.

Keywords : Implantable devices, neurostimulation, overactive bladder, triboelectricimplants, ultrasound energy harvesting

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Abstract No. : **OR-S12-0123**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Oral**

Electrochemical Ammonia Oxidation via Nickel-Single Atom Catalysts on Titanium Dioxide

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Recently, there has been significant interest in environmentally sustainable ammonia (NH_3) decomposition to mitigate water eutrophication in wastewater and enable the clean storage of H_2. Within various processes, electrochemical ammonia oxidation reactions (AOR) have garnered considerable attention, requiring catalysts that are active, stable, and cost-effective. In this context, Titanium dioxide (TiO_2) exhibits the broadest stable range of pH values and applied potentials, rendering it an excellent candidate for use as a stable electrochemical catalyst. Furthermore, TiO_2 is a non-toxic, readily available, and cost-effective material. But TiO_2 alone necessitates a high overpotential for electrooxidation reactions. Conversely, observations indicate that a transition metal nickel-based anode catalyst holds promise as an inexpensive material for AOR performance. Therefore, in this study we have synthesized Ni single atom catalyst on TiO_2 and employed for AOR. By strategically depositing nickel atoms in a monoatomic arrangement, their interaction with the TiO_2 substrate is intensified, leading to enhanced stability of the catalyst and increased activity for ammonia oxidation. Moreover, the mechanisms involved in ammonia oxidation with this innovative catalyst were thoroughly examined using *in situ* Attenuated Total Reflection Surface-Enhanced Infrared Absorption Spectroscopy (ATR-SEIRAS). The insights garnered from this research elucidate the pivotal role of non-precious metal SACs in ammonia oxidation, potentially paving the way for the development of cost-effective and efficient electrochemical processes for nitrogen cycle manipulation.

Keywords : Ammonia Oxidation Reaction, Non-noble metal, ATR-SEIRAS

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Abstract No. : **OR-S03-0122**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Oral**

Fabrication of Layer Engineered MXene based Resistance Pressure Sensors for Healthcare Monitoring

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Flexible pressure sensors are attracting attention due to their wide range of applications, such as electronic skin, speech recognition, and healthcare monitoring. To fabricate piezoresistive sensors with desired features, choosing suitable materials with optimal structures is essential. As widely studied 2D nanomaterials, the electrically conductive and hydrophilic MXene sheets also promising candidates for the fabrication of high-performance pressure sensors. In this study, we introduce layer-engineered delaminated Ti-MXene (DL-$Ti_3C_2T_x$), which has relatively wider interlayer spacing through intercalated large organic molecules and accordion-like open internal microstructure than the narrower pristine $Ti_3C_2T_x$ MXene (Ti-MXene). In addition, drop-casted DL-$Ti_3C_2T_x$ layers and flexible interdigitated electrodes are designed to face each other with an air gap between layers. Compared to 2D conductive film sensors that are relatively insensitive, the conductive layer with a 3D air gap structure is the optimal structure for achieving high sensitivity in a wide pressure range. This resistive pressure sensor induces various sensing mechanisms, especially, DL-$Ti_3C_2T_x$ exhibit a piezo-resistance effect by a reduced lattice interlayer distance and increased surface contact area under applied pressure. A two-fold increase in pressure sensitivity performance of DL-$Ti_3C_2T_x$ MXene than that of Ti-MXene, reduced graphene oxide could be attributed to the engineered wider interlayer distance among the delaminated MXene layers causing a facile interlayer atomic movements, contacts, and reversible compressibility. As a result, a rapid response time (< 500 ms) and excellent sensitivity of 242.3 kPa^{-1} even under a high-pressure range (20.8 kPa), the airgap structured DL-$Ti_3C_2T_x$ pressure sensor is suitable for detecting human vital signs and motion monitoring with real-time tracking ability.

Keywords : Wearable device, Pressure sensor, MXene, Air-gap, Piezoresistive effect

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Abstract No. : **PO-S13-0121**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Low-Temperature Synthesis of Triple-Cation Tin-Lead Perovskite Single Crystals for Narrow Bandgap Solar Cells

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Tin-lead mixed perovskite solar cells encounter durability challenges due to defective grain boundaries, structural disorder, and rapid tin oxidation within polycrystalline thin films. Developing thin perovskite single crystals holds promise for stable, high-efficiency photovoltaics by reducing defect densities and improving optoelectronic properties. However, the complexity of growing suitable tin-lead single crystals at low temperatures presents a barrier to exploring their benefits. Here, we introduce a co-solvent strategy for controlled, low-temperature growth of triple-cation mixed Sn-Pb perovskite single crystals for the first time. Our proposed co-solvent system facilitates the growth of tin-lead single crystals ranging from micrometer-thin to millimeter-thick, achieved by precise control of crystallization temperature and growth rate through minimizing the coordination strength of the solvent-precursor interaction. Subsequently, we fabricate single-crystal film-based solar cells with an inverted structure, incorporating electron transport layers and a metal electrode. The systematic studies demonstrate that the synthesized single crystals exhibit compositional homogeneity and excellent optoelectronic properties, including a lower trap density of 8.58×10^{12} cm^{-3} and a dark current of 1.32×10^{-11} A. This work underscores the importance of selecting a co-solvent to accurately regulate the growth rate of mixed Sn-Pb single crystals, thereby facilitating the production of thin single-crystal film-based devices for photovoltaic applications.

Keywords : Perovskite, Solar cell, Single crystal, Mixed Sn-Pb

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Abstract No. : **PO-S06-0120**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effect of fine precipitates on the microstructure and mechanical properties of lightweight Magnesium alloy with rare earth addition

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Magnesium alloys are attractive as structural materials for transportation systems, electrical components, and provide excellent damping with low density (1.74 g/cm^3) and high strength-to-weight ratio. However, the hexagonal close-packed (HCP) structure limits the use of Mg due to insufficient plasticity. Therefore, it is an important problem in the development of a new Mg alloy with high formability and improved production capacity. Among Mg alloys, when Li is added to the Mg alloy system, the crystal structure changes to body-centered cubic(BCC) along with HCP, resulting in more slip systems. The Mg-Li alloy exhibits a dual structure of 5-11 wt.%Li content consisting of an α-Mg(HCP) rich phase and a β-Li(BCC) rich phase. These Mg-Li alloys are very light because the density of Li is only 0.53 g/cm^3. Therefore, Mg-Li alloy has the advantages of very low specific gravity and excellent formability at room temperature, but its relatively low strength has limitations in practical engineering applications. To improve the mechanical properties, various alloying elements have been added to the Mg-Li alloy system. Zn is one of the main alloying elements added together with Mg to improve mechanical properties and corrosion resistance. In this study, Mg-10wt.%Li-1wt.%Al-1wt.%Zn alloys adding with 0.4 to 0.7 wt.% RE(rare earth) were extruded at 200 °C. The effect of RE addition on the microstructure and mechanical properties of the extruded alloy was investigated. In order to improve mechanical properties, a sample was additionally prepared through a rolling process. Differences in tensile properties depending on the RE content were investigated by metallographic observation.

Keywords : Magnesium, Lithium, Extrusion, Microstructure, Mechanical properties

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Abstract No. : **PO-S06-0119**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

Effects on Si addition on microstructure, mechanical properties and thermal conductivity of the Al-1RE based alloy

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Aluminum alloys are widely used in the fields of energy storage industries, automobiles and aircraft due to their high strength over weight ratio, high thermal conductivity and corrosion resistance. In the recent, the growing demand for weight reduction and heat dissipation capability in the current storage industries, aircraft and vehicle leads to higher mechanical and thermal loading of these Aluminum alloys. From the point of view of heat generation, the difficulty of temperature control has becoming a critical issue for the aluminum alloy-based heat-sinks. Commercial Al-Si alloys (such as ADC12, A356 etc.) have excellent castability, but their use is limited by their low thermal conductivity and corrosion resistance. Many researchers are studying the development of alloying elements to improve thermal conductivity, while minimizing the casability and formability. The rare-earth (RE) alloying elements have been commonly studied in the aluminum alloys as alloying elements. RE elements have been shown to significantly improve grain refinement, and mechanical properties. In this study, effects of Si addition on microstructure, mechanical properties and thermal conductivity of Al-1RE based alloy systems were investigated. The nominal compositions of the studied alloys were modified Al-1RE-xSi alloys ($x = 0, 0.5, 1.0, 2$ and 12 wt.%). In order to examine microstructure, a scanning electron microscope with an energy-dispersive X-ray spectrometer (EDS) and electron backscatter diffraction (EBSD) system. Phase analyses were performed using an X-ray diffractometer with Cu Kα radiation were used. Electric conductivity was measured using the eddy current method at room temperature. And thermal conductivity was calculated by using Wiedemann-Franz Law at room temperature. Tensile tests were performed using a universal material test machine at room temperature.

Keywords : Al alloy, RE, Si, Thermal conductivity, Microstructure, Mechanical prorperties

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Abstract No. : **IN-S06-0117**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Control of elemental partitioning in aluminum alloys using solidification path in laser powder bed fusion process

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Laser powder bed fusion (L-PBF) process enables the formation of non-equilibrium microstructure and metastable phases in rapid solidification (at an extremely high cooling rate of 10^5-10^7 K/s). The L-PBF-processed Al-Fe alloys exhibit significantly refined solidification microstructures, contributing to high mechanical performance. In the eutectic reaction in rapid solidification, alloy elements could be partitioned into a liquid phase rather than a primary solidified phase, resulting in the enhanced formation of the second solid phase (Al_6Fe phase in an Al-Fe system). In contrast, the alloy elements might be partitioned into the primary solidified a-Al phase (rather than the liquid phase) through a peritectic reaction in solidification. The partitioned solute elements in the a-Al matrix would play a significant role in solid-solution strengthening. These insights can open an opportunity for controlling refined microstructures of Al alloys by elemental partitioning via solidification paths of eutectic or peritectic reactions in the L-PBF process. In this concept, we have selected alloy elements exhibiting different solidification paths in Al-X binary phase diagrams. Cu and Ti elements were used as third alloy elements for the Al-Fe-X ternary system in the present study. Cu element exhibits a eutectic reaction in an Al-Cu binary system (partition coefficient, $k_{Cu}^{S/L} < 1$) and forms $(Al,Cu)_6Fe$ phase in an Al-Fe-Cu ternary system. In contrast, Ti element exhibits a peritectic reaction in an Al-Ti binary system (partition coefficient, $k_{Ti}^{S/L} > 1$) and independently forms the Al_3Ti phase (no partitioning into the Al_6Fe phase). Herein, we designed two ternary alloy compositions of Al–2.5Fe–2Cu and Al–2.5Fe–1.5Ti (mass%) available to the L-PBF process utilizing thermodynamic calculations. In this talk, the microstructure of the L-PBF processed ternary alloys will be presented and discussed in terms of Cu or Ti elemental distribution.

Keywords : Laser powder bed fusion, Aluminum alloy, Solidification path, Eutectic/peritectic reactions, Partition coefficient

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Abstract No. : **PO-S03-0116**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Temperature dependent up-conversion luminescence of strontium tungstate phosphors and its applications

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Thermally stable $SrWO_4$:[Er^{3+}]/[Yb^{3+}] upconversion phosphors were synthesized. X-ray diffraction analysis indicated a crystalline inorganic phosphor material with a tetragonal structure having a clear peak in the (112) phase, which is the main peak. The upconversion phosphor was synthesized using a precursor prepared by co-precipitation and sintered at 800 ┌C. When the phosphor was excited by a 980 nm laser with a pumping power of 200 mW, a strong green light was emitted. As the concentration of Er^{3+} ions increased, it was observed that the emission intensity decreased due to concentration quenching. The changes in the intensity of luminescence according to the pumping power are due to a two-photon process. As the temperature increased, the green emission intensity of the up-conversion phosphor increased. This was thought to be a phenomenon caused by efficient energy transfer between Yb^{3+} and Er^{3+} ions by the $SrWO_4$ host with negative thermal expansion. A composite was prepared by mixing phosphor powder and PDMS, that could be used for temperature sensing. For application as a temperature sensor, it was confirmed that when a composite was produced by mixing with PDMS and then subjected to a thermal change, as with the powder, the luminescence intensity increased as the temperature increased, so that it could be used as a material for a temperature sensor that could be identified by the naked eye.

Keywords : Temperature sensors, up-conversion, luminescence, strontium tungstate, phosphor

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Abstract No. : **PO-S03-0115**
Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Development of Polythiophene Nanostructure Film Using a Bump-shaped Electrode for Plasma Volume Expansion in Atmospheric Pressure Plasma Polymerization

Jae Young Kim*[1], Sebinn Jang[1], Eun Young Jung[1], Jung Bin Nam[1], Heung-Sik Tae[1]

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In synthesizing conjugated polymers, the atmospheric pressure (AP) plasma polymerization has several distinct advantages, such as a dry process using a small amount of monomer, an eco-friendly polymerization process that does not produce chemical waste, and a room-temperature process with low-power consumption. In the development of conductive polymer films for application as transducer layers of sensors, it is important not only to synthesize the conjugated polymer film, but also to have electrical properties in the film. In AP plasma polymerization, increasing the effective volume of the plasma medium by expanding the plasma-generating region within the plasma reactor is considered a simple method to create regular and uniform polymer films. Here, we propose a newly designed AP plasma reactor with a bump-shaped wire electrode that can expand the discharge volume. Based on the plasma vessel configuration, consisting of a wide tube and a substrate stand, triangular bumps are added to the wire electrode to intentionally induce a discharge at the tip of the bump. Since discharge ignites only at the lower part of the triangular bump, as the number of bumps increases, the discharge volume can be successfully expanded in the reactor. Although discharge imbalance due to differences in bump positions can adversely affect the uniformity of polythiophene (PTh) films, rotating the substrate using a turntable can greatly improve film uniformity. With this AP plasma reactor, PTh nanostructure films are synthesized and the morphology and chemical properties of the PTh nanostructure as well as the PTh film uniformity and electrical properties are investigated in detail.

Keywords : Atmospheric pressure plasma polymerization, Conductive polymer, Polythiophene film, Transducer layer

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Abstract No. : **IN-S03-0114**
Symposia : **Materials and Devices for Smart Sensors**
Abstract Preference : **Invited**

Reshaping Bio-Interfaces: Exploring the Potential of Mechanically Transformative Electronics

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Traditionally, electronics are designed with fixed form factors tailored to specific uses. However, the fixed mechanical properties of electronics make them highly target-specific, limiting their broad use in a more compliant manner. To address this limitation, we present a new type of device called 'transformative electronics' that can change their shape and stiffness as needed. By building electronics on a platform made of gallium, which can transition between solid and liquid states based on temperature, these devices can switch between rigid and flexible modes on demand, combining the benefits of both types of electronics. We explore how this technology could be used in wearable, implantable, and sensing devices to improve interactions between electronics and biological systems. This presentation will discuss the design principles, materials, and manufacturing methods of transformative electronics, emphasizing their potential for biological applications. This innovation opens up exciting possibilities for various biomedical uses, promising significant advancements in the field.

Keywords : Transformative electronics, Gallium, Variable stiffness, Bio-interface

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Abstract No. : **OR-S08-0113**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Oral**

Nanoscale resolution enhancement of AFM images using deep learning

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Within the context of continuously shrinking semiconductor devices, accurately capturing and improving the image resolution of these devices has become increasingly essential. For analyzing material properties at the nanoscale, atomic force microscopy (AFM) has been recognized as a practical method. However, AFM measurements are time-consuming, making it challenging to achieve high throughput. Previous reports have applied convolutional neural networks to enhance image resolution, improving the study of medical images such as CT scans and MRIs. In this study, we applied deep neural networks to enhance the resolution of patterned silicon oxide images obtained through AFM. Our results reveal that these resolution enhancement methods not only improve low-resolution images but also reduce the time required for high throughput AFM measurements. We anticipate that our approach can be extended to other patterned materials, enabling efficient data analysis.

Keywords : AFM, DNN

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Abstract No. : **PO-S13-0112**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Low-Temperature Synthesis of Triple-Cation Tin-Lead Perovskite Single Crystals for Narrow Bandgap Solar Cells

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Tin-lead mixed perovskite solar cells encounter durability challenges due to defective grain boundaries, structural disorder, and rapid tin oxidation within polycrystalline thin films. Developing thin perovskite single crystals holds promise for stable, high-efficiency photovoltaics by reducing defect densities and improving optoelectronic properties. However, the complexity of growing suitable tin-lead single crystals at low temperatures presents a barrier to exploring their benefits. Here, we introduce a co-solvent strategy for controlled, low-temperature growth of triple-cation mixed Sn-Pb perovskite single crystals for the first time. Our proposed co-solvent system facilitates the growth of tin-lead single crystals ranging from micrometer-thin to millimeter-thick, achieved by precise control of crystallization temperature and growth rate through minimizing the coordination strength of the solvent-precursor interaction. Subsequently, we fabricate single-crystal film-based solar cells with an inverted structure, incorporating electron transport layers and a metal electrode. The systematic studies demonstrate that the synthesized single crystals exhibit compositional homogeneity and excellent optoelectronic properties, including a lower trap density of 8.58×10^{12} cm^{-3} and a dark current of 1.32×10^{-11} A. This work underscores the importance of selecting a co-solvent to accurately regulate the growth rate of mixed Sn-Pb single crystals, thereby facilitating the production of thin single-crystal film-based devices for photovoltaic applications.

Keywords : Perovskite, Solar cell, Single crystal, Mixed Sn-Pb

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Abstract No. : **OR-S13-0111**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Oral**

Ge incorporated Cu-Zn-Sn precursor in CZTSSe thin film solar cells: A stacking order approach

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Kesterite-based thin-film solar cells (TFSCs) device performance has stagnated for some reasons, including recombination at grain boundaries and due to the development of defects. We have adopted a Ge doping technique to mitigate these issues, which can help with crystal formation during the selenization process and help to minimize Sn-associated defects and related defect clusters.

In this study, we have created a metallic precursor utilizing a sputtering-based engineering approach, and we have deposited Ge by thermal evaporation at different stacking orders. Furthermore, many research techniques, including XRD, EQE, XPS, etc., have been employed to investigate the impact of Ge stacking orders on the morphological, crystallographic, electrical, and optical characteristics of CZTSSe thin film and its TFSCs.

This study demonstrated that CZTSSe TFSCs exhibited a progressive performance due to the successful suppression of non-radioactive recombination through the promotion of crystallization and elimination of different defects. The best morphological characteristics were seen when Ge was deposited on the soft-annealed Cu-Zn-Sn precursor among the several Ge stacking orders. Ultimately, this leads to an improvement in power conversion efficiency (PCE) from 8.54% to 9.71% when compared to the standard device.

Keywords : CZTSSe, Kesterite, TFSCs, sputtering technique, Ge doping, thermal evaporation

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Abstract No. : **OR-S05-0110**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

2D Molybdenum Ditelluride Memristor Arrays Exhibiting Stable Switching Characteristics toward Artificial Synapses

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Neuromorphic computing applications have exhibited significant potential through the utilization of two-dimensional (2D) materials, particularly in low-power synaptic devices at the atomic scale [1-3]. Nevertheless, the stochastic forming process of 2D material-based memristors has presented challenges, leading to switching variability and suboptimal synaptic plasticity. This study introduces a novel synthesis approach aimed at mitigating these issues and achieving superior performance in memristor arrays constructed from highly polycrystalline hexagonal-phase molybdenum ditelluride (2H-$MoTe_2$). Our synthesis method entails the customization of tellurium (Te) flux within Te vapor-confined methods employing eutectic alloy to produce polycrystalline 2H-$MoTe_2$ films featuring uniformly sized nano-grains (~60 nm) and ultrahigh-density (1.37×10^{11} cm^{-2}) of grain boundaries (GBs) [4]. These GBs offer confined defective paths, resulting in stable memristive switching. Comparative analysis with single-crystalline 2H-$MoTe_2$-based memristors reveals that polycrystalline 2H-$MoTe_2$-based memristor (PMM) arrays demonstrate enhanced memristive switching uniformity, stable multi-level resistance states, high device yields (>83.7%), and minimal device-to-device variations (<13.8%). Furthermore, our PMM exhibits reproducible analog synaptic plasticity through over 2,500 repeated pulses and achieves a learning accuracy of 96.05% for MNIST handwritten digit classification. The incorporation of nanograins in PMM presents a novel approach to expedite the integration of 2D memristors into practical neuromorphic computing applications.

Keywords : 2D materials, memristor, resistive switching

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Abstract No. : **PO-S09-0109**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Improving the properties of In_2O_3 Transparent Conducting Oxides by Transition Metal Application

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Transparent conducting oxide (TCO) is a transparent material with high electrical conductivity and is currently used in various fields such as solar cells, displays, and TFT (Thin Film Transistor). TCO is a crucial layer that transmits sunlight and converts it into electricity as it moves carriers. The main used TCO is indium tin oxide (ITO), which shows excellent properties such as low sheet resistance and transmittance in the visible light range of about 80% or more. However, much research is continuing to improve its characteristics. According to recent research, a transparent conductive film with high mobility is created when In_2O_3 is doped with a transition metal instead of Sn. Thus, in the present work, Zr and W-doped In_2O_3 targets are prepared, and thin films are deposited on a soda-lime glass substrate using RF magnetron sputtering. Zr and W were added to In_2O_3 in 5 wt% and 10 wt%, respectively. Additionally, 200 nm thin films were deposited at room temperature and an RF power of 40W. X-ray diffraction (XRD) and scanning electron microscope (SEM) were performed to analyze the crystallographic and morphological properties. UV-Vis and hall measurements were performed to confirm the optical and electrical properties.

Keywords : Transparent conducting oxide, ITO, Transition metal, Sputtering

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Abstract No. : **PO-S04-0108**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Structuraly stable PEDOT:PSS/CNT Coiled Yarn Supercapacitor

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Carbon nanotube (CNT) yarns are recognized as promising candidates for one-dimensional (1D) supercapacitors with several advantages such as electrical conductivity, lightweight, and a large electrochemical specific surface area. Typically, CNT yarns can be transformed into coil-shaped yarns through continuously inserting mechanical twisting, exhibiting remarkable flexibility and stretchability.

However, their structural instability from torsional stress applied during the twisting process and intrinsic inertness due to graphitic carbon-carbon bonding limit the potential use for practical applications. To overcome this, we have reported that coiled composite CNT yarn supercapacitor which embedded the amphiphilic poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) as a guest material. This approach significantly improves the structural stability and electrochemical capacitance of the coiled composite CNT yarn supercapacitors. Remarkably, this yarn retains its coil shape without the need for tethering at each end, exhibiting only a 2.5% untwisting compared to the initially inserted twists. In terms of supercapacitor performance, it effectively stores energy through high ion affinity and the redox reactions of the pseudocapacitive effect. Furthermore, its exceptional stretchability, coupled with no degradation in electrochemical performance, makes it suitable for electrical wearable devices.

Keywords : Carbon nanotube, Supercapacitor, Yarn, Coil

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Abstract No. : **PO-S12-0107**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Intercalation of natural acidic clay with long-chain primary alkylamines for adsorptive removal of methyl orange dye from aqueous solutions

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Removal of toxic organic pollutants from wastewater is essential to realize a sustainable society. Among industrially discharged organic pollutants, synthetic dyes from dye production and dyeing processes must be thoroughly recovered for ecosystem management. To remove dyes efficiently from aqueous environments, adsorption is widely and frequently employed due to easy operation and low energy consumption. Various adsorbents such as activated carbon and zeolite have been developed. Recently, organic compounds-modified clays (i.e., organoclays) have attracted much attention as adsorbents for effective dye removal. In this study, an inexpensive natural clay (Japanese acid clay, similar to fuller's earth), mainly consisting of protonated montmorillonite, was simply modified by intercalating with long-chain primary alkylamines (decylamine, dodecylamine, tetradecylamine, hexadecylamine and octadecylamine) in water at low temperatures. The structure of the organoclays was investigated by X-ray diffraction analysis, which suggested that the alkylamine molecules formed a bilayer between the montmorillonite sheets. The basal spacing varied depending on the length of the alkylamine molecule. The properties of organoclays for the removal of methyl orange (MO) as model dye from aqueous solutions by adsorption at room temperature were also examined. The organoclays showed good adsorption properties. Among them, the dodecylamine-intercalated clay was found to be the most cost-effective adsorbent for the adsorptive removal of MO from aqueous solutions.

Keywords : Intercalation, Alkylamine, Organoclay, Methyl orange, Adsorption

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Abstract No. : **OR-S11-0106**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Fabrication and Optimization of Stretchable Piezoelectric Coils for Self-Powered Sensing

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Piezoelectric polymers, notably for their ability to flexibly convert mechanical energy into electrical energy and vice versa, are ideally suited for a variety of self-powered sensing applications. Poly(vinylidene fluoride) (PVDF) and its copolymers with tri-fluoroethylene [P(VDF-TrFE)], being semi-crystalline, stand out in the piezoelectric polymer due to their substantial piezoelectric coefficients and dielectric constants. Electrospinning emerges as an effective method for generating these fibers, where PVDF and P(VDF-TrFE) solutions undergo in situ electrical poling and mechanical stretching, resulting in nanofibers with highly aligned dipoles for enhanced piezoelectric functionality. Their nanofiber configurations are particularly advantageous for large-scale production, enabling assembly into orderly, large-scale structures like yarns and textiles. Previous research has explored these mats to fabricate flat mats or yarn-shaped devices for self-powered sensing. However, their application was limited to static locations due to structural limitations affecting flexibility. In this study, we overcome these structural barriers by fabricating helical piezoelectric devices through a twisting process. A thorough parametric study was conducted to analyze the mechanical properties, allowing us to identify the optimal conditions of piezoelectric coils. Furthermore, we improved the coil device's stretchability and resilience by chemically doping it with an elastic polymer via electrospraying. This innovation paves the way for affixing sensors on curved or stretchable surfaces, facilitating dynamic motion sensing in situations.

Keywords : Piezoelectric polymers, Electrospinning, Piezoelectric coils, Stretchability, Self-powered sensing

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Abstract No. : **IN-S05-0105**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Invited**

Spatially Controllable Growth of Quantum-Confined 2D Heterostructures

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Two-dimensional (2D) heterostructures have recently attracted interest as candidate materials for classical optoelectronics and in quantum information technology. Despite significant research, realizing deterministic, in-plane quantum confinement in synthetic 2D heterostructures at the nanoscale remains challenging. In this study, we present a breakthrough by demonstrating the spatially controlled growth of quantum-confined 2D heterostructures. These structures comprise 0D quantum dots embedded within a 2D matrix, achieved through a catalytic conversion reaction on a platinum template.[1] Furthermore, an in-depth investigation into the electrical and optical quantum properties of the resulting heterostructure was conducted. The confined 0D quantum dots within the 2D matrix, coupled with the formation of lateral heterointerfaces, result in novel electronic states in these heterostructures. [1-3] These emergent states hold significant potential for applications in tunneling transistors and quantum photonic devices. This work contributes to advancing our understanding of controlled quantum confinement in 2D heterostructures, paving the way for innovative developments in quantum technologies.

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Keywords : 2D materials, heterostructures, quantum confinement

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Abstract No. : **PO-S10-0104**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Poster**

Correlation Between Oxidative Crosslinking Pathway and Adhesiveness in Phenol-Hyaluronic Acid Conjugates

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Hyaluronic acid (HA) stands as a natural polysaccharide widely recognized for its biocompatibility across various biomedical applications, including tissue scaffolds, dermal fillers, and drug delivery systems. However, despite its significant medical utility, HA encounters challenges such as poor adhesiveness and limited in vivo stability, impeding its therapeutic effectiveness. To address these issues, a flexible modification approach for the HA backbone has been developed, involving the attachment of phenol groups onto HA. This modification enhances both adhesiveness and intermolecular cohesion, facilitating oxidative crosslinking of the polymer chain. Nonetheless, a knowledge gap remains regarding the variation in phenolic adhesion and cohesion depending on the type of oxidizing agent employed. In this study, we elucidate the relationship between phenolic adhesion and cohesion during the gelation of two distinct HA-phenol conjugates, HA-tyramine and HA-catechol, contingent upon the oxidant utilized. Various oxidizing agents, including horseradish peroxidase/hydrogen peroxide, chemical oxidants (e.g., base, sodium periodate), and metal ions, were employed for covalent/non-covalent crosslinking of HA. Our findings demonstrate that HA-catechol exhibits superior adhesion properties, while HA-tyramine demonstrates enhanced cohesion properties. Furthermore, covalent bonds exhibit superior adhesion compared to non-covalent bonds. These insights hold promise for the development of adhesive and mechanically robust biomaterials leveraging phenol chemistry.

Keywords : hyaluronic acid, phenol, adhesive hydrogels

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Abstract No. : **PO-S05-0103**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**
Abstract Preference : **Poster**

Harnessing Bifunctional Carbon Fiber for Next-Generation Flexible Triboelectric Nanogenerators: Enhanced Energy Harvesting and Human Activity Monitoring

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Traditional triboelectric nanogenerators (TENGs) rely on metal-based electrodes, which often pose limitations in flexibility and performance under humid conditions. In this study, we introduce a novel approach for developing a metal-free flexible TENG utilizing bifunctional carbon fiber paper, serving as both a conductive electrode and an effective tribo-positive friction layer. The carbon fiber paper-based TENG (CFP-TENG) demonstrates remarkable electrical performance with a peak-to-peak voltage of 109.1 V, a current of 10.8 μA, and a power density of approximately 0.093 W/m^2 at a frequency of 3 Hz. Moreover, the device successfully charges a 20 μF capacitor and powers 38 light-emitting diodes (LEDs) arranged in the form of 'DGU'. Notably, the high flexibility of the CFP-TENG enables it to endure 12,000 repeated mechanical contact-separation cycles, while maintaining performance integrity even under folding, twisting, and rolling conditions. Additionally, the inherent hydrophobic properties of carbon fibers contribute to enhanced moisture resistance, surpassing conventional copper electrodes.

Furthermore, we demonstrate the integration of the CFP-TENG into various human joints for self-powered motion sensing, enabling real-time monitoring of human activities such as finger and arm motions, as well as walking and running. This integration underscores the versatility and potential applications of metal-free TENGs in energy harvesting and self-powered biomedical sensors. Our findings highlight the significance of utilizing bifunctional carbon fibers in advancing the development of flexible TENGs, offering promising avenues for sustainable energy solutions and healthcare technologies.

Keywords : triboelectric nanogenerator, self-powered motion sensing

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Abstract No. : **PO-S12-0102**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Mechanochemically prepared magnetite nanocatalysts for Fenton degradation of methylene blue

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Heterogeneous Fenton catalysts have been attracting attention for environmental remediation. Typically, magnetite (Fe_3O_4) nanoparticles have been applied for heterogeneous Fenton and Fenton-like reactions due to their surface Fe(II) and Fe(III). However, pristine magnetite nanoparticles tend to show limited Fenton catalytic activities. We proposed a new method for synthesizing the magnetite nanoparticles via mechanochemical route. In this method, a mixture of $FeCl_3 \cdot 6H_2O$ and $(NH_2)_2CO$ was high-energy ball-milled with stainless steel balls and vessels. Subsequently, the milling vessel was sealed and the milled precursor was heated under static conditions. In addition, the effects of cobalt dopant on the particle and catalytic properties were also examined. The results suggested that the magnetite and cobalt-doped magnetite nanoparticles could be mechanochemically synthesized via iron corrosion and urea hydrolysis. Our magnetite nanocatalysts showed good catalytic properties for the decomposition removal of methylene blue.

Keywords : Heterogeneous Fenton catalysts, Mechanochemical reaction, Magnetite nanoparticles

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Abstract No. : **PO-S13-0101**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Moth-inspired Compound Eyes Substrate Using Shape Memory Polymer for Improving Efficiency of Perovskite Solar Cells.

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Perovskite solar cells, renowned for their high energy conversion efficiency, facile solution fabrication process, and cost-effective materials, are emerging as the frontrunners to potentially supplant silicon solar cells. Nonetheless, their structural characteristics necessitate light penetration through the substrate and transparent conductive oxide layer to reach the perovskite light-absorbing layer. During this process, light reflection and scattering occur, thereby diminishing the photocurrent of solar cells. In this study, we introduce a moth-eye-inspired compound structure on the front glass side utilizing shape memory polymers to augment light incidence onto the light-absorbing perovskite layer. This is achieved through both the light-trapping effects of microstructures and the anti-reflection properties of nanostructures. The moth-eye-inspired composite structures effectively mitigate structural light loss, resulting in a notable increase in photocurrent and power conversion efficiency. Furthermore, this innovative layer enhances the overall current value of a multi-junction perovskite solar cell without impeding current matching between narrow-bandgap and wide-bandgap sub-cells.

Keywords : Perovskite, Solar cell, Shape memory polymer, Anti-reflection, Tandem

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Abstract No. : **OR-S04-0100**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**

Abstract Preference : **Oral**

Foldable three-dimensional neural electrode arrays for simultaneous brain interfacing of cortical surface and intracortical multilayers

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The brain is a complex three-dimensional network composed of billions of interconnected neurons that respond to important activities such as cognitive function, memory, or even communication by transmitting neural signals. The development of neural interfaces that can precisely measure the complex activities of neurons are helping to understand for identifying unpredicted neuronal diseases and brain functions. Therefore, to understand the functionality of the brain via these diverse activities, it is essential to measure the brain activity with three-dimensional structure. The electrophysiological approach to the measuring the neural propagation is broadly classified into three methods, 1) Electrocorticography (ECoG), 2) Michigan probe, 3) Utah array. However, these traditional methods have limitation of two-dimensional measurements. Here, we introduce the foldable, flexible three-dimensional neural mapping electrode that achieved by extending the three-dimensional structure of the neural interface in way to accurately analyse complex neural signalling. The device establishes a single integrated platform with four flexible penetrating shanks and surface electrodes by combining advantages of the ECoG arrays and neural probe with Utah array shape for multisite recording. To demonstrate the performance of the device, inserting the device into the somatosensory cortex of mice and stimulating whisker of the mice. The device can measure both the local field potential (LFP) and single neuron spike in simultaneously from the surface and intracortical area of the brain. Consequently, this platform will pave the way for neuroscience studies and biomedical practices by providing unprecedented electrophysiological signals in three-dimensional form.

Keywords : Three-dimensional neural electrode array, local field potential, three-dimensional heatmapping

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Abstract No. : **OR-S11-0098**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Oral**

Control of contact electrification through molecular deformation

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Controlling triboelectricity (i.e., static electricity) is essential for ensuring the safety of electronics and promoting human health. Despite its importance, the lack of fundamental research into the mechanisms underlying contact electrification has hindered. In this study, we investigated the impact of material deformation on contact electrification, employing density functional theory and experiments. Our theoretical analysis reveals that deformation decreases the energy levels associated with the ability of materials to accept electrons, thereby intensifying tribonegative behavior of materials. In contrast, it also reduces the energy levels pertinent to electron donation, diminishing tribopositive behavior of materials. Experimental results corroborate these theoretical insights, showing that increased deformation boosts the output from tribonegative materials while diminishing that from tribopositive materials. These insights provide a fundamental basis for controlling triboelectricity and advancing the development of stagnant triboelectric materials.

Keywords : Contact electrification, molecular structure deformation, density functional theory

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Abstract No. : **OR-S05-0097**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Enhanced hole transport of abnormal grain-grown 2D single crystalline semiconductor through Fermi-level-tuned 2D semimetal electrodes

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A high-performance *p*-type two-dimensional (2D) transistor is a requirement for 2D nanoelectronics. However, the lack of a high-mobility *p*-type 2D semiconductor together with proper metallization process limits the potential use of 2D electronics. In this study, we report the realization of scalable *p*-type single-crystalline 2H-$MoTe_2$ transistor arrays with Fermi level-tuned 1T'-phase semimetal contact electrodes. By converting polycrystalline 1T' polymorph to an abnormal grain growth mode, we were able to produce not only 4-inch-scale 2H-$MoTe_2$ wafers but also spatially-controlled, single-crystalline 2H-$MoTe_2$ patterns at a low temperature (~500 °C). Moreover, on-chip *p*-type 2H-$MoTe_2$ FETs arrays with polymorphic heterostructure can be fabricated. With the Fermi level tuning of 1T'-$MoTe_2$ semimetal using a 3D metal (Au), we constructed the *p*-type polymorphic $MoTe_2$ FET arrays that offer minimal contact resistances of ~1.2 kΩ·μm, and near-zero SBHs of ~14 meV, I_{on}/I_{off} ratios exceeding ~10^5, and I_{on} of ~7.8 μA/μm, which outperformed most of the chemically synthesized *p*-type 2D semiconductors. Along with the single-crystalline characteristic of 2H-$MoTe_2$, additional metallization with 1T'-$MoTe_2$ semimetal contacts enables strong *p*-type transport of transistors with a minimal contact barrier.

Keywords : 2D materials, MoTe2, p-type transistor, hole transport, Fermi-level-tuned electrode

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Abstract Preference : **Poster**

Tunning Optical bandgap of $CoWO_4/Co_3O_4$ Composites through annealing temperature for Photodegradation of Methylene blue dye

Sagarika Sahoo[1], Reddy Prakash Maddipatla[1], Rebekah A[1], Lee Kee-Sun[*1]

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The present work focuses on temperature dependency bandgap variation in $CoWO_4/Co_3O_4$ composites leading to variable degradation efficiency of methylene blue dye. Hydrothermally obtained composite powders exhibited a mixture of amorphous and crystalline phases. Upon annealing (800, 850, and 900℃), the amorphous powders got crystallized showing two phases such as $CoWO_4$ and Co_3O_4 with different phase fractions. The bandgap of pure Co_3O_4 shows double bandgaps (1.28 and 2.09 eV) while $CoWO_4$ shows one bandgap (2.4 eV). The bandgap of the prepared powder after 800, 850, and 900℃ heat treatment, drastically changes to (0.85 ~ 4.17 eV), (1.067 ~ 4.27 eV), and (1.19~ 4.35 eV) respectively from (1.44 ~ 2.15 eV) bandgap of mixed amorphous phase. The FESEM, TEM, and HR-TEM images corroborate the surface morphology change, satellite structure, and interplanar spacing in composites. The SAED pattern showing both $CoWO_4$ and Co_3O_4 planes confirmed the interconnection between the two phases. The XPS spectra proved the presence of two oxidation states of cobalt in the composite. The FTIR spectra of all the composites show the stretching, bending, and vibrational modes of bonds present in the composites. The methylene blue degradation efficiency in 800, 850, and 900°C annealed samples is 41, 50, and 33 % in pH 7 under visible light irradiation respectively.

Keywords : Hydrothermal, Morphological variation, Photocatalysts, Dye degradation, Visible light sensitive, Phase evolution

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Keywords : Hydrothermal, Morphological variation, Photocatalysts, Dye degradation, Visible light sensitive, Phase evolution

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Abstract No. : **PO-S05-0094**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Neutron radiation shielding with a robust 2D layered MXene matrix for boron carbide fillers

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Large-scale fabrication of neutron-shielding films with flexible or complex shapes is challenging. Thus, to achieve good neutron-absorption capacity, high B_4C filler loads with sufficient workability and uniformity are needed. In this study, we show that the use of 2D titanium carbide $Ti_3C_2T_x$ (MXene) flakes can be an ideal matrix for incorporating B_4C fillers concentrations up to 60 wt.%. By optimizing the particle size and surface chemistry of the B_4C fillers, we have developed a stable and uniform MXene/B_4C hybrid colloidal dispersion. This mixture was then transformed into neutron shielding composite films through vacuum filtration, exhibiting an unprecedented neutron absorption efficiency of 39.8% against emissions from a ^{241}Am-^{9}Be source at a thickness of only 40 μm. Moreover, a novel and robust neutron-shielding coating ($Ti_3C_2T_x$/B_4C/polyvinyl alcohol hybrid paint) was developed and easily applied onto various large-scale substrates (e.g., stainless steel, glass, and nylon) using a blade-coating method. Especially, the painted hybrid films on a nylon base exhibited high shape variability and structural stability after repeated deformation over 20,000 bending cycles. This 2D $Ti_3C_2T_x$ MXene composite is particularly valuable because it can be directly integrated with various substrates, rendering it promising for use in wearable and lightweight applications.

Keywords : MXene, boron carbide, neutron shielding

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Abstract No. : **PO-S05-0093**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

In situ observation of strain-dependent electrical and photoelectrical behavior in monolayer MoS_2

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Flexible electronics and optoelectronic devices are emerging as essential components of next-generation, ubiquitous, and smart device systems. Semiconductor materials suitable for various flexible/transparent substrates have been needed as demand increases. Van der Waals (vdW) semiconducting materials, especially two-dimensional (2D) transition metal dichalcogenides (TMDCs), have received much attention due to their 2D monolayer structure, which enables super-flexibility, optical transparency, and easy integration with heterogeneous materials through vdW forces. They exhibit excellent electrical and photoelectric properties, thus creating tremendous potential for the ultra-thin, flexible, and transparent optoelectronic devices with novel and unique features. Such flexible device applications based on 2D TMDCs need to consider strain effects that profoundly affects device properties.

In this work, we demonstrated the strain-dependent electrical and photoelectrical behavior in monolayer MoS_2 through in situ strain electrical/photoresponse measurement. We observed that the contact energy barrier between the MoS_2 and metal electrode lowered and current increased when the tensile strain was applied. The strain-induced contact barrier lowering was further evaluated by the strain-induced photoresponse behaviors by illuminating laser with a wavelength of 450 nm. We demonstrated the enhancement of photocurrent generation and decrease of response time under tensile strain, which was attributed to reduced contact energy barrier and depletion width. These findings show an important pathway for developing future flexible and transparent electronics based on 2D TMDCs.

Keywords : molybdenum disulfide, monolayer, transition metal dichalcogenides, strain, photoresponse

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Abstract No. : **PO-S05-0092**
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Abstract Preference : **Poster**

In situ observation of domain dynamics-induced controllable metal-insulator transition behavior in two-dimensional single-crystalline VO_2 films

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In recent years, much effort has been focused on going beyond conventional optoelectronics by integrating various monofunctional optoelectronic devices into a single system. Multimode optoelectronic operation in a single component device is an attractive design strategy for creating novel next-generation optoelectronics, which demands unique and complex multifunction. Vanadium dioxide (VO_2) is one of the most promising multifunctional materials because it undergoes a metal-insulator transition (MIT) phenomenon, accompanied by structural phase transition from the tetragonal rutile to monoclinic phase at a temperature of 341 K. To date, it has been well-established that the MIT behaviors in VO_2 can effectively modulated by external stimuli, such as electric field, photons, and stress/strain. In particular, the manipulation of electric-field-induced MIT (E-MIT) in VO_2 has a great potential for realizing multifunctional optoelectronic devices operating at room temperature.
Herein, we demonstrated domain dynamics-induced metal-insulator transition behavior in two-dimensional (2D) crystalline VO_2 films. We observed that the 2D-VO_2 films exhibit metallic/insulating alternating aligned stripe domains under the presence of in-plane tensile strain during the heating and cooling. Based on in situ optical observation of phase evolution and electrical characterizations, we found that the strain-induced domain dynamics directly affects the hysteresis behavior in the E-MIT characteristics, being enabled to realize multifunctional optoelectronic operations with memory and switching functionalities by introducing a light pulse optically triggering MIT. These results suggest the unique domain dynamics-induced controllable hysteresis of 2D-crystalline VO_2 films can provide a novel strategy for future optoelectronics device applications.

Keywords : metal-insulator transition, vanadium dioxide, domain dynamics, in situ characterizations

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Abstract No. : **OR-S04-0091**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Oral**

Extremely durable electrical impedance tomography-based soft and ultra-thin wearable e-skin for three-dimensional tactile interface

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In the fast-developing Human-Machine Interface (HMI) sector, high-resolution wearable electronic-skin (e-skin) are essential at the front end of user interaction. However, an array structure tactile interfaces require an increased number of interconnect wires and are susceptible to mechanical deformation. Here, we introduce a thin, soft e-skin for tactile interface based on elastomeric materials, offering high mapping capabilities through the Electrical Impedance Tomography (EIT) method. We utilized the organic/inorganic hybrid through simple and cost-effective fabrication processes ensuring the interface's flexibility and stability. The active sensing area comprises a micro-patterned multi-wall carbon nanotube (MWCNT) and elastomer, forming a conductive nanocomposite that inherently enables soft sensing functionality. The soft skin-like tactile interface effectively detect pressure-induced dynamic conductivity changes, offering superior spatiotemporal resolution with fewer interconnects (pixel/interconnects > 57), presenting a significant advancement over traditional array structured tactile sensors. This EIT-based interface discerns external pressures to a submillimeter degree and vertical deformations as slight as a few hundred micrometers. Remarkably, it sustains stable mapping functions even under external damage or environmental changes, confirming its reliability for persistent wearable use. The processed and categorized data from tactile mapping is then integrated into a learning network for sophisticated applications. Effectiveness of the sensor has been proven in real-time wearable HMI contexts, such as handwriting recognition and drone control, underscoring its wide-ranging practicality and adaptability in interactive settings.

Keywords : E-skin, Electrical impedance tomography, HMI, soft tactile interface

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Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Study on the magnon valve effects in YIG/Pt/YIG trilayers

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The magnon valve has garnered considerable attention recently owing to its potential as a replacement for spin valves in logical and memory devices. In this study, we present an investigation into a magnon valve structure employing a platinum (Pt) spacer positioned between two magnetic insulator layers, specifically yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG). The magnon valve behavior of our structure was analyzed through vibration magnetometer (VSM) and spin Seebeck effect (SSE) measurements. Our findings demonstrate the ability to modulate the magnon valve ratio, a critical parameter for its practical applications, by manipulating experimental parameters such as layer thickness. Furthermore, we observe the independence of the magnon valve signal in SSE measurements to changes in electrode materials exhibiting different spin Hall angles. Through transmission electron microscopy (TEM) analysis of a representative sample, we discount the possibility of Pt diffusion into YIG, which could lead to YIG conductivity. Consequently, we attribute the observed results to tunneling effects facilitated by the thin top-YIG film insufficient to impede electron flow from the Pt spacer, influencing the electrical SSE detection.

Keywords : magnon valve, yttrium iron garnet, spin Seebeck effect, inter-diffusion

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Abstract No. : **IN-S01-0089**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

Recent Progress in Zinc-Based Aqueous Redox Flow Batteries: Hybrid design, Membrane-free, Cathode recycling

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Conventional Mn-based aqueous zinc-ion battery is highly safe energy storage system, but low operating voltage (<1.5V) and low energy density limits its broad application in large-scale energy storage system. Recently, a novel aqueous zinc-manganese dioxide redox flow battery is reported. This battery is composed of Mn^{2+} based acidic catholyte and Zn^{2+} based alkaline anolyte, respectively, exhibiting an open circuit voltage of 2.66 V. Also, a neutral electrolyte was located between two different membranes to prevent the cross contamination of acidic and alkaline electrolytes, maintaining the charge balance. However, Mn^{3+} ions suffer from the disproportionation side reaction, lowering battery performance. Thus, the low reversibility of Mn/MnO2 redox couple should be improved for broad application of Zn-Mn redox flow batteries. In addition, the formation of zinc dendrite should be suppressed when the zinc-based anolyte was used, which could deteriorate the cell performance.

In this work, we report a high voltage aqueous Zn−Mn hybrid redox flow battery with a high operating voltage of 2.75 V at the 100% state of charge. Also, we show the recycling process of lithium-ion battery's cathode by using the hybrid redox flow batteries. This work is a significant step forward by exploring the pH differential hybrid flow cell with the double-membrane, three-electrolyte configuration. Finally we introduce the membrane-free Zn-Mn redox flow battery with high stability.

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Keywords : Redox Flow Batteries, Hybrid design, Membrane-free, Cathode recycling

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Symposia : **Materials and Devices for Smart Sensors**

Abstract Preference : **Poster**

Improvement of Electrical Property of Polythiophene Nanostructure Film prepared by Atmospheric Pressure Plasma Polymerization using Ex-situ Heated Iodine Doping Technique.

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In general, conductive polymers (CPs), such as polypyrrole, polythiophene (PTh), polyacene, and polyaniline, exhibit the structural characteristics of π-conjugated polymers. CPs are widely studied and have attracted great interest for their applicability to various devices in the optoelectronic industry, such as polymer light-emitting diodes, solar cells, and gas sensors. However, the electrical conductivity of CPs is relatively low compared to that of inorganic substances. These CPs possess electrical conductivity properties when doped to form charge carriers. Thus, to synthesize CPs with excellent electrical properties, doping is performed using materials such as iodine (I_2), chlorine, hydrogen chloride, and iron trichloride. To use CPs as a transducer layer in gas sensors, it is essential to have a stable conductive baseline whose inherent resistance does not change over time in air. Accordingly, we investigated the structure and electrical properties of PTh thin films deposited by atmospheric pressure (AP) plasma polymerization according to the ex-situ heated I_2 doping technique in terms of deposition time (10, 30 min), dopant type (solid and liquid I_2), and doping temperature (room temperature, 60^oC) by using field emission-scanning electron spectroscopy (FE-SEM), Fourier transforms-infrared spectroscopy (FT-IR), and 2-point probe analyzer. The experiment results of ex-situ I_2-doped PTh films are under study and will be discussed in detail.

Keywords : Atmospheric pressure plasmas, polythiophene thin film, ex-situ iodine doping, Gas sensor application

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Abstract No. : **PO-S01-0087**
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Abstract Preference : **Poster**

Facile synthesis of Ce doped MnCoTe@N-doped porous carbon for long-lasting and flexible rechargeable zinc-air battery

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A new research trend involves exploring highly efficient and prolonged catalysts for the oxygen evolution reaction (OER) and oxygen reduction reaction (ORR). However, understanding electrochemical performance enhancement in this field remains a considerable challenge. Herein, we synthesized Bifunctional Ce doped MnCoTe@N-doped Graphene Air Electrode and are reported as efficient cathode materials for flexible Zinc-Air batteries. Hierarchical porous interlayers create more active sites owing to their unique architecture. As a result of the synergistic interaction between the Ce-doped MnCoTe@N-doped Graphene interfaces, the rate of charge transfer was facilitated, the number of active sites was increased, and the OER/ORR kinetics were positively influenced in an alkaline environment. Theoretical studies indicate that tuning the interconnect architecture of the electronic structure of the Ce-doped MnCoTe@N-doped Graphene nanocomposite significantly increases the electrical conductivity and catalytic activity. The Ce doped MnCoTe@N-doped Graphene catalyst demonstrates exceptional electrochemical capabilities for rechargeable liquid and flexible all-solid-state Zn−air batteries. Specifically, it exhibits a high open circuit voltage (OCV) 1.45 V and peak power density as well as energy density respectively.

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Keywords : Rational design, Ce-doped MnCoTe, Multifunctional catalysts. Water splitting, Rechargeable zinc-air batteries.

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Abstract No. : **OR-S02-0085**
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Abstract Preference : **Oral**

Reversible Phase Conversion between Amorphous SiO_2 and Crystalline Si at Gate Insulators in Thin-Film Transistors

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Amorphous SiO_2 is a commonly utilized material for gate insulators in conventional thin-film transistors (TFTs). However, TFTs often encounter a critical issue known as dielectric breakdown, caused by plasma-induced gate oxide damage, commonly referred to as the antenna effect. In this study, we simulate the antenna effect at the gate insulator in TFTs through in-situ high-resolution transmission electron microscopy (HR-TEM) analysis. By subjecting the gate insulator to electron-beam irradiation at a high temperature of 500°C, our in-situ TEM analysis successfully replicates the phase transition of amorphous SiO_2 to crystalline Si, a phenomenon known to contribute to dielectric breakdown in TFTs. Moreover, employing a newly developed auto-sliced focused ion beam (FIB) milling technique enables us to observe sequential live-milling images at the gate insulator in TFTs. Combining HR-TEM analysis with this innovative FIB technique, we demonstrate the reversible phase transition of amorphous SiO_2 to crystalline Si at the gate insulator in TFTs. Upon applying a negative potential bias to the gate in TFTs, the crystallization of amorphous SiO_2 to Si is confirmed in both FIB milling and HR-TEM images. Interestingly, we also observe reverse amorphization when a positive potential bias is applied at the gate in TFTs, further highlighting the reversible nature of the phase conversion process. These findings, facilitated by novel FIB and in-situ HR-TEM techniques, represent significant strides towards simulating operando electronic devices.

Keywords : Reversible phase conversion, Gate insulator, Breakdown, SiO2

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Abstract Preference : **Oral**

THz phonon engineering with van der Waals heterostructures

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Phononic engineering at gigahertz (GHz) frequencies form the foundation of microwave acoustic filters, acousto-optic modulators, and quantum transducers. Terahertz (THz) phononic engineering could lead to acoustic filters and modulators at higher bandwidth and speed, as well as quantum circuits operating at higher temperatures. It can also enable new ways to manipulate and control thermal transport, as acoustic phonons at THz frequencies are the main heat carriers in nonmetallic solids. Despite its potential, methods for engineering THz phonons have been limited due to the challenges of achieving the required material control at sub-nanometer precision and efficient phonon coupling at THz frequencies. Here, we demonstrate efficient generation, detection, and manipulation of THz phonons through precise integration of atomically thin layers in van der Waals heterostructures. We employ few-layer graphene (FLG) as an ultrabroadband phonon transducer, converting femtosecond near-infrared pulses to acoustic phonon pulses with spectral content up to 3 THz. A single layer of WSe_2 is used as a sensor, where high-fidelity readout is enabled by the exciton-phonon coupling and strong light-matter interactions at the monolayer limit. By combining these capabilities in a single heterostructure and detecting responses to incident mechanical waves, we perform THz phononic spectroscopy, similar to conventional optical spectroscopy which detects responses to incident electromagnetic waves. Using this platform, we demonstrate high-Q THz phononic cavities using hexagonal boron nitride (hBN) stacks. We further show that a single layer of WSe_2 embedded in hBN can efficiently block the transmission of THz phonons. By comparing our measurements to a nanomechanical model, we obtain the important force constants at the hBN-graphene and hBN-WSe_2 heterointerfaces. Our results could enable THz phononic metamaterials for ultrabroadband acoustic filters and modulators, and open novel routes for thermal engineering.

Keywords : Van der Waals heterostructures; ultrafast spectroscopy; THz phonons; phononic cavity

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Abstract Preference : **Poster**

Reversible adsorption and desorption of PFAS from water

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Water pollution caused by PFASs poses a growing threat to both the environment and human health due to their persistence and nonbiodegradability. Recent studies have revealed that PFAS concentrations in contaminated water reach the scale of parts per trillion (i.e., 10^-12), presenting a significant challenge for scientists in both detection and removal. Various methodologies, such as functionalized nanoparticles, bioassays, activated carbon, anion exchange resins, and molecularly imprinted polymers, have been employed to address this issue. Dynamic adsorbents have shown promise in adsorbing PFASs from water and releasing them upon an external trigger for reuse, providing a means for effective removal and retention for preconcentration. Here, we report on a poly(isopropylmethacrylamide) (P-NIPMAM)-based adsorbent capable of adsorbing and retaining PFASs at temperatures above its lower critical solution temperature (LCST), while releasing them at lower temperatures. Perfluorooctanoic acid (PFOA) and perfluorohexanoic acid (PFHxA) are utilized as representative PFASs with long and short fluoroalkyl chains, respectively. The adsorption capacity for PFOA and PFHxA is measured at approximately 37 and 18 mg g^(-1) at 75°C, respectively. Upon submersion in water at a temperature below the LCST (e.g., 23°C < LCST), the adsorbent begins to release the adsorbed compounds, resulting in desorption efficiencies of approximately 0.66 and 0.81 for PFOA and PFHxA, respectively. Finally, we have engineered a prototype PFAS sampler utilizing P-NIPMAM, demonstrating LCST-driven reversible adsorption and desorption of PFASs.

Keywords : PFAS, Adsorbent, LCST, Adsorption-Desorption

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Abstract Preference : **Oral**

Multifunctional Optoelectronic Logic Gates via Polymer-Blended Perovskite

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AI technology is advancing, driven by big data processing, leading to a growing demand for high-speed computing devices such as neuromorphic and in-memory devices. However, integrated components are causing heat generation during signal input/output processes. Consequently, optical computing, where heat is not generated during signal transmission, is being emphasized, especially for devices utilizing optoelectronic materials, offering a promising alternative to enhance data processing speed. While optoelectronic devices designed with transistor structures for channel modulation require additional signal inputs such as electric fields and heat, increasing system complexity.

In this study, we propose a solution to address heat generation and computational speed limitations by introducing multifunctional logic gates utilizing optoelectronic materials. Initially, we successfully implemented bidirectional electrical field output within a single device by alleviating rectification effects through a blending of cationic polymers. The $MAPbI_3$ photoactive layer modulated by cationic polymers exhibited various polarity outputs depending on the function of the electrode under light illumination. Leveraging this phenomenon, we achieved bidirectional electrical field output from two different materials, ITO and Au, each with distinct functions, within a single device. Furthermore, we demonstrated of logic gates like XNOR and XOR, which typically require complex circuits, by utilizing the phenomenon of reverse photocurrent occurring as light intensity increases. Consequently, we achieved the operation of eight logic gates within a single device with only light input, without the need for external electric fields or additional heat sources.

Keywords : Perovskite, Logic gate, Optical computing

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Abstract Preference : **Poster**

Highly Efficient Nitrogen-Fixing Microbial Hydrogel Device for Sustainable Solar Hydrogen Production

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Conversion of sunlight and organic carbon substrates to sustainable energy sources through microbial metabolism has great potential for the renewable energy industry. Despite recent progress in microbial photosynthesis, the development of microbial platforms that warrant efficient and scalable fuel production remains in its infancy. Efficient transfer and retrieval of gaseous reactants and products to and from microbes are particular hurdles. Here, inspired by water lily leaves floating on water, a microbial device designed to operate at the air–water interface and facilitate concomitant supply of gaseous reactants, smooth capture of gaseous products, and efficient sunlight delivery is presented. The floatable device carrying *Rhodopseudomonas parapalustris*, of which nitrogen fixation activity is first determined through this study, exhibits a hydrogen production rate of 104 mmol h^{-1} m^{-2}, which is 53 times higher than that of a conventional device placed at a depth of 2 cm in the medium. Furthermore, a scaled-up device with an area of 144 cm^2 generates hydrogen at a high rate of 1.52 L h^{-1} m^{-2}. Efficient nitrogen fixation and hydrogen generation, low fabrication cost, and mechanical durability corroborate the potential of the floatable microbial device toward practical and sustainable solar energy conversion.

Keywords : applied microbiology, biocatalysis, energy harvesting device, hydrogel bio-composite, nitrogen fixation, solar energy conversion, sustainable hydro-gen energy

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Abstract No. : **PO-S09-0079**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Improving the performance of $Cu_2ZnSn(S, Se)_4$ solar cells via cation doping (Cd^{2+}, Ge^{4+}).

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Solar energy has been highlighted as an alternative energy source that can solve the problems of fuel depletion and climate change. It is used as a renewable energy source instead of fossil fuels, making it environmentally friendly and providing an endless source of energy.

CZTSSe thin-film solar cells are currently being actively studied as an alternative to solve the price problem caused by the scarcity of In and Ga in CIGS thin-film solar cells, which are currently commercialized.

Currently, the highest efficiency achieved by CZTSSe thin film solar cells is 14.9%, lower than the CIGS world record of 23.35%.

CZTSSe thin films have poor performance compared to other materials when applied to devices due to problems such as lattice defects, conduction band offset, secondary phase formation, and narrow stable phase region, so improving the performance of CZTSSe thin films is essential.

Research for improving this has been actively carried out by improving performance through doping such as Ge and Cd. In particular, Ge^{4+} is doped into CZTSSe and replaced with Sn to reduce pinholes and bulk recombination. Additionally, replacing Zn with Cd^{2+} can facilitate grain growth and suppress the secondary phase formation.

In this study, we analyzed the performance of the device by doping Ge into CZTSSe thin film using evaporation and doping Cd using chemical bath deposition.

Ge^{4+} and Cd^{2+} doped thin film solar cells showed the highest V_{oc} of 494 mV and J_{sc} of 36.9 mA/cm^2, respectively.

Keywords : CZTSSe, Solar cells, Doping, Photovoltaic, Cation

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Abstract No. : **PO-S04-0078**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Electrical Shortage-Free, Double-Helix Buckle (DHB) Electrode-based One-body Fiber Systems for Soft Multifunctional Fibertronics

Wonkyeong Son[2], Jae Myeong Lee[1], Seon Jeong Kim[1], Changsoon Choi[*1]

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Soft and elastic fiber-based electronic devices exhibiting high electromechanical stability are highly desirable for sustainable and continuous utilization in various applications. Fiber-based one-dimensional (1D) systems with parallel, twisted, and coaxial electrode configurations have been reported to date. However, effectively assembling the cathode and anode in a single body without unwanted interconnections and realizing an intimate contact interface between the electrode and substrate remain challenging.

Here, we report an electrical shortage-free one-body fiber system with double-helix buckle (DHB) electrodes created by torsion- and strain-mismatch between carbon nanotube (CNT) ribbons and a rubber substrate. The as-used CNT ribbons serve as the strain-insensitive electrode, while the rubber mandrel-core fiber acts as the key matrix in the following three aspects: as an elastic substrate that ensures reversible structural changes during mechanical deformations; as a dielectric layer for capacitive strain sensing; and as an electrothermal expansion element for tensile contraction. Moreover, because of the mismatch-induced torque-balance structure, the helically wrapped CNT buckle electrodes can effectively absorb the applied stresses without noticeable delamination and electrical conductance loss. Consequently, the DHB fiber system can reliably provide multiple functions, viz. detection of various deformations (e.g., stretching, twisting, and pressing), electrochemical energy storage with excellent strain tolerance, and reversible electrothermal tensile actuation.

Keywords : Double-helix electrodes, carbon nanotube buckles, one-body systems, multifunctionality, soft fibertronics

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Abstract No. : **IN-S14-0077**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

Organic Photoelectrochemical Cells for Overall Solar Water Splitting

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Solar-driven water splitting to produce hydrogen and oxygen offers a promising avenue for reducing reliance on fossil fuels as hydrogen can be converted into electrical energy using a fuel cell or transformed into useful chemical feedstocks. Despite its potential, the search for cost-effective light harvesting semiconductors suitable for industrial-scale deployment remains a challenge. Organic photoelectrochemical cells (OPECs) utilizing organic semiconductors (OSs) coupled with co-catalysts have recently attracted great attention as alternative photoelectrodes for solar water splitting, considering unique features of OSs such as precisely tunable optoelectrical properties and solution-processability at low temperature. However, the conversion efficiency and stability of OPECs (both photocathode and photoanode) have remained particularly poor. Herein, we present high-performance and robust organic photoelectrochemical cells by employing a bulk heterojunction (BHJ) blend of semiconducting polymers as a photoactive layer. Our in-depth study on photoreduction and photooxidation by OPECs identifies critical parameters that determine the performance and operational stability: (i) rational selection of semiconducting polymer donor and acceptor to generate free charges efficiently and ensure chemical stability upon illumination, (ii) large surface roughness of interlayers to improve interfacial adhesion, and (iii) mitigation of charge accumulation at the interfaces. By leveraging these findings, our optimized polymer BHJ photocathode and photoanode show outstanding performance and unprecedented robustness compared to previous OPECs, demonstrating a new benchmark of OPECs for solar water splitting. Consequently, this advancement, combined with the simplicity of the polymer blending process, establishes polymer BHJs as a promising route for efficient and scalable solar-driven water splitting technology.

Keywords : Organic semiconductors, Photoelectrochemical cells, Solar water splitting

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Abstract No. : **PO-S08-0076**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Poster**

The developed HR-SSRM technique in-operando for advaced materials

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As the size of chips becomes smaller, technology for measuring the carrier concentration in devices has become important. In particular, as the amount of carrier concentration becomes smaller, it is very necessary to know how the actual doping is distributed. In this study, we aim to find out how to non-destructively analyze the carrier concentrations and resistances of advanced materials in the power semiconductor and 2D lithium-ion battery using high resolution scanning spreading resistance microscope(HR-SSRM). The developed HR-SSRM system is very powerful to quantitatively analyze the characteristics of electrical/electronic materials in-operando condition. In addition, we developed the various techniques for HR-SSRM such as the reference materials(RM), measurement process recipe, lateral resolution enhancement and measurement stability study. This technique is expected that it will accurately measure the activated carrier concentration and resistivity in a length less than the mean-free path for the carriers in the advanced materials. It will be of great help in the production of various new devices using the advanced materials.

Keywords : In-operado, HR-SSRM, Carrier concentration, Resistivity

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Abstract No. : **PO-S14-0075**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Boosting Photoelectrochemical and Photovoltaic Performance through Compositional Engineering of Kesterite via Se-Induced Synergy

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Kesterite materials are a promising candidate that is an abundant and eco-friendly material for photo devices that need high absorbance like thin film solar cells and PEC photocathode. However, these devices based on kesterite had low power conversion efficiency and solar to hydrogen efficiency, so, is essential to study for increasing carrier movement in the active layer. Its bandgap energy can be adjusted through the S/Se ratio and has a high absorption coefficient. In this work, the kesterite active layer fabricated using DC-sputtering and heat-annealing with controlling S/Se ratio improved charge carrier transfer and separation efficiency also, these thin films were applied to photo devices; thin film solar cells, and PEC photocathode. The structure was a planar type Mo/kesterite/CdS/(TiO_2/Pt or i-ZnO/AZO/Al), and the kesterite active layers were CZTSe, CZTSSe, and CZTS, respectively. As a result, the CZTSSe photocathode had a higher photocurrent and HC-STH of ~ 33.82 mA/cm^2, and 2.95%, respectively. Additionally, the charge carrier transfer and separation efficiency inside the CZTSSe active layer achieved 86.33%, and 79.17%, respectively. When it was applied to thin film solar cells, the power conversion efficiency was the highest value of 9.48%, and also, FF and Rs that were affected by absorber layer quality were 61.6%, and 2.55 $\Omega \cdot cm^2$, respectively. Hence, the CZTSSe photocathode had the highest photocurrent and HC-STH and was the best performance-based inorganic photocathode using a DC-sputtering system.

Keywords : Kesterite, PEC, photocathode, hydrogen, DC-sputtering

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Abstract No. : **PO-S09-0074**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Comparison of the characteristics of MGZO and AZO thin films according to deposition temperature

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ZnO-based materials are emerging as attractive candidates for transparent electrodes in various optoelectronic devices due to their low cost and stability. However, the poor optical and electrical properties of pure ZnO present challenges that must be overcome. In this study, we aimed to enhance the performance of ZnO through co-doping with Mg and Ga. For comparison, Aluminum-doped ZnO, the most commonly used, was also prepared. All thin films were deposited using RF sputtering at detailed deposition temperatures ranging from 280°C to 350°C, after which they were subjected to comparative analysis. Subsequently, by actually applying each of the thin films to CZTSSe solar cells, It was confirmed that solar cells fabricated with MGZO effectively reduced recombination at lower processing temperatures and exhibited higher photovoltaic conversion efficiencies compared to those fabricated with AZO.

Keywords : MGZO, AZO, TCO, Solar cell, CZTSSe

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Abstract No. : **OR-S11-0073**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**
Abstract Preference : **Oral**

Triboelectric charges induced self-powered microbial blocking textiles

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Conventional methods for protecting air-transmitted pathogens, such as face masks, often cause discomfort due to pressure drops and prolonged wear. Other methods, like textile antimicrobials that incorporate nanomaterial-modified functional fabrics, offer an alternative approach for effective microbial prevention, but this approach suffers from limited treatment throughput, high cost, and potential toxicity from nanomaterial release. Here, our study proposes a new microbial blocking textiles that efficiently block both bacteria and viruses in the air. The textiles are composed of a two-layer with rib-knitted structure to maximize triboelectrification. Thes textiles can produce triboelectric charges in situ by harvesting human motion, which effectively blocks microbes through electrostatic repulsion. The self-powered triboelectrification-induced microbial blocking textile (TE-MBT) was developed to address the limitations of conventional air-transmitted pathogen protection methods, such as face masks and filters, which have insufficient treatment throughput and cause obvious pressure drops. Our study presents a proof-of-concept for a highly efficient and self-powered microbial blocking method with low pressure drop. This method could be applied to personal protection applications, addressing the urgent need for protection against air-transmitted pathogens.

Keywords : triboelectrification, energy harvesting, human motion, electrostatic repulsion, antimicrobial textile

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Abstract No. : **IN-S15-0071**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Invited**

Fabrication of Microvillus-like Structured Oxide Films by Glancing-angle Deposition in Reactive Plasma Processes

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The glancing-angle deposition (GLAD) method established in vacuum evaporation processes can be utilized in fabrication of microvillus-like nanostructured thin films based on a geometric self-shadowing effect. We have found that high crystallinity and strong preferred orientation of the films are the key conditions for application of GLAD to reactive plasma processes which shorten the mean-free path length of the material atoms leading to dissipation of the self-shadowing effect. The films of titanium dioxide in an anatase phase, tin dioxide in a rutile phase, and copper(I) oxide in a cubic system with the microvillus-like structures were successfully fabricated by using a conventional sputtering system at the substrate angle of 85 degree with respect to the target normal. These nanostructured films have huge surface areas comparing to the dense films with smooth surfaces, and can be utilized in photocatalytic, gas-sensing, and electrochromic applications, respectively.

Keywords : glancing-angle deposition, reactive sputtering, preferred orientation

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Abstract No. : **PO-S11-0070**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Ultrasound-driven triboelectric nanogenerator tailored for transient electronics power supply.

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In clinical environments, on-demand transient electronics have promising applications. Their distinctive capability to disintegrate by specific triggers or within predefined time frames could innovate medical environment. One of the advantages of transient electronics lies in their potential to mitigate risks of infection whileoffering economic benefits. By simplifying the removal procedure of treatment devices after patient recovery, transient electronics can reduce the burden of both healthcare systems and patients.

However, despite the advantages they offer, the widespread adoption of transient electronics faces a significant hurdle. Their reliance on non-transient power sources. Addressing this challenge, our study presents an ultrasound-mediated transient triboelectric nanogenerators (TENGs). In this device, ultrasound assumes dual roles, governing both energy generation and degradation timing.

Through finite element method simulations, we uncover the porous structures within poly(3-hydroxybutyrate-co-3-hydroxyvalerate) facilitates the transient process under conditions of high-intensity ultrasound. Furthermore, the integration of polyethylene glycol improved triboelectric output, leading to 58.5% increase in voltage from 2.625 to 4.160 V.

Our research extends to practical ex-vivo experiment on porcine tissue. Here, we successfully demonstrate the finely tunable transient performance of our device, proving its potential for real-world implementation. In short, this research made practical application of implantable TENGs, specifically designed to respond to ultrasound triggers for transient material design.

Keywords : Energy generation, Ultrasonic degradation, Triboelectric nanogenerator, Transient electronics

Corresponding Author : **Sang-Woo Kim** (kimsw1@yonsei.ac.kr)

Abstract No. : **PO-S09-0069**
Symposia : **Semiconductor Thin Films, Materials and Devices**
Abstract Preference : **Poster**

Enhancing Crystallinity of Al_2O_3/TiO_2 through Sn Dopant Concentration Control by ALD supercycle

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In this study, the deposition of TiO_2 thin films is explored, particularly focusing on enhancing the rutile crystal phase, known for its superior dielectric properties characterized by a high dielectric constant (ε). The rutile phase dielectric constant value is approximately 127. Achieving rutile crystallinity while lower the leakage current remains a challenge, even though the rutile crystal phase of TiO_2 has a high dielectric constant. As a way to lower the leakage current, Al_2O_3 was integrated into a 1 nm thin film to mitigate the leakage current during TiO_2 deposition. However, this approach has shown to compromise the development of the rutile crystal phase in TiO_2. To address this issue, a novel solution is proposed by doping Sn, which shares the rutile crystal phase with TiO_2, aiming to bolster the rutile crystallinity in TiO_2 thin films. These findings significantly advance high-k material research, offering promising applications in DRAM Capacitors and various other thin film technologies. These findings significantly advance high-k material research, offering promising applications in DRAM Capacitors and various other thin film technologies.

This study focuses on thin film deposition using ozone as a reactant at a concentration of $100 g/m^3$ at 400°C via the Atomic Layer Deposition (ALD) process, with Sn doping introduced through a supercycle. Initial characterization involved X-ray Photoelectron Spectroscopy (XPS) analysis to confirm TiO_2 deposition and Sn doping, complemented by Grazing-Incidence X-ray Diffraction (GI-XRD) analysis to assess Rutile crystal phase formation and crystallinity variations with Sn doping concentrations. Subsequent measurements included current-voltage (I-V) analysis to evaluate leakage current and capacitance-voltage (C-V) analysis to determine dielectric constant influenced by Sn doping concentrations. This comprehensive approach provides detailed insights into both structural and electrical properties of the thin films, essential for their potential applications.

Keywords : Crystallinity, Dielectric constant, Leakage current, Atomic layer deposition

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Abstract No. : **IN-S13-0068**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Invited**

Deep level transient spectroscopy and capacitance transient of silicon heterojunction solar cells

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Deep Level Transient Spectroscopy (DLTS) and Capacitance Transient (CT) are widely used experimental techniques for characterizing the electronic properties of semiconductor materials and devices, including solar cells. This work presents a comprehensive study on the application of DLTS and CT in investigating deep-level defects in solar cells. The DLTS technique enables the identification and quantification of deep-level defects within the semiconductor bandgap, significantly impacting the performance and efficiency of solar cells. By measuring the device's transient response under certain bias conditions, DLTS provides valuable information about the energy levels, capture cross sections, and densities of these defects. This information is crucial for understanding charge carrier recombination processes and optimizing solar cell fabrication processes. The CT behavior of pn junctions can be analyzed using exponential fitting, providing direct information about the trap density, emission rate, and capture cross section of the defects. However, in modern semiconductor devices, including high-efficiency solar cells, the complicated device structure results in multiple exponential decays in its CT behavior that overlap. Therefore, an appropriate method to interpret CT results is required. In this study, DLTS and CT measurements were performed on silicon heterojunction solar cells. The obtained results shed light on the nature of defect states, leading to a better understanding of the device physics and potential avenues for performance enhancement. The findings presented in this work demonstrate the significance of DLTS and CT techniques in characterizing solar cells, providing valuable information for device optimization and the development of more efficient photovoltaic technologies.

Keywords : Silicon Heterojunction Solar Cell, Defect, Deep Level Transient Spectroscopy, Capacitance Transient

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Abstract No. : **PO-S13-0067**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**

Abstract Preference : **Poster**

Study on interfacial charge carrier transport characteristics via optoelectronic analysis

Sunkyu Kim[1], Muhammad Adnan[1], Zobia Irshad[1], Wonjong Lee[1], Siwon Yun[1], Hyeji Han[1], Jongchul Lim[*1]

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Perovskite solar cells (PSCs) have emerged as a potential candidate to produce state-of-the-art highly efficient (over 26% power conversion efficiency), and low-cost device manufacturing. However, the efficiency of these PSCs is still limited owing to their undesirable non-radiative recombination that is mainly caused by the various trap-states and energy losses because of poor charge-carrier characteristics. Mainly, the state-of-the-art PSCs suffer from either lower mobilities or higher trap-densities. Hole transporting layers(HTLs) can modifying by side chain substitution and by changing the length of main chain. So plenty of research is being done on HTL. Therefore, our work presents a comprehensive evaluation of the impact of the mobility, thickness, and doping density of the hole transporting layers(HTLs) for PSCs. Herein, we specifically investigated the impact of the HTLs thickness on the photovoltaic characteristics and charge-carrier dynamics of PSCs through optoelectronic analysis. These analyses are based on the combination of compositional and structural engineering analysis to prepare efficient HTLs of perovskite film. From these analyses, we tried to introduce the basic guidelines for the optimization of HTLs to prepare highly efficient and stable PSCs.

Keywords : Interface, Solar cell, Perovskite, Optoelectronic

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Abstract No. : **OR-S13-0066**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Oral**

Mechanism of Improved photo-stability of Perovskite Passivation via Anti-Solvent Additive Method

Wonjong Lee[1], Muhammad Adnan[1], Zobia Irshad[1], Sunkyu Kim[1], Siwon Yun[1], Hyeji Han[1], Jongchul Lim*[1]

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Over the past decade, the photovoltaic performances of perovskite solar cells (PSCs) have been improved rapidly. However, the commercialization of PSCs has been delayed due to their poor stability issues, such as moisture, heat, and ultraviolet (UV) light. In particular, the UV light causes ions to escape and produce lattice stress in the perovskite core, deteriorating the PSCs device's performance and stability. Herein, we employed an anti-solvent additive strategy by introducing different site functional group additives to passivate ions and to elucidate the mechanism of photostability. As a result, the incorporated additives efficiently passivate the perovskite ions and grain boundaries and further enhance the photovoltaic performances and photostability of PSCs. Therefore, our presented anti-solvent mixed additives approach is highly useful for preparing efficient and photo-stable PSCs and would be a step forward toward their commercialization.

Keywords : Perovskite solar cells, anti-solvent additive, ion passivation, photostability, spectroscopy

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Abstract No. : **PO-S02-0065**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Self-clocking Quantum Random Number Generator via Stochastic Polymer-Perovskite Device

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Random numbers play a crucial role in diverse fields, including lotteries, simulations, and cryptographic applications. As the Internet of Things (IoT) and edge computing continue to grow, the emphasis on robust encryption methods to safeguard personal information has become paramount. Currently, software-based algorithms predominantly employ deterministic random numbers due to their cost-effectiveness and ease of use. However, the vulnerability of these systems to powerful supercomputers necessitates exploration into more secure alternatives. The rise of artificial intelligence technologies has propelled hardware-based random number generators into the spotlight. Specifically, Quantum Random Number Generators (QRNGs) utilizing photonic sources are emerging as promising alternatives. This study present a novel approach by introducing a hybrid (anionic polymer and perovskite) photodetector-based QRNG designed to maximize randomness. Leveraging a simple circuit with JK flip-flops, this system achieves remarkable miniaturization, generating 10,000 bits per sec without succumbing to resets or time delays. NIST testing, comparing it with a commercial Si photodiode-based QRNG, meticulously validates the quality and safety of the generated random numbers, ensuring reliability across various frequency operating environments. The hybrid perovskite-based QRNG holds significant potential to contribute to the development of more secure and reliable computing and Internet of Things technologies.

Keywords : QRNG

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Abstract No. : **IN-S01-0064**
Symposia : **Emerging Materials for Rechargeable Batteries**
Abstract Preference : **Invited**

Development of Intimate Contact Technology for High Performance All-Solid-State Batteries

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The widespread adoption of electric vehicles (EVs) as alternatives to fossil fuels to facilitate a greener and more sustainable future is the most remarkable technological development of recent years. Nevertheless, the exponential increase in energy demand has given rise to significant concerns regarding the safety of batteries, which necessitates urgent consideration. While conventional lithium-ion batteries (LIBs) employ flammable liquid electrolytes, they have demonstrated susceptibility to thermal runaway incidents, which present significant safety hazards and necessitate a fundamental transformation in energy storage technologies. All-solid-state batteries (ASSBs) have emerged as a promising alternative that is able to revolutionize the energy storage industry.

One of the primary obstacles that greatly hampers the performance of ASSBs is the issue of point contact between the solid electrolytes and the active materials. This problem stems from poor interfacial adhesion and restricted intimate contact between the two components, impeding effective charge transfer and ion diffusion. The presence of non-conductive interfaces, voids, or delamination zones hinders the efficient diffusion of lithium ions, resulting in increased interfacial resistance and restricted usage of active materials within the electrodes. Furthermore, the issue of solid contact contributes to the localized stress concentration and mechanical strain that occurs during charge-discharge cycles. In this presentation, the concepts of intimate contact in both the anode and cathode will be discussed.

Keywords : All-solid-state batteries, intimate contacnt, electrochemical modeling

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Abstract No. : **PO-S12-0063**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Synthesis of Zeolite using Aluminum Black Dross for Removal of Heavy Metal ions from Aqueous Solution

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Zeolites, minerals with the formula Mx/n[AlO_2]x(SiO_2)y] zH_2O, are environmentally friendly materials used as water treatment adsorbents, gas adsorbents, and petrochemical catalysts. This study used a mixture of aluminum black dross and waste glass to synthesize zeolites via a hydrothermal synthesis and analyzed the effects of varying reaction time on phase changes under different synthesis conditions. With increased reaction times, a phase change from zeolite Na-P1 to analcime was observed; on employing hydrothermal synthesis at 150 °C for 96 h, the majority of the crystalline structures changed into analcime. Heavy metal cation adsorption was tested to assess the applicability of the synthesized analcime to water treatment. Zeolite adsorption of at least 95% was observed for both Pd and Cd ions. Although a higher level of adsorption was observed for Pb ion than Cd ion, Cd ion was demonstrated to undergo relatively faster adsorption when tested under optimal pulp density at the same level of adsorption (95%).

Keywords : Zeolite, Hydrothermal Process, Pb, Cd, Waste resource

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Abstract No. : **IN-S09-0062**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Invited**

Alkali Ion-Based Memristors for Neuromorphic Computing Applications

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Nanoscale memristive systems are emerging as an alternative platform to conventional silicon transistors for energy-efficient hardware implementation of neuromorphic computing. The memristor (ionic memristor) is referred to as the fourth circuit element, which the resistance can be changed gradually by the electric pulse signals that have been applied to it. Moreover, the stored resistance state in a memristor is non-volatile, and their large on/off ratio with analog resistive memory characteristics makes this system appealing as a circuit element for neuromorphic computing devices. Their gradual resistance change characteristics induced by ion migration depend on the magnitude, duration, and number of programming pulses, with the resulting synaptic response mimicking the synaptic function of biological neurons. However, the stochastic nature of defect-induced switching coupled with limited control over intrinsic materials defects have been identified as the primary factors undermining the reliability of memristors in scaled crossbar-array architecture.

In this talk, I will present a Na-doped TiO_2 memristor that uses high-mobility sodium cations instead of oxygen anions (oxygen vacancies) as the main agent for resistive switching. In this manner, reversible switching is achieved even under rectifying characteristics involving more than three orders of magnitude smaller current than a forward-biased memristor. We adopted TiO_2 as the matrix material since it can be controllably grown by atomic layer deposition (ALD) and acts as an effective host for Na-ion migration. Therefore, unlike conventional memristors based on oxygen anions, the high mobility of Na ions can be expected to produce memristive behavior regardless of the underlying oxygen vacancy concentration and even under a low electrical current.

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Keywords : memristors, alkali ion, neuromorphic hardware, reliability, deep neural network

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Abstract No. : **IN-S12-0061**
Symposia : **Materials for Enviromantal Science**
Abstract Preference : **Invited**

Synthesis of novel remedial materials from solid wastes and their uses for removal of contaminant in wastewater

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Massive amounts of various solid wastes have been produced worldwide from different industrial plants (e.g., coal fly ash from coal fired power plant, red mud from alumina production by Bayer process, and steel slag from steel plant). The solid wastes are usually composed of various metal oxides which can be reutilized as sources of novel material synthesis. Herein, many elements (i.e., Si, Al, Ca, and Fe) were selectively extracted from various solid wastes or used them as support material to effectively remove organic, inorganic, and radioactive pollutants in aqueous environments. All the remedial materials developed from this study showed a great performance in each treatment process which shows the potential conversion of solid wastes into much value-added materials.

Keywords : solid waste, material synthesis, wastewater treatment

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Abstract No. : **PO-S14-0060**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Sulfonated polyvinylidene fluoride and 3-amino benzene sulfonic acid interpenetrating network as proton exchange membrane for water electrolysis

BeeLyong Lang[*1], Debabrata Chanda[1], Shahbaz Ahmed[1], Mikiyas Mekete Meshesha[1], Ranjith Balu[1], VIKASH KUMAR[1]

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Inter-penetrating polymeric network (IPN) of sulfonated polyvinylidene fluoride (PVDF), nano-alumina (Al_2O_3) and 3-amino benzene sulfonic (BSA) acid, with initiator azo-bis-isobutyronitrile (AIBN) were synthesized as membranes. In this, divinyl benzene (DVB) was further used as cross-linker, to hold the polymeric chains together and prevent the re-solubilisation of membrane polar constituents. The membrane compositions were varied with 10, 20 and 30 wt% of BSA with corresponding DVB concentrations. The casted membranes were examined through a number of characterization techniques viz. FTIR spectroscopy, XRD, water uptake, swelling ratio, ion-exchange capacity (IEC), proton conductivity, SEM and tensile tests. Membrane hydrophilicities were found to be increased by incorporation of 3-amino benzene sulfonic acid that eventually aided in enhanced water uptake, IEC and proton conductivity of casted IPN membranes. Increasing BSA content aided in enhanced membrane property, where higher DVB ratio (> 1.4 wt%) resulted in constricted membrane spacing, and thus, lower performance in BSA30 membrane Finally, the membranes were applied in proton exchange membrane water electrolyzer (PEMWE) as proton exchange membrane.

Keywords : 3-amino benzene sulfonic acid, Sulfonated polyvinylidene fluoride, Proton exchange membranes, Water electrolyzers.

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Abstract No. : **IN-S14-0059**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

(Photo)electrocatalysis towards water splitting and CO_2 reduction based on inorganic materials from solution based synthesis

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Solution-based synthesis methods for inorganic materials share a common starting point: the liquid solution phase. These methods encompass various classes like sol-gel, precipitation (hydro- or solvothermal), each offering different variants based on reagents, structure directing agents, and process parameters such as temperature and pressure. This variability allows for control over material composition, structure, and morphology, influencing catalytic properties relevant to applications like water splitting and CO2 conversion.

Hydrothermal precipitation, illustrated by CuFeO2 synthesis, involves Cu(II) and Fe(II) precursors undergoing redox reactions to form Cu(I) and Fe(III), crucial for CO2 reduction. Optimizing conditions is vital to prevent undesired secondary phases. Systematic investigation of Fe/Cu ratios during synthesis aids in this optimization, offering insights into reaction mechanisms. Oxide synthesis involves anion supply either from ambient O2 during calcination or from the solvent (water) during hydrolysis. Conversely, sulfide synthesis relies on precise control of metal ion precipitation through selected sulfide sources to manage nucleation rates and particle size. Hydrothermal conditions, including temperature and pressure, impact crystallinity and morphology of the reaction products obtained. For instance, MoS2 spherical aggregates synthesized under varying conditions exhibit different electrocatalytic properties for water splitting.

For thin films, chemical solution deposition via spin coating is preferred over hydrothermal methods. Aqueous solution-gel synthesis, suitable for complex oxides like CuBi2O4 used in photoelectrochemical water splitting, yielded optimal performance at a film thickness of 135 nm, achieving high photocurrent densities.

In summary, the importance of solution based synthesis routes for water splitting and CO2 reduction via (photo)electrochemical methods will be demonstrated in this overview presentation of our group’s recent work.

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Keywords : photoelectrochemical water splitting, photoelectrochemical CO2 reduction, electrocatalytic water splitting, electrocatalytic CO2 reduction

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Abstract No. : **IN-S06-0058**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Invited**

Characterization of Oxide-Dispersion-Strengthened Ti-6Al-4V Alloy Produced via Additive Manufacturing Processes

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This research serves as a preliminary investigation to assess the viability of oxide dispersion strengthened (ODS) alloy based on Ti-6Al-4V. ODS Ti-6Al-4V powder was fabricated using the electrode induction melting gas atomization (EIGA) method. Rod-shaped Ti ingots, enriched with Y, were prepared through vacuum arc remelting (VAR) to examine the composition and content of oxides that can dissolve in molten Ti during melting and precipitate within powders during cooling in gas atomization. In this study, we attempted the in-situ synthesis of oxide nanoparticles in ODS Ti-6Al-4V alloy during the additive manufacturing (AM) process. By pre-alloying the powder and controlling the partial pressure of oxygen, we successfully prevented abnormal growth behavior of oxide nanoparticles. Following AM, a preicipitation of oxide nanoparticles were formed in-situ and uniformly distributed within the ODS Ti-6Al-4V. The average size and number density of nanoparticles were approximately 20 nm and 10^22/m^3, respectively. This AM process yielded relatively higher strength with slightly lower ductility. Notably, a well-developed dimple structure was observed, and no evidence of cleavage fracture surfaces was noted in the fracture surface of the tensile specimen. Furthermore, we provide a detailed examination and discussion of the microstructural characterization and formation mechanism of nanoparticles in this newly AMed ODS Ti-6Al-4V alloy.

Keywords : Ti-6Al-4V, Oxide-Dispersion-Strengthened, Additive Manufacturing

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Abstract No. : **IN-S01-0057**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

3D Interconnected Polymer Networks for Energy Storage Applications

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The rapid advancement of portable, lightweight, and flexible/wearable electronics has spurred significant research into solid-state deformable energy storage devices. Such devices can be realized through either modifying the geometrical structures of active components or utilizing inherently flexible/deformable polymer materials. Structural alterations, including buckling, the incorporation of rigid islands/elastic bridges, helically coiled springs, and the creation of 2D/3D porous structures, necessitate precise geometrical design and complex multistep fabrication processes. Conversely, inherently deformable active components can be achieved by blending rigid active materials into rubbery composites capable of accommodating strain, and by incorporating 1D nanomaterials with substantial aspect ratios, such as nanowires and nanofibers, to maintain electrical contact during mechanical deformation. Intrinsic deformable components offer versatility, particularly due to their compatibility with conventional layer-stacking processes, enabling cost-effective and large-scale fabrication. This presentation discusses various strategies for developing flexible and stretchable solid polymer electrolytes and electrodes incorporating 3D interconnected rubbery networks. These materials were successfully utilized in deformable supercapacitors and batteries.

Keywords : 3D Polymer networks, Solid polymer electrolytes, Deformable energy storage devices

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Abstract No. : **IN-S10-0056**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**
Abstract Preference : **Invited**

Nano biomaterials for hard tissue regeneration and multimodal tracing

Xiyu Li[*1]

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Background

Dentistry still faces numerous scientific challenges, including insufficient early bone formation and suboptimal osseointegration of implants, and susceptibility to bacterial infections. Also, the current restorative materials used in clinical dentistry lack the capability of multimodal tracing, which hinders effective tracking of the implanted material or its degradation, and bone/tooth repair processes, as well as limits comprehensive and accurate reconstruction information acquisition. In light of these limitations, we proposed a novel approach that combines the improvement of restorative properties in implant materials with the integration of multimodal tracing capabilities.

Methods

We employed rare earth ions (Yb/Ho), antibacterial ions (Zn), and paramagnetic ions (Fe) to prepare various nano hydroxyapatite (HA) crystals with multimodal tracing properties. These crystals can exhibit fluorescence, CT, and MRI tracing characteristics. Additionally, we designed and fabricated a groundbreaking titanium dental implant (magnet@Ti) with a localized static magnetic field, which promotes early osteogenesis and osseointegration with the synergistic effect of superparamagnetic HYH-Fe nanocrystals. Furthermore, we developed a composite bone scaffold containing HYH-Zn nanocrystals with pro-osteogenic, anti-infective, and traceable functions. We also used the uniform HA-Tb nanocrystals to elucidate the mechanism of interaction of HA nanocrystals in osteoblasts and new bone tissues.

Conclusions

By endowing implant materials with multimodal tracing capabilities, our approach harnesses the advantages of various imaging modalities, enabling precise tracking of in vivo material changes, evaluation of tissue reconstruction and repair, exploration of material-cell/tissue interactions, and enhanced understanding of tissue regeneration mechanisms. This achievement further facilitates micro-level regulation in the biological processes of bone regeneration.

Keywords : ion-doped hydroxyapatites; multifunctional implants; multimodal tracing

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Abstract No. : **IN-S04-0055**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Invited**

Flexible, Foldable, and Stretchable QLEDs

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Recent advances in soft electronics have attracted great attention due in large to its potential applications in personalized mobile and wearable electronic devices. The mechanical mismatch between conventional electronic/optoelectronic devices and soft human tissues/organs, however, often causes various challenges, such as the mechanical fracture in the device under deformations, and discomfort and consequent stress to users. Ultra-flexible and stretchable electronic and/or optoelectronic devices have low system modulus and intrinsic softness and solve these issues. Here, our unique strategies in the synthesis of nanoscale materials such as quantum dots and metal nanowires, their seamless patterned integration with ultrathin electronics, and unconventional device designs toward flexible, foldable, and stretchable quantum dot light emitting devices are presented. These wearable and stretchable light emitting devices can be integrated with various skin-mounted soft sensors and electronics. Such soft integrated systems are the results of recent breakthroughs in unconventional soft electronics, and will create many new opportunities toward next-generation human-friendly mobile electronics.

Keywords : Flexible device, Foldable display, Stretchable display, Quantum dot, LED

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Abstract No. : **IN-S08-0054**
Symposia : **Advanced Materials Imaging Technique**
Abstract Preference : **Invited**

Operando TEM investigation of polar domain dynamics in 2D sliding ferroelectrics

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Control of interlayer stacking angle in two-dimensional (2-D) van der Waals (vdW) heterostructure enables one to engineer the crystal symmetry to imprint novel functionality. By stacking two layers of transition metal dichalcogenides (TMD) with designed twist angle, one can break the inversion symmetry and thereby develop vertical electric polarization. The direction of the electric polarization can be switched electrically, suggesting that the twisted bilayer TMD can host ferroelectricity. Such ferroelectricity reported in twisted bilayer vdW system is distinguished from conventional ferroelectrics in that the lateral sliding of the constituent layers induces vertical electric polarizations.

Here we employ *operando* transmission electron microscopy (TEM) to investigate the domain dynamics in 2-D vdW sliding ferroelectrics. *Operando* TEM technique enables one to examine the structural change in the environment that mimics the electrical device operating condition. We find the domain dynamics in response to vertical electric fields is governed by the consecutive domain wall pinning-depinning process as noted by Barkhausen noises in the polarization hysteresis loop[1]. Moreover, exploiting stroboscopic operando TEM on the vdW ferroelectrics, we directly measured the domain wall velocity which is found to be limited by various disorders present in the specimens[1]. Aberration corrected scanning transmission electron microscopy analysis identifies the microstructural origin for the domain wall pinning, providing structural insight on how to improve the switching speed of the sliding ferroelectrics.

[1] K. Ko et al., Operando electron microscopy investigation of polar domain dynamics in twisted van der Waals homobilayers, Nat. Mater. 22, 992 (2023)

Keywords : operando TEM; 2D sliding ferroelectrics

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Abstract No. : **PO-S15-0053**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Chemical Resistance Property of Electroless Deposited Ni-Sn-P Layers Having High Sn Content

Futoshi MATSUMOTO[*1], MIka Fukunishi[1]

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Chemical resistance of electroless-deposited nickel-tin-phosphorus (Ni-Sn-P) with a high Sn content (> 30 at. %) and Ni-P layer on a cold-rolled commercial steel plate (SPCC) against a 5% aqueous solution of sodium hypochlorite (NaClO aq.), which was used as a disinfectant solution, was examined. After immersion of Ni-Sn-P and Ni-P layers at 25℃ for 72 hrs to NaClO aq., the surface of the Ni-P layer showed a clearly corroded surface. On the other hand, the Ni-Sn-P layers were not corroded, so the Ni-Sn-P layers have chemical resistance properties against NaClO aq. The importance of the Sn addition to Ni layers for NaClO chemical resistance was confirmed. In addition, the chemical resistance of the Ni-Sn-P layers against hydrogen sulfide (H_2S) gas and nitrogen acid (HNO_3) vapor was also determined.

Keywords : Chemical resistance, electroless-deposited nickel-tin-phosphorus layer, sodium hypochlorite

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Abstract No. : **OR-S15-0052**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Enhancement of Oxygen Reduction Reaction Activity of Pt by Tuning its *d*-Band Center via Transition Metal Oxide Support Interactions

Futoshi MATSUMOTO*[1], Mika Fukunishi[1], Tamaki Matsumura[1]

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The enhancement of the oxygen reduction reaction (ORR) activity of platinum nanoparticles (Pt NPs) using transition metal oxide (MO_x, M = Ti, Nb, Ta, W, Y and Zr) supports has been examined. In order to enable the use of transition metal oxides having low electric conductivity as supports, the Pt NPs were formed on thin transition metal oxides formed on conducting cup-stacked carbon nanotubes (CSCNTs). Metal oxide composites ($M_1M_2O_x$) prepared from two types of transition metal (M_1M_2: TiNb, NbTa and TaW) precursors were also used as supports. Pt NPs were photodeposited on MO_x/CSCNTs and $M_1M_2O_x$/CSCNTs supports, resulting in MO_x/CSCNTs and $M_1M_2O_x$/CSCNTs-supported Pt NPs catalysts (abbreviated as Pt/MO_x/CSCNTs and Pt/$M_1M_2O_x$/CSCNTs). Their ORR activities in 0.1 M $HClO_4$ aqueous solution were found to significantly depend on the atomic ratio of M_1 and M_2 in $M_1M_2O_x$ as well as the type of metal oxide support. A "volcano-type" dependence of the ORR activity (represented as current density, mass activity and specific activity at 0.9 V *vs.* RHE) on the Pt *d*-band center, relative to the Fermi level, was obtained in a series of the Pt/MO_x/CSCNTs and Pt/$M_1M_2O_x$/CSCNTs catalysts. It was found that the *d*-band center values (ranging from -3.83 to -3.42 eV) of the Pt deposited on MO_x/CSCNTs and $M_1M_2O_x$/CSCNTs supports were lower than that (-3.39 eV) of the reference Pt/carbon black (CB), and that the Pt/$TiNbO_x$ (Ti:Nb = 1:6.6 in atomic ratio)/CSCNTs with a *d*-band center of -3.59 eV exhibited the maximum ORR activity, in agreement with the theoretical expectation that an ORR catalyst having a *d*-band center which is *ca.* 0.2 eV lower than that of Pt would have maximal ORR activity.

Keywords : Oxygen reduction reaction (ORR), Platinum nanoparticle, d-Band center, Strong Metal-Support Interaction (SMSI)

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Abstract No. : **PO-S13-0051**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Poster**

Study on the Development of Coatings Solutions for Self-Cleaning and Selective UV-B Absorption Applied to Solar Panel Cover Glass

Youjeong Kim[1], Seungha Yoon[2], Eun Mi Kim[2], Jin Hyeok Kim[*1]

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Technologies that extend the lifespan of commercial solar panels and prevent performance degradation due to surface contamination can significantly contribute to the spread of future renewable energy. However, cleaning the cover glass to prevent efficiency reduction due to contamination on the surface of solar panels can lead to increased maintenance costs, and harmful UV wavelengths can also cause partial degradation to the solar panels, reducing their lifespan and causing functional damage to the solar cell or other components.

In this study, polysilazane with hydrophobic properties was applied to the UV coating solution for the self-cleaning effect of the solar panel cover glass surface. Additionally, a function was added that selectively absorbs UV wavelengths other than UV-C, which can directly contribute to the efficiency of solar panels, thereby maintaining performance while improving lifespan. The hydrophobicity of the prepared coating solution was verified by measuring the contact angle, and UV-Vis spectrometer was used to measure the absorption of UV-A and UV-B radiation and the transmittance in the visible light region. The specific research and development content will be discussed in this presentation.

Keywords : photovoltaic, coating solution, hydrophobic, self-cleaning, UV absorbing

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Abstract No. : **IN-S14-0050**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Invited**

Direct observation of hydrogen-sorption kinetics in metal-hydrides for solid-state hydrogen storage through in-situ transmission electron microscopy

Dong Won Chun[*1]

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Hydrogen is being widely explored as a promising alternative to fossil fuels in light of its numerous advantages, for example, its abundance on Earth, high energy density, and low environmental impact upon combustion. In particlular, solid-state hydrogen storage system is attracting significant attention due to its potential for lower working pressures and higher volumetric energy density. Nevertheless, the utilization of metal-hydrides as hydrogen storage systems faces significant challenges owing to thermodynamic and kinetic limitations, hindering their widespread adoption.

Detecting hydrogen atoms, consisting of a single electron and proton, is challenging particularly when they are incorporated into metals to form metal-hydrides. Therefore, the hydrogen-sorption processes in metal-hydrides have not been thorougly studied. The development of in-situ transmission electron microscopy (in-situ TEM) systems allows to observe materials behaviors directly under working conditions including heating, electrica biasing, and exposure to liquid or gaseous environments at the atomic scale with high temporal resolution.

In this presentation, I will discuss direct observation of hydrogen absorption and desorption process in Mg-X composite metal-hydrides (where X represents Fe and Ni) for solid-state hydrogen storage system. By using an in-situ gas holder system, I track the hydrogenation and dehydrogenation processes of Mg-X metal hydrides. Also, I will explain how we can extract the thermodynamic and kinetic parameter from our experimental findings.

Furthermore, I will introduce the hydrogen absorption and desorption processes in single Pd nanoparticles using environmental-TEM where the relationship between hydrogen-sorption kinetics and crystal orientations are explored.

Keywords : Solid stage hydrogen storage system, metal-hydride, in-situ TEM

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Abstract No. : **PO-S17-0049**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Influence of substrate roughness on the magnetic anisotropy and coercivity of ultrathin thulium iron garnet films

Viet Duc Duong[1], Phuoc Cao Van[1], Jong-Ryul Jeong[*1]

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Nowadays, the control of magnetic anisotropy in magnetic insulators has a great interest in non-volatile magnetic memory device applications. In this report, we have investigated the magnetic properties of thulium iron garnet ($Tm_3Fe_5O_{12}$, TmIG) thin films grown on a (111) oriented gadolinium gallium garnet ($Gd_3Ga_5O_{12}$, GGG) substrates fabricated by the facing target sputtering method (FTS). The magnetic properties of the film are systematically manipulated by the annealing temperature, thickness, and substrate roughness. Here, we revealed that the annealing temperature is a main key factor for obtaining the high quality of the surfaces and strong perpendicular magnetic anisotropy (PMA) in TmIG films. Besides, the easy axis of magnetization was also changed by increasing the thickness of the sample. Specifically, the perfect PMA property was observed in the film which has a thickness of less than 20 nm and is annealed at 1000 ^{o}C. In addition, the surface roughness of the substrate essentially contributes to the increase of the coercive field of the perpendicular magnetic anisotropic films. We supposed that this observation is regarding the behavior of the Néel domain wall motion.

Keywords : thulium iron garnet; facing target sputtering; surface morphology; perpendicular magnetic anisotropy; magnetic coercivity

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Abstract No. : **PO-S17-0048**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Effect of post annealing temperature in the HoIG film grown by MOD method

Phuoc Cao Van[1], Hyeongyu Kim[5], Trinh Nguyen Thi[1], Viet Anh Cao[1], Junghyo Nah[1], Sang-Jun Park[4], Hyungyu Jin[4], Younghun Jo[3], Seung-Young Park[3], Jungjae Park[2], Jong Min Yuk[2], Kab-Jin Kim[2], Jong-Ryul Jeong[*1]

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In this study, we report on the fabrication of ultrathin $Ho_3Fe_5O_{12}$ (HoIG) films deposited on 111-oriented-$Gd_3Ga_5O_{12}$ (GGG) substrates using the metal-organic decomposition (MOD) technique, followed by a sequential annealing process. The investigation focuses on the impact of annealing temperature variations on the structural, morphological, and magnetic characteristics of the MOD-derived HoIG films. Observation reveals the migration of Iron (Fe) atoms from the HoIG layer into the GGG substrate at annealing temperatures exceeding 800 °C. Particularly notable is the pronounced enhancement of Fe diffusion in samples annealed at 1000 °C, leading to alterations in crystal structure and magnetic properties. Conversely, annealing temperatures below 800 °C result in compromised surface smoothness and crystalline integrity. This underscores the significance of an 800 °C annealing temperature as the optimal condition for achieving high-quality MOD-produced HoIG films. Further validation of sample quality is obtained through spin Hall magnetoresistance (SMR) measurements on HoIG/Pt structures, revealing unconventional angular dependencies and spin mixing conductance levels comparable to those reported for other single crystalline IG materials.

Keywords : Holmium iron garnet; Metal-organic decomposition; Annealing temperature; Magnetization compensation temperature; Spin Hall magnetoresistance

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Abstract No. : **PO-S17-0047**
Symposia : **K-MRS/V-MRS Joint symposium**

Abstract Preference : **Poster**

Study on the enhancement of spin thermoelectric in $Y_3Fe_5O_{12}$ thin flims embedded Pt nanoparticles

Jae-Hyeon An[1], Phuoc Cao Van[1], Jong-Ryul Jeong[*1]

[1] *Chungnam National University*

Spin Seebeck devices utilizing magnetic insulators are free from the constraints of Wiedemann-Franz's law, which allows for independent control of thermal conductivity and electrical conductivity, making them of high research value as the next generation of thermoelectric devices. However, current spin Seebeck devices exhibit significantly lower efficiency compared to conventional thermoelectric devices, making the enhancement of their efficiency a major research topic.

This study fabricated YIG thin films on silicon(Si) substrate by metal organic decomposition(MOD) method on a Pt underlayer and evaluated the SSE (Spin Seebeck Effect) performance. Additionally, the correlation between the thickness of the Pt layer and the SSE signal was investigated by adjusting the thickness of the Pt underlayer.

The SSE voltage was significantly increased by the Pt underlayer, showing up to a 300% increase in signal compared to previous methods. The SSE signal linearly decreased as the thickness of the Pt underlayer increased, showing a sharp decline at 5nm.

Through this study, the SSE signal was successfully enhanced, and it appears to have potential applications in thermoelectric energy harvesting.

Keywords : yttrium iron garnet, metal-organic decomposition, spin Seebeck effect, energy harvesting, fast annealing, magnetic hysteresis loop

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Abstract No. : **PO-S11-0046**
Symposia : **Energy Harvesting Materials and Devices for Self-powered Electronics**

Abstract Preference : **Poster**

Utilizing Electrostatic Charges Generated by Walking for In-Situ Electroporation-Based Disinfection in Portable Water Bottles

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We have engineered an advanced and highly efficient method for purifying water within portable bottles, a technology that shows tremendous promise for use in areas that are remote, resource-limited, or impacted by natural disasters where access to clean drinking water is scarce. Traditional methods for decentralized water disinfection are often hampered by their dependence on external chemical agents, the necessity for consistent energy supplies, or the complexities inherent in their design and operation. In contrast, our pioneering approach leverages naturally occurring electrostatic charges that are generated by the mere act of walking to trigger a process known as electroporation, thereby avoiding the need for these external dependencies. Through a refined nanopatterning technique, we've embedded an array of nanorods into this material, ensuring they are both densely arranged and uniformly distributed. This electrode is seamlessly incorporated into the architecture of a compact, portable water bottle. As a person walks, the electrostatic charges that naturally build up on the skin's surface are transferred through a designated low-resistance pathway and progressively collect on the tips of the nanorods. This accumulation process significantly amplifies the electric fields at these focal points. This process is powerful enough to achieve complete sterilization, eradicating more than 99.9999% of various microorganisms in half a liter of water with just 10 minutes of walking.

Keywords : Water Disinfection, Triboelectric Nanogenerators, Electroporation, Portable

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Abstract No. : **PO-S15-0045**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Magneto-optical imaging measurement of nominal $\mathbf{SmFeAsO_{0.77}H_{0.12}}$

Tomoki Suemura*[1], Hideo Namita[1], Ryosuke Sakagami[3], Tsuyoshi Tamegai[3], Masanori Matoba[2], Yoichi Kamihara[2]

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Iron-based superconductors exhibit a superconducting phase under T ~ 60 K and $\mu_0 H$ = 5 Tesla, but the critical current density J_c is small when processed into wire, which is a challenge for practical use. As a result of magnetization measurement of the iron-based superconductor nominal $SmFeAO_{0.77}H_{0.12}$ synthesized by Sakai et al., J_c^{mag} was J_c^{mag} = 19 kA/cm^2 at 5 K. However, the temperature dependence of J_c and that of molar susceptibility χ_{mol} were different. This result suggests that J_c may not be homogeneous. The purpose of this study is to visualize the J_c distribution of the sample by using the magneto-optical (MO) effect.

The light emitted from the polarizing microscope is reflected by a magnetic garnet film placed on top of the sample. The light was recorded by a CCD camera to obtain MO images. They were obtained at 20 K, 30 K, 40 K, and 50 K by applying magnetic fields B in the order of B = 0 Oe, 71 Oe, 142 Oe, 283 Oe, 570 Oe, 0 Oe, respectively.

Obtained MO images showed unevenness in lightness and darkness, which is thought to be due to intra-grain and inter-grain structure. The Images were also observed in the remanent state returned to 0 Oe. We will calculate J_c from obtained images and compare it with the results of magnetization measurements.

Keywords : Superconductivity, Critical current density, SmFeAsO, Magneto-optical imaging

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Abstract No. : **IN-S08-0044**
Symposia : **Advanced Materials Imaging Technique**

Abstract Preference : **Invited**

Hydrogen imaging using Atom Probe Tomography (Hi-APT)

Se-Ho Kim[*1]

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Hydrogen may result a ubiquitous influence on the properties of various materials, yet its quantitative assessment remains a challenge in microscopy and microanalysis. Recent advancements in atom probe could offer promising detection sensitivity and could evaluate the structural and functional impacts of hydrogen. However, hurdles persist in specimen preparation and handling. This has spurred innovative developments in methodology and instrumentation and enable comprehensive understanding of hydrogen's effects on material properties. In this presentation, I will briefly introduce cryogenic atom probe and discuss preliminary results and the outcomes.

Keywords : Hydrogen, Atom Probe, Cryogenic sample preparation,

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Abstract No. : **PO-S14-0043**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Improving Oxygen Evolution Reaction Efficiency by Decorating Synthesized Ni/Mn-LDH Nanosheets with Amorphous FeOOH Quantum Dots

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Layered double hydroxides (LDHs) have been limited in their application for oxygen evolution reactions (OER) due to their poor conductivity and instability. This study presents a novel approach involving hydrothermal synthesis followed by mechanical stirring to fabricate a composite electrode comprising nickel foam (NF), FeOOH quantum dots (QDs), and NiMn-LDHs. The resulting FeOOHQDs@NiMn-LDH composite catalyst exhibits exceptional OER catalytic activity, requiring only a modest overpotential of 200 mV at a current density of 50 mA cm-2 and displaying a Tafel slope of 110 mV dec-1.The superior performance of the composite catalyst can be attributed to the effective integration of ultrathin NiMn-LDH sheets, FeOOH QDs, and NF. This integration significantly reduces charge transfer resistance while simultaneously increasing the electrochemically active surface area. The enhanced catalytic activity is attributed to the synergistic effects among the components, facilitating rapid charge transfer and efficient oxygen evolution.By combining the unique properties of NiMn-LDHs with the catalytic activity of FeOOH QDs and the conductive framework of NF, the composite electrode demonstrates remarkable electrocatalytic performance. This innovative approach offers promising prospects for the development of high-performance catalysts for various electrochemical applications, including water splitting and energy conversion.

Keywords : water splitting , oxygen evolution reaction , LDH , Nanosheets

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Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Invited**

Control particle ensembles in Li intercalation layered oxides: Autocatalysis and Autoinhibition

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Layered oxides widely used as lithium-ion battery electrodes are designed to be cycled under conditions that avoid phase transitions. Although the desired single-phase composition ranges are well established near equilibrium, operando diffraction studies on many-particle porous electrodes have suggested phase separation during delithiation. Notably, the separation is not always observed, and never during lithiation. These anomalies have been attributed to irreversible processes during the first delithiation or reversible concentration-dependent diffusion. However, these explanations are not consistent with all experimental observations such as rate and path dependencies and particle-by particle lithium concentration changes.

This presentation, I will show that the apparent phase separation is a dynamical artifact occurring in a many-particle system driven by autocatalytic electrochemical reactions, that is, an interfacial exchange current that increases with the extent of delithiation. I experimentally validate this population-dynamics model using the single-phase material $Lix(Ni_{1/3}Mn_{1/3}Co_{1/3})O_2$ ($0.5 < x < 1$) and demonstrate generality with other transition-metal compositions. Operando diffraction and nanoscale oxidation-state mapping unambiguously prove that this fictitious phase separation is a repeatable non-equilibrium effect. I quantitatively confirm the theory with multiple-datastream-driven model extraction. More generally, our study experimentally demonstrates the control of ensemble stability by electro-autocatalysis, highlighting the importance of population dynamics in battery electrodes (even non-phase-separating ones).

Keywords : Fictitious phase separation, diffusion-limited, reaction-limited, layered cathode

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Abstract No. : **PO-S02-0041**
Symposia : **Materials and Devices for Displays and Optoelectronics**
Abstract Preference : **Poster**

Investigation of effect of sputter power on room temprature grown high responsivity amorphous gallium oxide thin film photodetector.

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Amorphous gallium oxide thin films were deposited at room temprature by using redio frequency (RF) magnetron sputtering system. The sputter power veriation effect on structural, morphological, and optical properties was investigated by utilizing X-ray diifraction (XRD), Ultraviolate-Visible (UV-Vis.) spectroscopy, Scanning electron microscopy (SEM), Atomic probe microscopy (AFM) and X-ray photoelectron spectroscopy (XPS). The results indicated that with increasing sputter power bandgap decreased while, RMS value increased. It is observed that high sputter power growth formed unevenly distributed hillock-like surface topography. It is concluded that high growth rate hinders atomic migration and re-adjustment during initial nucleation stage, thus accelerating high defect formation and rough surface morphology. Furthermore, the optoelectronic properties were investigated by utilizing 254 nm wavelength UV-C lamp. The photodetector at high sputter power of 100 W exhibited enhanced photocurrent, responsivity, and detectivity of 1.82 × 10-6 A, 60.6 mA/W, and 2.81 × 109 Jones, respectively. However, the photodetector device with low sputter power of 40 W displayed higher PDCR performance and rapid response time of 141 and 0.66/1.95 s (τr1/ τd1) in all devices.The increasing Vo content with sputter power was ascribed for high photoconduction gain and persistent photoconductivity (PPC) effect causing slow recovery time. The effect of sputter power on defect state generation and subsequent role of Vo content on optoelectronic performance is correlated and illustrated in detail. The effect of sputter power on amorphous gallium oxide thin film growth and Vo generation can provide insights for controlling Vo content via growth parameters and improve the fabrication of photodetector device development.

Keywords : gallium oxide, sputtering, ultrawide bandgap materials, photodetector.

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Abstract No. : **PO-S14-0040**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Effect of Sputtering Time and Annealing Temperature on Growth of GeSe: Its Application in Photoelectrochemical Water Splitting

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The significance of energy, its consumption, and addressing related challenges is paramount in today's world. Recently, there has been a growing preference for sustainable, cleaner, and renewable technologies to address environmental concerns associated with conventional fossil fuels and their derivatives. Natural hydrogen production offers an inexhaustible and eco-friendly energy option. The photoelectrochemical (PEC) water-splitting method, which converts sunlight into storable hydrogen energy, is acknowledged as an environmentally friendly methodology for harnessing solar energy. Consequently, interest in chalcogenide-based materials has risen due to their distinctive properties, leading to notable research in this field. Among various materials, Germanium Selenide (GeSe) is favorable for photocathode material due to its appropriate bandgap for light absorption, activity in the visible light range, and chemical steadiness. Moreover, GeSe is non-toxic, abundant in the Earth's crust, and cost-effective to fabricate, making it appealing for energy applications. Here the GeSe has been synthesized using a Radio Frequency (RF) sputtering system. The effect of deposition time and annealing temperature on the growth of GeSe has been studied. Structural and morphological analyses were conducted utilizing X-ray diffraction (XRD) and scanning electron microscopy (SEM), providing insights into the crystalline structure and surface morphology of the synthesized GeSe films. Furthermore, the photoelectrochemical (PEC) functioning of synthesized GeSe was measured to assess its suitability for solar energy conversion applications.

Keywords : Germanium Selenide, RF sputtering, Photocathode, Photoelectrochemical Water Splitting

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Abstract No. : **PO-S14-0039**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Crystalline-Amorphous Interface between FeCo-LDH and CoS to Modulate the Local Electronic Structure for Water and Methanol Electrolysis

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Exploring earth-abundant, efficient, and stable electrocatalysts for water and methanol electrolysis is urgent and necessary for the development of hydrogen energy technology. Here, crystalline/amorphous hybrid structures (FeCo-LDH/CoS) are created using a straightforward self-derivation method. The electrode exhibits an impressive bifunctional catalyst with overpotentials of 212 and 80 mV for the oxygen evolution reaction (OER) and methanol oxidation reaction (MOR), respectively, at 10 mA cm^{-2}. The durability of OER and MOR is higher than 100 and 25 h respectively at 10 mA cm^{-2} without significant changes. The addition of Fe inhibits the dissolution of S and accelerates the reconstruction of the catalyst. With the construction of the heterogeneous interface, the interaction between sites, especially the interaction between Co species in CoS and Fe species in FeCo-LDH, is enhanced, thereby accelerating the electron transfer process. This work holds great promise for industrial water and methanol electrolysis applications.

Keywords : crystalline-amorphous interface, CoS, FeCo-LDH, multifunctional electrocatalysts

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Abstract No. : **PO-S14-0038**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Poster**

Synergetic engineering of metal organic framework derived FeNi layered double hydroxides for efficient and stable overall water splitting

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Exploring efficient, low-cost overall water splitting (OWS) electrocatalysts is crucial to achieving large-scale hydrogen (H_2) production. Here we describe the synthesis of Co, V co-doped FeNi-based layered double hydroxides (Co,V-FeNi-LDHs) 3D hierarchical structures as bifunctional electrocatalysts on nickel foam (NF) using Zeolitic imidazolate framework-67 (ZIF) as a template. Herein, ZIF not only acts as a framework for morphology engineering but also functions as a Co atom source, along with creating more active sites. A dual doping strategy with Co and V leads to lattice distortion and stronger electronic interactions in the electrocatalyst, thereby increasing its active surface area and intrinsic activity, with excellent electrocatalytic performance. The resulting Co,V-FeNi-LDH electrocatalyst exhibited excellent bifunctional activities. The overpotentials of the oxygen evolution reaction (OER) at 50 mA cm^{-2} and the hydrogen evolution reaction (HER) at 10 mA cm^{-2} are 244 and 180 mV, respectively. Moreover, the cell voltage of 1.62 V has been achieved at a current density of 10 mA cm^{-2} with excellent stability of 60 h. This study emphasizes the significance of enhancing the electrocatalytic performance of LDH through a synergistic approach involving dual cation doping and morphology engineering.

Keywords : Keywords: synergetic engineering, dual-doping, 3D hierarchical structure, metal-organic frameworks, overall water splitting

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Abstract No. : **OR-S14-0037**
Symposia : **Water splitting, CO2 reduction**

Abstract Preference : **Oral**

Enabling efficient PV-assisted solar hydrogen production coupled with methanol oxidation by tailoring charge transfer at the in-situ formed FeOOH/FeCo-LDHs interface with Cr modification

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The research for efficient electrocatalysts that can effectively accelerate both the hydrogen evolution reaction (HER) and the methanol oxidation reaction (MOR) alongside overcoming the sluggishness of the anodic oxygen evolution reaction (OER) is crucial yet challenging for achieving energy-efficient hydrogen (H_2) production. Herein, by employing simultaneous engineering strategies, we report the synthesis of self-supported hierarchical FeOOH/$Fe_{0.5}CoCr_{0.5}$-LDHs as an advanced bifunctional electrocatalyst for producing value-added formate from MOR at the anode while simultaneously generating H_2 at the cathode. The collective experimental and theoretical studies demonstrate the superior charge transfer enabled by the in-situ formed heterostructure. Additionally, electronic modulation due to Cr insertion, and the presence of a superhydrophilic hybrid surface morphology contribute to the remarkable electrocatalytic activity and stability of the FeOOH/$Fe_{0.5}CoCr_{0.5}$-LDHs electrocatalyst. The overall water splitting process necessitated a cell voltage of 2.01 V to achieve a current density of 50 mA cm^{-2}, whereas a lower cell voltage of 1.76 V was sufficient for overall methanol oxidation. Remarkably, a solar-driven system prototype, consisting of a commercial Si photovoltaic cell combined with a methanol splitting electrolyzer utilizing FeOOH/$Fe_{0.5}CoCr_{0.5}$-LDHs, achieved a stable photocurrent density of 8.1 mA cm^{-2} over 2h. This work demonstrates the synthesis of earth-abundant elements-based electrocatalysts and their capability for sustainable and selective electrochemical synthesis. As a result, it enables the production of valuable chemicals and clean H_2 in an energy-efficient manner.

Keywords : In-situ formed interface, Methanol oxidation reaction, PV-assisted solar hydrogen production

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Abstract No. : **IN-S12-0036**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Invited**

Battery Materials for Water Treatment and Desalination

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Electrochemical water treatment/desalination processes have been actively investigated for centuries as an alternative to membrane processes due to their low energy consumption. However, it was recently revealed that the process represented by capacitive deionization (CDI) uses less energy, but its energy efficiency is not high (thermodynamic efficiency <1%). In other words, a small amount of energy is used to adsorb a small amount of ions.

To overcome this low energy efficiency, water treatment/desalination processes using Faradaic electrodes, typically battery electrodes, are being developed. This process is very energy efficient because it utilizes ion-selective electrodes (thermodynamic efficiency >10%), and can be widely used from the recovery of ions such as ammonium to brackish water desalination. Another battery technology is a desalination battery, including seawater batteries, which refers to a device that can store ions in the form of energy in electrodes while desalinating water (i.e., sodium ions present in seawater).

Therefore, in this presentation, recent research cases will be introduced on how battery materials can be used for water treatment/desalination. In addition, it will be discussed whether this technology can overcome the limitations of existing electrochemical water treatment/desalination systems.

Keywords : Battery materials, Electrochemical cells, Water treatment, Desalination

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Abstract No. : **PO-S05-0034**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Poster**

Hyperbolic phonon polariton waveguide in low dielectric medium

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Polar van der Waals (vdW) crystals, composed of atomic layers held together by vdW forces, can host phonon polaritons—quasiparticles arising from the interaction between photons in free-space light and lattice vibrations in polar materials. These crystals such as hexagonal boron nitride (hBN), alpha-molybdenum trioxide (α-MoO_3), Silicon carbide (SiC), etc. offer advantages such as easy fabrication, low Ohmic loss, and optical confinement. Among them, recent studies on hBNs, known for having hyperbolicity in the mid-infrared range, have explored multiple modes with high optical confinement. This opens up possibilities for practical polaritonic nanodevices with subdifferential resolution. However, hyperbolic polariton (HPhP) waves still face exposure to the surrounding environment, leading to significant energy losses.

In this work, we propose a simple approach to HPhP waveguide in hBN by incorporating a low dielectric medium, ZrS_2. The low dielectric medium serves a dual purpose—it acts as a pathway for polariton propagation while inducing high optical confinement. We establish the criteria for HPhP waveguide by measuring various thicknesses of ZrS_2 using scattering-type scanning near-field optical microscopy (s-SNOM) experimentally. In addition, by conducting numerical COMSOL electromagnetic simulations, we investigated the dependence of thickness and dielectric constant of incorporating materials. Our work presents a feasible and straightforward method for developing practical nanophotonic devices with low optical loss and high confinement. Potential applications include energy transfer, nano-optical integrated circuits, light trapping, and optical sensors.

Keywords : Two-dimensional Materials, van der Waals Heterostructures, hexagonal boron nitride, hyperbolic phonon polariton, waveguide

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Abstract No. : **OR-S05-0033**
Symposia : **Two-dimensional Materials and van der Waals Heterostructures**

Abstract Preference : **Oral**

Hyperbolic polariton mode conversion and energy redistribution in engineered van der Waals structures

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Polaritons are quasiparticles generated through the strong interaction between photons in illuminated electromagnetic waves and electric or magnetic dipoles. Recently, there has been active research on low-dimensional van der Waals (vdW) materials like graphite and hexagonal boron nitride (hBN) due to their distinct properties, particularly in nano-polaritonic devices. These materials exhibit covalent and vdW bondings along parallel and perpendicular directions between their elements, leading to anisotropic optical properties. The anisotropic optical characteristics of hBNs, attributed to opposite signs of in- and out-of-plane dielectric constants ($\varepsilon_d\varepsilon_z < 0$), make them intriguing as they support multiple branches of hyperbolic phonon polaritons (HPhPs) at nanoscales. Particularly, higher-order HPhP modes can extremely confine light and possess higher energy density than their fundamental mode, making them suitable for nano-polaritonic devices in spectroscopic fields at the atomic scale. Despite the importance of high-order HPhPs mode, recent research has primarily focused on the manipulation of fundamental HPhPs.

Here, we investigate HPhP mode conversion and energy redistribution through edge symmetry in hBN heterostructures. To visualize clear optical phenomena, we employ a scattering-type scanning near-field optical microscope (s-SNOM), serving as an antenna and signal detector. Unlike the standing waveform of fundamental HPhPs, our heterostructure exhibits multiple HPhPs, encompassing both fundamental and high-order modes with different edge symmetries. The experimental and theoretical results demonstrate mode conversion and energy redistribution in HPhPs with varying edge symmetries. These findings hold significant promise for applications in polaritonic circuits, light energy transfer, nano-optical sensing, and other functional uses.

Keywords : Two-dimensional Materials, van der Waals Heterostructures, hexagonal boron nitride, hyperbolic phonon polariton, multiple mode

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Diffusion control methods for synthesizing metastable materials.

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How to achieve metastable states is one of the important topics for advances in materials science. We focus on controlling the diffusion of specific ions with weak chemical bonding in compounds to obtain the metastable materials by applying a strong driving force at appropriate temperatures. Based on this strategy, we have developed some synthesis methods: the anisotropic diffusion control (ADC), the proton-driven ion introduction (PDII), and the high-pressure diffusion control (HPDC). These methods must be used depending on the characteristics of the sample. Also, induced anisotropic diffusion by these methods can proceed with the ion introduction, extraction, and exchange while maintaining the basic crystal structure of the compounds. The electric field is a useful driving force for diffusible ions in a solid. However, it is not applicable in metallic compounds due to the electrostatic shielding effect. The ADC method skillfully induces the chemical potential gradient as a driving force and promotes ion diffusion in the metallic compounds. The PDII utilizes the proton irradiation to solid electrolytes and can drive the various monovalent cations into host materials. The HPDC method can adjust the three synthesis parameters, temperature, pressure, and voltage, at the same time. It combined the techniques for high-pressure synthesis using the cubic multi-anvil apparatus and the ADC method. It is particularly effective for ion control in polycrystalline materials. The details of these synthesis methods and obtained metastable compounds will be presented at the conference.

Keywords : New materials, Metastable, Diffusion,

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Optical Characterization and Fabrication of Transparent Y_2O_3 by Spark Plasma Sintering

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As the representative transparent ceramics, the Y_2O_3 ceramics has received significant attention as promising host materials for high-power solid-state lasers. The characteristics of the spark plasma sintering (SPS), such as densification using an electric field and short sintering time, suppress the microstructure coarsening and act as a strength to achieve high transparency, so it is a very promising sintering technology in the fabrication of transparent ceramics. However, further research is required in the SPS process to solve the non-uniform sintering behavior and carbon contamination and simultaneously achieve microstructure control and high transparency. The main objectives of present work are that the SPS process with high sinterability and two-step profile are applied to Y_2O_3 ceramics to improve optical and microstructural characteristics.

During SPS of Y_2O_3 ceramics, the evolution of non-uniform microstructure was observed. At high heating rates, the sintered samples are apparently non-uniform to reveal opaque center and translucent periphery, and a difference in the grain size between the center and the periphery increases remarkably. The porosity and the pore size in the center also increase with increasing the holding times. The non-uniform microstructure is explained by using a concept of dynamic grain growth and defect diffusion from the periphery to the center under complicated electric field effects during SPS. Highly transparent Y_2O_3 ceramics were successfully fabricated by SPS applying two-step pressure and heating profiles. After the first-step SPS at 1250°C, the second-step SPS, which had the highest transmittance, was completed at 1500°C. The two-step SPS improved the shrinkage behavior and was able to achieve sufficient densification without excessive coarsening. As a result, the transmittance was 80.6% at 1100 nm, which is close to the theoretical transmittance of 81.6%. The two-step SPS revealed a significant advantage in manufacturing ceramics that were transparent and had sufficient densification.

Keywords : Spark plasma sintering; Two-step profile; Densification behavior, Optical properties, Transmittance

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Fabrication and evaluation of molecular nanojunctions utilizing magnetic thin-film edges

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Molecular spintronics has been attracted much attention because of the unique possibilities. Especially, a large magnetoresistance (MR) effect has been observed in nanosized molecular spintronic devices, in which a high spin polarization is realized due to the effective orbital hybridization between molecules and magnetic materials. Recently, the positive MR effect at room temperature was observed in $Ni_{78}Fe_{22}$ (Py)/2,7-dioctyl[1]benzothieno[3,2-*b*][1]benzothiophene (C8-BTBT)/Py nanojunction with a junction area of 42 × 42 nm^2. However, the properties of nanojunctions with junction areas larger than 42 × 42 nm^2 have not been clarified. In this study, we fabricate molecular nanojunctions with junction areas of 85 × 85 and 186 × 186 nm^2, and investigate spin transport properties. Py/C8-BTBT/Py nanojunctions have been fabricated by our proposed techniques, which include sputtering, thermal pressing, mechanical cutting, polishing, and off-center spin coating. The magnetic properties were measured by focused magneto-optical Kerr effect. The structural properties were examined by transmission electron microscope (TEM). The electro-magnetic properties of the fabricated nanojunctions were evaluated by four-probe method under a magnetic field at room temperature. As a result, we have successfully controlled the coercivities of Py thin films during the thermal pressing process. This means that we can realize the parallel and anti-parallel magnetization configurations in Py/C8-BTBT/Py nanojunctions. The cross-sectional TEM observation reveals that the C8-BTBT films with smooth and clear interfaces can be formed on the Py edge. Using the established technique, we have successfully fabricated Py/C8-BTBT/Py nanojunctions with junction areas of 85 × 85 and 186 × 186 nm^2, and observed positive MR effect at room temperature. The junction area of 186 × 186 nm^2 is the largest one in our proposed nanojunctions. The present study may pave a new avenue to reveal spin transport mechanism in molecular nano-devices.

Keywords : Spintronics, magnetoresistance effect, nanojunctions.

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Abstract No. : **PO-S12-0029**
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Abstract Preference : **Poster**

Tunable structure of TiO2 deposited by DC magnetron sputtering to adsorb Cr (VI) and Fe (III) from water

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TiO2 thin films with a mixture of anatase, rutile, and brookite were deposited by magnetron sputtering over glass substrates. According to the XRD and Raman results, the TiO2 films were composed for the brookite, anatase and rutile phase. The ability to adsorb heavy metals from TiO2 films was tested with Cr(VI) and Fe(III) solutions, where the maximum adsorption capacity from Cr (VI) and Fe(III) was 334.5 mg/g and 271.3 mg/g, respectively. SEM-EDS results exhibit the presence of Cr and Fe at the surface of the films, thus corroborating the capacity of TiO2 films to adsorb and remove heavy metals, making them a good candidate for application in the wastewater treatment plants.

Keywords : Semiconductors, thin films, heavy metals, adsorption capacity

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Abstract No. : **OR-S10-0028**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Oral**

Investigation of host-guest interactions in organic anion intercalated layered double hydroxides and their influence on L-lactate uptake

Valentina Podolinnaia[1], Tomohito Kameda[1], Fumihiko Kitagawa[2], Shogo Kumagai[1], Yuko Saito[1], Masayuki Kondo[2], Yoichi Jimbo[2], Toshiaki Yoshioka[1], Tomohito Kameda*[1]

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The production of human induced pluripotent stem cells (hiPSCs) at industrial scale is crucial for advancements in regenerative medicine. Stem cells consume D-glucose and produce L-lactate during proliferation, which, if accumulated in the culture medium, can hinder cell mass production. Therefore, optimizing D-glucose supply and L-lactate removal from the cell culture medium is essential for successful stem cell culture. In this research, novel L-lactate-selective Mg-Al layered double hydroxide (LDH) adsorbents with exchangeable anions compatible with cell culture were developed. Various stem cell nutrients such as L-alanyl-L-glutamine, L-glutamine, L-serine, L-methionine, L-cysteine, L-glutamate, and α-ketoglutarate and a cell culture buffer component 4-(2-hydroxyethyl)-1-piperazineethanesulfonate or HEPES were incorporated into the LDHs using a rehydration method. The arrangement of organic components within the LDHs interlayer regions and host-guest interactions were analyzed using a set of analytical and computational methods. It was found that the LDHs' ability to adsorb L-lactate and selectivity over D-glucose depended on factors such as the charge density of the LDH guest compared to L-lactate, guest orientation, and hydrogen bond formations within the host–guest, guest–guest, and guest–host–glucose complexes. This study offers insights into designing efficient and potentially biocompatible adsorbents for regenerating cell culture media, thereby facilitating cost-effective mass production of stem cells.

Keywords : Layered double hydroxide; L-lactate; Adsorption; Amino acid, HEPES

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Fabrication of nanoscale junctions using high-mobility molecules and their structural, electrical and magnetic properties

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Molecular spintronics is an emerging field of research that combines spintronics and organic molecules. A typical molecular spintronic device, organic spin valve (OSV), exhibits magnetoresistance (MR) effect. Nanosized OSV showed a large MR effect owing to the enhancement of spin polarization. However, in most studies of nanosized OSV, a large MR effect was observed at low temperature. Here we focused on using high-mobility molecules, 2,7-dioctyl[1]benzothieno[3,2-*b*][1]benzothiophene (C8-BTBT), which can suppress the spin scattering in OSV. In our previous study, we have fabricated $Ni_{78}Fe_{22}$ (Py)/C8-BTBT/Py nanoscale junctions by using our proposed method. As a result, we have successfully observed MR effect in the fabricated devices with junction area $S = 42 \times 42$ nm^2 at room temperature. In this study, towards the realization of the devices with a smaller junction area, we fabricate Py/C8-BTBT/Py nanoscale junctions with $S = 7.5 \times 7.5$ and 20×20 nm^2 and investigate their structural, electrical and magnetic properties. The fabrication procedure of Py/C8-BTBT/Py nanoscale junctions mainly consists of sputtering, thermal pressing, mechanical cutting, and polishing techniques. C8-BTBT thin films were deposited by off-center spin-coating method. MR effect was measured by a four-probe method under a magnetic field at room temperature. By using our proposed fabrication method, we have successfully fabricated ultra-small nanoscale junctions. Especially, the junction area of 7.5×7.5 nm^2 in fabricated devices is the minimum value ever reported for the devices fabricated in this study. Furthermore, it is found that the resistance decreases with increase of the junction area. Finally, a positive MR effect is observed in the Py/C8-BTBT/Py devices at room temperature. The observation of positive MR effect indicates that a spin signal through C8-BTBT can be successfully observed. This study opens up a new research field, “high-mobility molecular nano-spintronics”.

Keywords : Spintronics, magnetoresistance, high-mobility molecules.

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Strongly correlated oxygen evolution catalysts and their recent progress

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The oxygen evolution reaction (OER) is the key reaction of electrochemical water splitting and rechargeable metal-air batteries. In this talk, strongly correlated materials will be introduced as excellent OER catalysts eligible for future candidates as anode materials in electrochemical water splitting and cathode materials in rechargeable metal-air batteries. The first example for a strongly correlated material that serves as an OER catalyst is $Ca_{1-x}Sr_xRuO_3$. When the electron correlation strength is sufficiently large, stronger electron correlation led to higher OER activity for $Ca_{1-x}Sr_xRuO_3$. Specifically, when the system is near the metal-insulator boundary, it leads to a remarkable activity enhancement by a factor of 17, which is also accompanied with improved OER stability. Other examples of strongly correlated materials with high OER performance are the transition metal oxide solid solutions containing Mn. In the case of $BaIr_{1-x}Mn_xO_3$, it becomes an excellent OER catalyst with both high activity and stability after repeated OER cycling under acidic conditions. Specifically, the substitution of Ir-site with Mn leads to a remarkable activity enhancement by a factor of 28 and an overall improvement in stability. This dual enhancement of OER performance is accomplished by the reconstruction of the catalytic surface with a robust $BaIrO_3$-type structure. In the case of $Ca_3Co_{4-x}Mn_xO_9$, it becomes an excellent OER catalyst with both high activity and stability especially after the solution plasma treatment.

Keywords : strongly correlated material, oxygen evolution reaction, oxygen evolution catalyst, electron correlation

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Abstract No. : **PO-S10-0025**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

Development of catechin-containing GelMA hydrogel to improve inflammation for chronic wound dressing

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A wound is a type of injury that occurs relatively quickly, in which the skin is torn, cut, or punctured (open wounds) or blunt bruises (closed wounds). In pathology, a typical wound refers to damage to the skin epidermis caused by physical external factors. According to the healing process, wounds are divided into acute wounds and chronic wounds. Acute wounds heal in a state similar to the surrounding tissue within 2 weeks. Most of these wounds heal through the normal healing process without a separate dressing. The causes of chronic wounds are not significantly different from those of acute wounds, but due to an abnormal healing process, the chronic wound does not heal and causes inconvenience of daily life due to various complications and pain. In most chronic wounds, hyperinflammatory reactions were observed. Complications from this cause serious diseases such as skin necrosis, chronic inflammation, and chronic pain. In hyperinflammatory response, reactive oxygen species (ROS) imbalance is caused by excessive cytokine production. In general, ROS is present in small amounts as a mediator of cell homeostasis and cell signaling, but high ROS levels induce tumor and apoptosis. Therefore, controlling high ROS levels in hyperinflammatory responses can induce an effective anti-inflammatory response. This study aims to develop an effective chronic wound dressing by controlling the high ROS level appearing in hyperinflammatory response.

Keywords : GelMA hydrogel, wound dressing, antioxidant, controlling ROS, chronic wound

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Abstract No. : **KN-S09-0024**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Keynote**

Thin film atomic layer deposition and selective processesThin film atomic layer deposition and selective processes

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In the past decades, Moore’s law drives the semiconductor industry to continuously shrink the critical size of transistors. However, the current fabrication processing is causing challenges toward future downscaling, especially for the complex stacking and 3D structures. Atomic layer deposition provides high accuracy with nanometer or close-to-atomic scale to fabricate nanostructures. In this talk, the thin films fabrication via atomic layer deposition is presented, including selective deposition process and films with different properties. Selective ALD process enabling depositing atoms at desired surface locations. Through embedding selective atomic layer deposition into patterned substrates, vertical angstrom resolution can be achieved as well as lateral resolution. The downscaling of transistors drives the selective deposition of dielectrics and metals for alignment. Various template-assisted selective deposition methods, e.g. self-assembled monolayers, have been utilized for the alignment of 3D complex structures. Furthermore, the inherent selective deposition depends on initial nucleation control rather than relying on introducing surface modification steps will be presented. The fundamental mechanism lies in tuning the chemical thermodynamic and kinetic differences. Thin films with different properties are important for various functions. Low k value films are fabricated for ILD in ICs devices to form binary oxides as well as in situ conversion of ALD film to MOF structures. Functional oxides such as SnO, IGZO are studied with process tuning to obtain high mobility, etc. Encapsulations via oxides for optoelectronics and optics are also studied. These bottom-up approaches may provide ultimate solutions to achieve advanced technology nodes. Thus, the atomic layer deposition enables integrated manufacturing of nanomaterials, nanostructures, nanodevices and nano-systems with high accuracy to extend Moore’s law in semiconductor and emerging fields.

Keywords : atomic layer deposition, selective deposition process, 3D structures, self-alignment, high mobility oxides

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Abstract No. : **PO-S12-0023**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Intermittent applied potential-driven selective enrichment of electroactive microbial consortium to convert CO_2 to CH_4 in microbial electrosynthesis cell

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Recently, the development of renewable energy of utilizing biogas (e.g., CH_4, CO_2) generated from anaerobic digestion (AD) progresses, and the need for a biogas upgrading process is emerging. Among them, microbial electrosynthesis can use this power to capture CO_2 and produce valuable compounds such as CH_4 for energy storage. Selective stabilization of electroactive bacteria using inorganic sources such as carbon dioxide rather than organic materials as carbon sources take a lot of time. Rapid, selective stabilization of these electroactive communities is required to introduce a microbial electrosynthesis cell into an industrial field. Here we present a simple but effective approach based on the selective cultivation of CO_2 electrophs by supplying an intermittently applied potential. This culture was successfully upgraded to 97% biomethane using CO_2 contained in biogas. Also, a methane conversion rate shows 8.34 L/m^2 cat/day. With this technology, the selective stabilization of CO_2-utilizing electrotrophic bacteria was accomplished significantly faster than in other studies. Electrochemical analysis, FE-SEM, confocal laser scanning microscopy, and community analysis of cathodes suggested the potential involvement of biogas upgrading in MES. An intermittent applied potential strategy supply method enables immediate start-up and reproducible biomethane conversion profiles of upgrading bioelectric synthesis of biogas from anaerobic digesters.

Keywords : Intermittently applied potential, Microbial electrosynthesis cell, Biogas upgrading

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Abstract No. : **IN-S10-0022**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Invited**

Stable Tissue-interfacing Self-healing Bioelectronics

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Conventional flexible/stretchable devices capable of monitoring bio-signals and delivering the feedback information have been considered as essential functional components in realizing the stable closed-loop bioelectronics. Despite such significant progress, their mechanical and electrical instability, originating from materials fatigue and the absence of tissue adhesion, still remains a challenge in pursuit of strain-durable tissue-interfacing capability.

Here, we report optimal stretchable materials design strategies and device fabrication/integration technologies for the two different kinds of self-healing tissue-adhesive bioelectronics: i) A patch-type platform for either facile peripheral nerve repair (neurorrhaphy) in rodents and nonhuman primates or large-scale conformal cardiac interfacing; ii) A syringe-injection-type platform for instantaneous closed-loop rehabilitation. The patch-type self-healing bioelectronics consists of ionically conductive hydrogel adhesive and tough composite electrodes with solid and liquid micro-/nano-fillers, enabling both on-tissue strain-insensitive electrical performance and mechanical adaptation. In terms of the injectable type, tough hydrogel with irreversible yet freely rearrangeable biphenyl bonds and reversible coordinate bonds with conductive gold nanoparticles was applied to injured nerves/muscles for realizing immediate closed-loop robot-assisted rehabilitation and effective tissue regeneration.

Keywords : Tissue-interfacing, Stretchable, Self-healing, Bioelectronics, Injectable

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Abstract No. : **PO-S01-0021**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Poster**

Research on manufacturing nickel metal powder from ESS waste resources through continuous liquid reduction process

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Recently, with the expansion of the LIBs industry market such as electric vehicles and power storage devices, the demand for secondary batteries in a wide range of types from medium to large LIBs to small lithium secondary batteries has increased, and the amount of waste resources generated from lithium secondary batteries is also steadily increasing. In the current situation where raw materials are scarce, recycling of valuable metals from these waste resources is essential. In particular, as the demand for high-performance LIBs has increased rapidly recently, interest in recycling of the main raw materials of cathode materials with high nickel content and recycling technology in preparation for limited raw materials continues to increase.

In this study, a study was conducted to produce nickel metal powder with high crystallinity based on a solution recovered in the form of a nickel sulfate precursor from ESS wastes. To produce highly crystalline nickel powder a continuous wet process of precipitation and liquid phase reduction process was performed by controlling experimental condition such as nickel hydroxide production concentration ratio and reaction time. A comparative study was conducted with the concentration ratio of nickel sulfate and sodium hydroxide, a precipitant, at 1:7,14, and hydrazine was used as a reducing agent. The entire progress of this study was nickel hydroxide was first manufactured from nickel sulfate, which is a raw material, through a precipitation process depending on the concentration of the precipitant. Nickel powder was prepared from the prepared nickel hydroxide solution through a continuous reduction process.

Keywords : Nickel sulfate, Lithium Ion Battery, Lithium hydroxide, precipitation, ESS, Ni metal powder

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Abstract No. : **OR-S15-0020**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Investigation of iridium solubility into β-Ga_2O_3 single crystals by floating zone method

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Iridium is employed for the crucible of commercial single crystal growth. The possibility of iridium contamination into β-Ga_2O_3 single crystals was investigated using floating zone method which is a crucible-free method. Iridium metal inclusions was observed from the single crystals grown with the nominal composition of above 0.05 at% iridium doped. And iridium was detected to approximately 0.00026 at% in the β-Ga_2O_3 matrix.

Keywords : β-Ga2O3, Iridium solubility, Wide bandgap semiconductors

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Abstract No. : **OR-S07-0019**
Symposia : **Computational Materials Science**

Abstract Preference : **Oral**

Finite-Temperature Hole-Magnon Dynamics in an Antiferromagnet

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Employing the numerically accurate multiple Davydov Ansatz (mDA) in combination with the thermo-field dynamics (TFD) approach, we delve into interplay of the finite-temperature dynamics of holes and magnons in an antiferromagnet, which allows for scrutinizing previous predictions from self-consistent Born approximation while offering, for the first time, accurate finite-temperature computation of detailed magnon dynamics as a response and a facilitator to the hole motion. The study also uncovers pronounced temperature dependence of the magnon and hole populations, pointing to the feasibility of potential thermal manipulation and control of hole dynamics. Our methodology can be applied not only to the calculation of steady-state angular-resolved photoemission spectra, but also to the simulation of femtosecond terahertz pump-probe and other nonlinear signals for the characterization of antiferromagnetic materials. It seems especially promising to compare predictions of our simulations on magnon dynamics with measurements of femtosecond terahertz 2D spectroscopy, which is capable of monitoring inter-magnon temporal and spacial correlations. In addition, the mDA-TFD framework holds the potential to extend its application to an analysis of magnon polaritons, AFM bilayers, and nonequilibrium dynamics of multiple holes in strongly interacting lattice models. Such extensions could foster a more nuanced comprehension of the interplay between holes, magnons, and polarons, and further illuminate fascinating phenomena such as d-wave Cooper pairs, stripe phases, and d-wave superconductivity.

Keywords : variational method; coherent states; Davydov Ansatz; t-J model; hole dynamics; magnetic polarons

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Abstract No. : **IN-S13-0018**
Symposia : **Advanced Materials and Technologies for Next-Generation Solar Cells**
Abstract Preference : **Invited**

Efficient and stable inorganic perovskite solar cells

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Inorganic perovskites hold promise for improving stability of perovskite solar cells (PSCs). [1] However, the narrow-bandgap inorganic perovskite is thermodynamically unstable at room temperature, limiting the development of stable PSCs. In addition, severe nonradiative charge recombination at interface restrains the obtainment of high efficiency devices. Among different types of defects responsible for energy loss, iodide vacancies exhibit the lowest formation energy and therefore dominate at perovskite surface. We show that compositional engineering by doping significantly stabilizes the α-phase of inorganic perovskite at room temperature. [2-3] By further developing interfacial modifiers with functions such as synergetic passivation [4], chelation [5], the defect density of inorganic perovskite films can be appreciably reduced. The coordination of lithium ions and the introduction of cross-linked hydrophobic layer further enhance the device stability, while maximizing the power conversion efficiency of inorganic PSCs to 21.8% (n-i-p structure) and 21.0% (p-i-n structure), both are the highest efficiencies so far for the corresponding device structures [6-7].

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Keywords : inorganic; perovskite solar cells; power conversion efficiency; stability

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Abstract No. : **PO-S04-0017**
Symposia : **Materials, Processing, and Devices for Unconventional Electronics**
Abstract Preference : **Poster**

Characterization Analysis of $Hf_xAl_{(1-x)}O_y$ Ceramic Targets

IN PYO HONG[1], Chung Wung Bark[1], HE RUI[*1]

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The potential of HfO_2 as a memory semiconductor material with ferroelectric properties in thin-film deposition has been recently analyzed. In this study, the preparation, composition, and physical properties of Al-doped hafnium oxides were analyzed. $Hf_xAl_{(1-x)}O_y$ (HAO) [$x = 0.33$, 0.5, and 0.67] powders were prepared by controlling the ratio of Hf to Al and using ball milling. The HAO powder was calcined at 1000 °C in a furnace and then sintered in a temperature range of 1000 to 1600 °C by a solid-state reaction method to fabricate high-quality targets with high densities. The density and crystal size increased with the sintering temperature. The 1600-°C $Hf_{0.67}Al_{0.33}O_y$ target was optimal for thin-film deposition. In addition, the target properties were affected by an increase in the HfO_2 content x. The crystal structures and sizes, surface free energies, contact angles, and band gaps of the HAOs were evaluated to analyze their potential as high-*k* dielectric materials. HAO is a promising high-*k* dielectric and memory material, valuable for further studies on ferroelectric gate oxide materials. This study contributes to the increasing number of studies on the ferroelectricity of HfO_2 thin films and provides a fundamental understanding of this material and its potential for novel device applications.

Keywords : Ball Milling, HfO2, Al2O3, RF sputter ceramic target

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Abstract No. : **OR-S15-0016**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Oral**

Thermoelectric properties of a mixed anion layered compound, LaCuChO (Ch = S, Se) with copper defects

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Several mixed anion layered compounds (MALCs) exhibit relatively high figure of merit (ZT).[1,2] Experimental and theoretical researches expect a promising functionality for the MALCs as thermoelectric materials, [3,4] however detailed carrier-doping mechanism and relations between crystallographic defect and resistivity are still controversial for representative mixed anion layered compounds, polycrystalline LaCu(S, Se)O bulk.[5,6,7,8] In the symposia, we demonstrate thermoelectric properties of polycrystalline LaCu(S, Se)O with a little deficient in Cu site.

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Keywords : Mixed anion layered compounds, thermoelectric properties, ZrCuSiAs, transparent semiconductor

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Abstract No. : **PO-S09-0015**
Symposia : **Semiconductor Thin Films, Materials and Devices**

Abstract Preference : **Poster**

Improved polarization of metal-ferroelectric-metal capacitors deposited by Rf sputtering of Al2O3-doped HfO2 on epitaxial ITO films on yttria-stabilized zirconia (100) substrate.

IN PYO HONG[1], Jae Ho Park[1], Min Joon Park[1], Ma Ro KIM[1], Chung Wung Bark*[1]

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This paper describes the design, fabrication, and characterization of a capacitor structure consisting of a YSZ(100) substrate, an indium tin oxide (ITO) lower top electrode layer, and a hafnium aluminum oxide (HAO) dielectric layer. The objective of this research is to investigate the electrical and dielectric properties of the capacitors and evaluate their suitability for various applications. The fabrication process utilized RF sputtering to deposit a bottom electrode ITO layer on a YSZ(100) substrate, followed by $Hf_xAl_{(1-x)}O_y$(HAO) deposition and lithographic (N-type) process treatment, and finally ITO layer deposition and etching as the top electrode to fabricate a three-layer structure MFM capacitor. A total of three models were fabricated with different HfO_2 and Al_2O_3 ratios. With the thickness of each layer optimized to 50 nm/20 nm/50 nm, the performance of the fabricated capacitors was evaluated, including capacitance-voltage (C-V) measurements, polarization curve (P-V) and current-voltage (I-V) measurements. The results showed well-defined polarization curve behavior, indicating the presence of functional dielectric layers with adequate charge storage capacity. In addition, the dielectric properties of the HAO layer, including permittivity, dielectric loss, and breakdown voltage, were investigated to evaluate its suitability as a high-performance dielectric material. The developed $Hf_xAl_{(1-x)}O_y$ MFM capacitor structure exhibits excellent electrical and dielectric properties and is expected to be suitable for various applications such as power system conversion devices and integrated circuits due to its potential for utilization in low-frequency environments.

Keywords : Ferroelectric Capacitor, YSZ, Al-doped HfO2, Dielectric Properties

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Abstract No. : **PO-S15-0014**
Symposia : **The 9th Korea-Japan International Symposium on Materials Science & Technology (KJMST2024)**
Abstract Preference : **Poster**

Aqueous Zn-ion battery based on ammonium vanadate nanofiber cathode and Al_2O_3 coated anode with high cycle stability

Younghee So[1], Sihyun Lee[1], Eunseo Lee[1], Jinyoung Lee[1], Sungwook Mhin*[1]

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Aqueous zinc-ion batteries (ZIBs) have recently been in the spotlight as an Lithium ion battery alternative because ZIBs have characteristics such as high energy density per volume, eco-friendliness, low cost, and high safety. However, parasitic reactions such as hydrogen evolution reaction, corrosion, and dendrite growth in the Zn anode can result in the degradation of the electrochemical performance of AZIBs. In this study, an ammonium vanadate nanofiber (AVNF) intercalated with NH^{4+} and H_2O as a cathode material for ZIBs was synthesized within 30 minutes through a facile sonochemical method. In addition, an effective Al_2O_3 layer of 9.9 nm was coated on the surface of zinc foil through an atomic layer deposition(ALD) technique. Herein, we report the effect of AVNF cathode and Al_2O_3-coated Zn anode on enhanced cycle performance of the AZIBs. As a result, AVNF//Al_2O_3@Zn batteries showed a high rate capability of 108 mA h g^{-1} even at 20 A g^{-1} and exhibited high cycle stability with a capacity retention of 94% even after 5000 cycles at a current density of 10 A g^{-1}. Based on this study, it is expected that advanced research on the active material and surface modification of the anode with improved electrochemical performance of zinc ion batteries will be possible in the future.

Keywords : AZIBs, Vanadium cathode, Al2O3-coated Zn anode, ALD

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Abstract No. : **PO-S12-0013**
Symposia : **Materials for Enviromantal Science**

Abstract Preference : **Poster**

Eco-Friendly Food Packaging Solutions with Nanocellulose-derivatives: Enhancing Sustainability and Performance

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With the growing demand for single-person household-sized food packages, the development of advanced food packaging materials is increasingly vital. This study presents an innovative approach to address this demand by focusing on the creation of sustainable and effective food packaging solutions. We introduce a novel method involving dialdehyde-modified cellulose (DAC) blended with polyvinyl alcohol (PVA), applied onto PLA films using the doctor blade coating method. This eco-friendly and scalable process leads to the formation of films with exceptional gas barrier properties.

These films offer superior gas barrier performance and possess key environmentally friendly attributes. They are fully biodegradable, alleviating concerns related to end-of-life disposal. Furthermore, the films demonstrate optical transparency, facilitating easy identification of packaged products for consumers. Additionally, their radio frequency identification (RFID) transparency opens up possibilities for enhanced inventory management and traceability in the food supply chain.

Our research findings suggest that these PLA/h-DAC-PVA films hold great promise as eco-friendly food packaging materials. By effectively preserving food quality and extending shelf life, these coatings contribute to environmental responsibility in the food industry. This study represents a significant step toward sustainable food packaging solutions that meet the needs of both consumers and the environment.

Keywords : Nanocellulose, food packaging, transparent

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Abstract No. : **PO-S02-0012**
Symposia : **Materials and Devices for Displays and Optoelectronics**

Abstract Preference : **Poster**

Highly Conductive Transparent Hybrid Superlattices with Excellent Gas-Barrier Properties and Flexibility

Sangho Cho[*2], Jaeyoung Park[1], Pham Hoang Giang[1], Jongchan Kim[1], Myung Mo Sung[1]

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Introducing a novel hybrid superlattice of ZnO and self-assembled monolayers, we present a versatile solution for transparent electrodes and gas diffusion barriers in optoelectronic devices. Fabricated using low-temperature deposition techniques, our hybrid superlattice achieves robust electrical conductivity (>1400 S cm^{-1}), exceptional moisture barrier properties (WVTR < 4 × 10^{-7} g m^{-2} day^{-1}), and remarkable flexibility. Through systematic investigation, we elucidate the mechanism behind its enhanced electrical performance, attributed to a well-defined amorphous/crystalline phase-composite structure. Additionally, the integration of organic layers enhances resilience against environmental degradation and mechanical stress, positioning our hybrid superlattice as a promising solution for transparent conductive gas diffusion barriers in emerging optoelectronics.

Keywords : Transparent conducting oxide, gas diffusion barriers, flexible

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Abstract No. : **OR-S01-0011**
Symposia : **Emerging Materials for Rechargeable Batteries**

Abstract Preference : **Oral**

Toward High-Capacity Carbon Fiber Cathodes for Structural Batteries using Electrophoretic Deposition: Effects of Oxidative Surface Treatment on Carbon Fibers

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Structural batteries are a breakthrough and novel concept of “massless” energy storage that possess multifunctional capability to store electrochemical energy and carry mechanical load concurrently. Carbon fiber cathodes (CFC), one of the main components in structural batteries, can be fabricated by depositing cathode active materials on carbon fibers using techniques such as electrophoretic deposition (EPD). However, intrinsically inert surface of carbon fibers may result in weak adhesion. In this study, different oxidative surface treatments (acid, electrochemical, and heat) are evaluated based on their ability to activate surfaces of carbon fibers. The mechanical and electrochemical performance of resultant CFC fabricated with high-voltage cathode active materials- lithium nickel manganese cobalt oxide (NMC 111) via EPD are analyzed. The best performing CFC are achieved using acid-oxidized carbon fibers due to their improved interfacial adhesion. Acid-oxidized AS4C 3k CFC yield a high specific capacity of 151 mAh g^{-1} after 100 cycles at 1 C and are stable over 100 cycles at 1 C with capacity retention close to 100 %, and give a stiffness of 25 GPa and ultimate tensile strength of 260 MPa. Acid-oxidized 12k CFC show higher mechanical performance with stiffness of 53 GPa and ultimate tensile strength of more than 500 MPa, which make them more favorable to be used for structural batteries.

Keywords : structural batteries, multifunctional composites, surface treatments, energy storage

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Abstract No. : **PO-S10-0010**
Symposia : **Emerging Materials and Devices in Advanced Biomedical Application**

Abstract Preference : **Poster**

NEW TYPE OF POLYURETHANE POLYMER BIOMATERIAL APPLIED IN DIFFERENT KINDS OF MEDICAL DEVICES IN BIOMEDICAL FIELD

Hyungtae Kim[*1], HYUNG TAE KIM[1]

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Introduction

There are many different types of biomaterials applied in many different kinds of medical devices (stent grafts, stents, vascular grafts). The examples of biomaterials used in medical devices are : polyester, polytetrafluoroethylene (PTFE), polyurethane. There are various advantages of these biomaterials.

Good biocompatibility and flexibility are the representative advantages of these biomaterials. However, bad mechanical properties and easily changing shapes are the disadvantages of these biomaterials. To overcome these disadvantages, S&G BIOTECH INC tried the research of new type of polyurethane biomaterial.

Body

To check the biocompatibility, following tests are proceeded. Tests such as hemolysis test, cytotoxicity test, pyrogen tests pass the test criteria. Tests are conducted with the ISO 10993 standard (ISO 10993-4, ISO 10993-5, ISO 10993-11). And new type of polyurethane biomaterial maintain the good features of existing biomaterials applied to covering of stent grafts, stents, vascular grafts such as easy to make, flexibility, superior biocompatibility. And it enhanced the high mechanical properties and no change of shape difference.

Conclusion

It is concluded that the new type of polyurethane biomaterial can be applied as an alternative biomaterial in many different kinds of medical devices. Even though, this new type of polyurethane biomaterial passed the several types of biocompatibility tests, further studies and research are necessary to prove the quality and safety of this new type of polyurethane biomaterial.

Keywords : polymer, biomaterial, polyurethane

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Abstract No. : **PO-S06-0009**
Symposia : **Advanced Structural Materials**

Abstract Preference : **Poster**

The Interplay of Precipitation Hardening and Conductivity in Al-Si-Mg Alloys

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This study examines the precipitation evolution during T5 heat treatment (casting and direct aging) and its impact on the conductivity of an Al–7Si–0.35Mg alloy component. We employ a step mold casting technique to develop an Al–7Si–0.35Mg alloy component with cavity thickness ranging from 4-40 mm. Our experimental investigations unveil varying solidification times (from 5.0 to 152.2 sec) and cooling rates (ranging from 2 to 50 K/s) due to the step mold casting. The thermal conductivity of component sections increase from 174.1 to 178.9 W/mK as the cooling rate surged to 50 K/s. Microstructure analysis of 50 K/s alloy reveals a large number density of coarse Mg-Si-rich pre-precipitates near dendritic cell boundaries, alongside fine GPII and b^2 pre-precipitates within the cell interior. The pre-precipitation behavior in 50 K/s alloy is attributed to the retention in the mold until thick sections fully solidify, leading to low solute supersaturation and higher conductivity. Contrarily, 2 K/s alloy exhibits the formation of fine dot-like b^2 and a few coarse Mg-Si-rich pre-precipitates along the cell boundaries. This alloy demonstrates superior age-hardening behavior and its low thermal conductivity increases during aging. This increment is associated with a small lattice misfit between precipitates and matrix in the as-cast state, inducing significant lattice distortion which lowers the thermal conductivity. Upon peak aging, these distortions are replaced by dislocations at the precipitate-matrix interface due to large lattice misfits. Finally, we offer an insight into how the solidification microstructure affects T5 treatment considering hardness and conductivity synergy.

Keywords : Al–Si–Mg alloy; Cooling rate; Pre-precipitation; Age-hardening; Thermal conductivity

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Failure data analysis of polymer composite cage materials for cryogenic ball bearings

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Rotating machinery companies face strong pressure to develop new products with high reliability. It was experimentally elucidate the mechanism of friction wear surface for the sliding and rolling contact movement in the cryogenic atmosphere. To evaluate the reliability of the solid lubricating cage, we should minimize the frictional wear of the contact surface at a low temperature conditions. Investigations of wear resistance of polymers with additives, using the cryogenic pin-on-disk apparatus has been carried out and analyzed by machine learning algorithms. Normal load, rotating speed and liquid nitrogen flow rate were considered variables in the cryogenic wear tests. The friction and the wear mechanisms are briefly reviewed. Various polymeric materials containing solid lubricants were investigated.

Cage center-of-mass orbits for cryogenic ball bearing with different solid lubricant are demonstrated. In the case of MoS_2 containing composite cage, circular orbit is observed. Among the tested materials, the composites PTFE with additive MoS_2 have shown good friction coefficient.

In this study, wear shape microstructure data of cryogenic bearings were analyzed by deep learning method.

Keywords : Failure analysis, polymer composice cage, cryogenic ball bearing, Deep learning

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Dynamics of compound droplet on curved surfaces for controlling of the hydrodynamics

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Multi-component droplets are comprised of two or more immiscible materials with a covalent interface. These materials can take the form of compound droplets, such as Janus or core-shell structures. Recent research has focused on droplet rebound or acceleration by combining numerous compound droplets with patterned surfaces. This study employs experiments and simulations to investigate the impact of surface curvature on Janus droplet rebound and separation efficiency. The dynamic characteristics are explored across various Weber numbers and viscosity ratios. The Janus droplet, characterized by a high-viscosity component attached to a low-viscosity component, assumes a Janus shape with two fluid parts during collision with a solid surface. The study examines threshold Weber numbers for separation after collision under different droplet sizes, viscosity ratios, and surface curvatures. A regime map illustrating the separation efficiency of compound droplets is presented, considering viscosity ratio and Weber number. The curved surfaces contribute to increased asymmetry in mass and momentum distributions, synergizing with the effect of anisotropic curvature to significantly reduce residence time. The alteration in residence time is explained by momentum asymmetry, and the distinct impact behavior holds promise for applications in controlling water repellency, preventing pathogen depositions, and enhancing heat transfer performance.
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Keywords : superhydrophobic surface, self-cleaning, interfacial dynamics

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Exploring Corrosion Behavior of Al–Si–Mg Alloys: Role of Intermetallic Phases

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The influence of Cu-, Ni-, and Mn-rich intermetallic particles (IMPs) on the microstructure, high-temperature mechanical properties, and corrosion behavior of Al–Si–Mg based alloys was investigated. Microstructural analyses reveal the presence of Chinese script Mn-rich a-AlFeMnSi, Cu-rich Q-$Al_5Cu_2Mg_8Si_6$, and coarse block-like g-Al_7Cu_4Ni and thin needle-like d-Al_3NiCu IMPs, which contribute to the alloy's strengthening. All IMPs exhibit a cathodic electrochemical nature due to their high electron work function compared to the adjacent a-Al matrix, leading to strong galvanic corrosion as indicated by Volta potential differences. Additionally, a significantly high misorientation is observed at the IMPs and matrix interphase boundary, contributing to stress localization during pitting attacks. However, due to their large Volta potential difference with matrix, Ni-rich g-Al_7Cu_4Ni phase acts as the primary cathode among IMPs, amplifying localized pitting while deteriorating the overall corrosion resistance of the Al–Si–Mg based alloys.

Keywords : Aluminum; intermetallic particles; pitting corrosion; dislocation

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