Functional Thin Films and Surfaces
Room Golden State Ballroom - Session MB-ThP
Functional Thin Films and Surfaces Poster Session

MB-ThP-1 Two-Dimensional Vacancy Confinement in Anatase TiO_2 Thin Films for Enhanced Photocatalytic Activities*, Junwoo Son [junuson@snu.ac.kr],* Seoul National University, Republic of Korea

Light-driven energy conversion devices call for the atomic-level manipulation of defects associated with electronic states in solids. However, previous approaches to producing oxygen vacancy (V_O) as a source of sub-bandgap energy levels have hampered the precise control of distribution and concentration in V_O.

Here, a new strategy to spatially confine V_O at the homo-interfaces is presented by exploiting the sequential growth of anatase TiO_2 under dissimilar thermodynamic conditions. Remarkably, metallic behavior with high carrier density and electron mobility is observed after sequential growth of the TiO_2 films under low pressure and temperature (L-TiO_2) on top of high-quality anatase TiO_2 epitaxial films (H-TiO_2), despite the insulating properties of L-TiO_2 and H-TiO_2 single layers. Multiple characterizations elucidate that the V_O layer is geometrically confined within 4 unit cells at the interface, along with low-temperature crystallization of upper L-TiO_2 films; this two-dimensional $V_O$layer is responsible for the formation of in-gap state, promoting photocarrier lifetime (~ 300 %) and light absorption. These results suggest a synthetic strategy to locally confine functional defects and emphasize how sub-bandgap energy levels in the confined imperfections influence the kinetics of light-driven catalytic reactions.

This work is performed by the collaboration with Mr. Minwook Yoon,Dr. Yunkyu Park, Ms. Hyeji Sim, Ms. Hee Ryeung Kwon, Dr. Yujeong Lee, Prof. Ho Won Jang, Prof. Si-Young Choi.

MB-ThP-2 Fabrication of Metal-Based Superhydrophilic and Underwater Superoleophobic Surfaces by Laser Ablation and Magnetron Sputtering*, Adham Al-Akhali [alakhali.adham@gmail.com],* Guizhou University, China

Fabricating underwater superoleophobic surfaces is an advanced technique for controlling undesirable oil and wax adhesion on engineering structures and household appliances. This article presented a facile method based on the combination of laser ablation of stainless steel substrates followed by magnetron sputtering of a metallic tungsten target to fabricate superhydrophilic and underwater superoleophobic surfaces. The results showed that the laser-ablated stainless steel substrate without coatings exhibited hydrophilicity and underwater oleophobicity. However, its transition to superhydrophilicity and underwater superoleophobicity with a 0˚ water contact angle and higher than 156◦ underwater oil contact angles occurred after the deposition of a thin tungsten film followed by annealing at 300 ˚C. In addition, the prepared surface maintained its wetting behavior for more than 4 weeks, even in corrosive aqueous HCl and NaOH solutions. According to the data from SEM and XPS, this distinguished wetting behavior resulted from the presence of the regular microscale texture patterns, abundant hydroxyl content, and low carbon content on the tungsten layer after annealing at 300 ˚C. Thus, laser ablation combined with magnetron sputtering of tungsten demonstrated effective results in fabricating superhydrophilic and underwater superoleophobic surfaces that are independent of the initial wetting of the substrates.

MB-ThP-3 Synthesis and Characterization of Zn Doped $CsPbI_3$ Perovskite Quantum Dots*, Ya-Fen Wu [yfwu@mail.mcut.edu.tw], Hao-Yu Jhai,* Ming Chi University of Technology, Taiwan

The increasing focus on sustainable energy has driven advancements in renewable technologies, with quantum dot solar cells gaining particular interest in photovoltaics for their ability to efficiently convert sunlight into electricity. Early cells used II-VI semiconductors with high crystallinity and luminescence but were limited by toxicity and complex synthesis.In contrast, all-inorganic perovskite quantum dots such as $CsPbX_3$ (X=Cl, Br, I) have gained prominence due to their excellent photoelectric properties, low cost, and easy to be manufactured. Moreover, compared to organic-inorganic perovskites, all-inorganic perovskites are more stable under high temperature and with extremely high quantum yield.Consequently, they are gradually becoming mainstream in research and development.

Metal ion doping is widely recognized as one of the most effective strategies to enhance the efficiency of perovskite light-emitting devices. In this study, $CsPbI_3$ all-inorganic perovskite QD thin films were prepared with various concentrations of zinc acetate (0%, 3%, 5%, and 7.5%) added as dopants. Temperature-dependent photoluminescence was carried out from 20 K to 300 K. To investigate the thermal behaviors of peak energy, full width at half maximum, and intensity of the PL spectra measured from our samples, the carrier emission mechanism, electron-phonon scattering, electron-phonon interaction and thermal expansion effect on the band-gap are discussed. As the increasing of the Zn doping concentration from 0% to 7.5%, the PL peaks were shifted from 1.74 eV to 1.73 eV at 20 K. In addition, a noticeable blueshift of emission peaks was observed with increasing temperature for all the samples, which attributed to the effects of lattice thermal expansion and electron-phonon interactions. The PL intensity increases as the Zn doping concentration increases from 0% to 5% and then decreases as the doping concentration is 7.5%. It implies that Zn doping lowers the defect density in QDs by reducing lattice distortion and enhancing crystal quality; but under higher doping concentration, the dopants may not have enough time to move into the right positions of the structure, result in the degradation the thin film quality. Furthermore, the PL intensity decreases with increasing temperature for all the samples; however, the sample with 5% Zn doping concentration exhibited the highest intensity at 300 K. It reveals that the optical properties of $CsPbI_3$ QD thin films was improved by an appropriately increasing Zn doping.

MB-ThP-4 Improved Photovoltaic Performance of Si-Based Hybrid Solar Cells via Mo_2C Bridging in 2D MoS_2 nanosheets @ 0D Carbon Colloid Dots*, Ta-Cheng Wei [dv8756713@gmail.com], Chia-Yun Chen,* National Cheng Kung University (NCKU), Taiwan*; Chih-Chiang Yang,* National Yunlin University of Science and Technology, Taiwan

Recent advances in silicon-based hybrid solar cells, distinguished by high photovoltaic efficiency, low production costs, and strong environmental resilience, position them as promising candidates for solar energy conversion.[1] Solution-processed few-layer MoS_2 sheets enhance solar capture, but improved charge separation is essential, and their moisture sensitivity limits stability by attracting electrons. [2] This study introduces MoS_2/Mo_2C/carbon colloid dots (CCDs) heterostructures within a PEDOT:PSS matrix, utilizing Mo_2C electron-transport channels to facilitate the transfer of photoexcited electrons from MoS_2. This configuration fosters positive trion formation via interactions with defect-bound excitons on CCD surfaces, reducing recombination rates and enhancing photovoltaic performance. [3, 4] To elucidate carrier transfer mechanisms in these heterostructures, MoS_2@CCD heterojunctions with Mo_2C bridging interfaces facilitate efficient electron transfer. Photoluminescence (PL) enhancement factors (β) were used to characterize trion emissions across HT interfaces compared to intrinsic trion emissions in CCDs, by analyzing three distinct MoS_2@CCD blends within a PEDOT:PSS matrix, grounded in fundamental transport phenomena. [5] This design achieves a 16.1% efficiency, 1.6 times higher than conventional hybrid solar cells, with outstanding long-term stability, advancing photophysical bound-carrier research in photovoltaics.

[1]T. C. Wei, S. H. Chen, C. Y. Chen, Mater. Chem. Front. **2020**, 4, 3302.

[2]G. H. Lee, X. Cui, Y. D. Kim, G. Arefe, X. Zhang, C. H. Lee, F. Ye, K. Watanabe, T. Taniguchi, P. Kim, ACS Nano. **2015**, 9, 7019.

[3]T. Kim, S. Fan, S. Lee, M.-K. Joo, Y. H. Lee, Sci. Rep. **2020**, 10, 13101.

[4]A. Behranginia, P. Yasaei, A. K. Majee, V. K. Sangwan, F. Long, C. J. Foss, T. Foroozan, S. Fuladi, M. R. Hantehzadeh, R.

Shahbazian-Yassar, Small. **2017**, 13, 1604301.

[5]L. Zhang, A. Sharma, Y. Zhu, Y. Zhang, B. Wang, M. Dong, H. T. Nguyen, Z. Wang, B. Wen, Y. Cao, Adv. Mater. **2018**, 30, 1803986.

MB-ThP-5 Top-Emitting QLEDs with a Thin Stabilizing Layer to Prevent Ag Agglomeration*, Jaehyung Park [parkja0404@kyonggi.ac.kr], Kangsuk Yun, Jaehwi Choi, Jiwan Kim,* Kyonggi University, Republic of Korea

Colloidal quantum dots (QDs) are semiconductor nanoparticles composed of a core, shell, and organic ligands. They have unique optical and electrical properties due to quantum confinement effects, which enable the bandgap to vary with particle size. This characteristic allows easy modification of emission wavelengths, producing various colors of light. QDs are compatible with solution process and notable for their narrow full-width at half-maximum for the high color purity. Due to these advantages, quantum dot light emitting diodes (QLEDs) that use QDs as light emitting layers are being recognized as a promising next-generation display technology. In the field of AR/VR devices, Organic Light Emitting Diode on Silicon (OLEDoS) has received significant attention recently. This technology uses silicon as a substrate and emits light from the top with micropatterned structure, thus research on top-emitting devices is essential. However, there is still limited research on QLEDs in this area.

In top-emitting quantum dot light emitting diodes (TQLEDs), a transparent metal such as Ag is commonly used as the top electrode due to its high transparency and electrical conductivity. However, the deposition of thin Ag layer to achieve high transparency leads to agglomeration, which prevents the formation of a uniform layer, and results decreased conductivity. In this study, we used 2,2',2''-(1,3,5-Benzinetriyl)-tris(1-phenyl-1-H-benzimidazole) (TPBi) as a stabilizing layer to suppress the agglomeration of Ag in TQLEDs. TPBi has high electron affinity, which makes it effective in interacting with Ag to inhibit agglomeration. Various thickness of TPBi was applied to investigate the change of Ag agglomeration. As a result, the transmittance of transparent top electrode was over 50%, and TQLEDs incorporating TPBi as a stabilizing layer successfully achieved a maximum luminance exceeding 100,000 cd/m^2. Enhanced top electrode can provide another approach to improve the performance of top-emitting devices.

MB-ThP-6 Impact of Chlorine Incorporation on the Electrical and Structural Properties of Solution-Processed a-IGZO TFTs*, Giyoong Chung [qu3xing29@gmail.com], Dae Woong Kim, Yong-Sang Kim,* Sungkyunkwan University (SKKU), Republic of Korea

We investigated the influence of chlorine incorporation on solution-processed amorphous indium-gallium-zinc oxide (a-IGZO) thin-film transistors (TFTs). During the TFT fabrication process, materials inevitably interact with unintended elements. Notably, chlorine is an essential component in various stages of TFT fabrication, including as a precursor for metal oxide deposition and as a dry etching gas, making exposure to chlorine nearly unavoidable. Therefore, understanding chlorine's role in affecting the electrical and material properties of TFT devices is crucial.

In this study, we immersed a-IGZO films in NaCl solution to incorporate chlorine into the films. X-ray Photoelectron Spectroscopy (XPS) analysis revealed that chlorine formed bonds with metals and increased oxygen vacancies (Vo). The area ratio of M-O was lower in the IGZO thin film soaked in NaCl, reaching 46.5%, compared to 52.8% in the unsoaked film. Additionally, the concentration of oxygen vacancies, which can act as trap sites in the oxide channel layer, increased from 38.0% in the unsoaked sample to 44.4% in the NaCl-soaked sample. This structural change led to a degradation in IGZO's electrical performance. Compared to pristine TFTs, the saturation mobility of a-IGZO TFTs soaked in NaCl solution decreased from 1.46 to 0.20 $cm^2/V\cdot s$, while the subthreshold slope increased from 0.38 to 0.99 V/dec, indicating higher defect density. XRD analysis showed that soaking in NaCl solution did not alter the film's crystallinity. Furthermore, we compared the impact of chlorine diffusion on IGZO films deposited via the sputtering process. These findings suggest that chlorine exposure during fabrication must be carefully controlled to achieve the desired electrical performance targets for a-IGZO TFTs.

MB-ThP-7 Electrochemical Insights into All-Solid-State Symmetric Supercapacitors Based on Sputter-Grown WSe_2*, Akshay Tomar [atomar@ic.iitr.ac.in], Somdatta Singh, Ananya Bansal, Prachi Gurawal, Ramesh Chandra,* IIT Roorkee, India

All-solid-state supercapacitors represent a promising advancement in energy storage technology, providing superior energy density, enhanced safety, and a compact design compared to conventional supercapacitors and batteries. Their potential as flexible, bendable, and wearable energy storage solutions have garnered significant interest. The capacitance and energy density of supercapacitors can be improved through the introduction of novel electrode materials or by utilizing electrolytes with high potential windows. In this study, we successfully fabricated a high-quality porous thin film of tungsten diselenide (WSe_2) on a flexible graphite substrate using an environmentally friendly DC magnetron sputtering technique, without the need for additives or binders, under optimized conditions. The resulting thin film exhibited a nanoflake morphology with an increased surface area, which provided a greater number of active sites for ion adsorption and desorption, thereby enhancing both capacitance and energy density. The WSe_2@graphite composite demonstrated a remarkable specific capacitance of 310 F/g at a scan rate of 10 mV/s, with 95% capacitance retention after 5000 charge-discharge cycles in a three-electrode configuration. An all-solid-state flexible symmetric supercapacitor (FSS) device was subsequently constructed, utilizing WSe_2 as both the cathode and anode, separated by a highly flexible 6M KOH/PVA solid-state gel electrolyte. This device achieved a high cell voltage of 1.4 V and an excellent specific capacitance of 38.932 F/g at a scan rate of 50 mV/s. Comprehensive electrochemical performance analyses, including charge-discharge measurements at varying current densities, revealed a specific capacitance of 17 F/g, an energy density of 4.62 mWh/g, and a power density of 3457 mW/g, along with outstanding electrochemical stability of 92% after 5000 cycles at a current density of 5 mA/g. The exceptional electrochemical performance, combined with the flexible characteristics of the WSe_2@graphite thin-film-based symmetric supercapacitor, positions this device as a promising candidate for the development of next-generation flexible, bendable, and wearable energy storage systems.

MB-ThP-8 Highly efficient of QLEDs Using SnO_2 Electron Transport Layers Deposited by RF Sputtering*, Jaehwi Choi [jksix@kyonggi.ac.kr], Jaehyung Park, Kangsuk Yun, Jiwan Kim,* Kyonggi University, Republic of Korea

Colloidal quantum dots (QDs) are semiconductor nanoparticles with unique optical and electrical properties. By controlling particle size, QDs can exhibit various colors and provide excellent color reproducibility. Due to these advantages, quantum dot light-emitting diodes (QLEDs) using QDs as the emissive layer are studied actively. In QLEDs, the electron transport layer (ETL) is essential for electron transport and charge balance, and optimizing ETL can enhance device stability and efficiency. In general, ZnO nanoparticles (NPs) are commonly used as ETL for their high electron mobility and transmittance. However, ZnO NPs aggregate easily at room temperature, leading to reduce stability. Therefore, SnO_2, which offers high electron mobility, transmittance, and excellent stability, is gaining attention as an ETL material. Typically, the ETL is deposited via solution processes like spin coating, but this method has challenges such as difficulty in thickness control, poor crystallinity and uniformity of the thin films. In this study, we deposited SnO_2 as the ETL using RF sputtering process for high reproducibility and excellent crystallinity. It is well known that crystallinity of inorganic materials are directly related to their electrical properties. To adjust the physical and chemical properties of SnO2thin film, we controlled the substrate temperature and Ar/O2ratio during RF sputtering while fabricating inverted devices with the structure of ITO/SnO_2/QDs/CBP/MoO_3/Al. As the substrate temperature increased, the crystallinity of sputtered SnO_2 thin film improved, which leaded the enhancement of electron mobility and improvement of electrical properties of devices. QLEDs employing the optimized SnO_2 ETL exhibited more than 120,000 cd/m^2 and a current efficiency of 15 cd/A which showed comparative performance with QLEDs using soluble SnO2NPs as an ETL. Additionally QLEDs with sputtered ETL showed better stability due to the uniform SnO_2 layer, which is advantage for practical display mass production.

MB-ThP-9 Optimizing Y_2O_3 Coating for Improving Plasma Resistance in Dry Etching Process*, Sunil Kim [sunil725.kim@semes.com], Sunghwan CHO, Ja Myung Gu, Seungpil Chung, Gil Heyun Choi,* SEMES Co., Ltd., Republic of Korea

Plasma-resistant Y_2O_3 coating is essential for extending the durability and replacement cycles of semiconductor components that face intense etching conditions. Plasma etching typically involves both physical ion bombardment and chemical reactions with surface. To counter these effects, recent advancements in Y_2O_3 coating focus on enhancing etch resistance and film density through physical vapor deposition (PVD) methods. While several studies have aimed to further improve the plasma resistance of PVD Y_2O_3 coatings by increasing hardness, our observations suggest that beyond a certain hardness threshold (>900 HV), the relationship between hardness and plasma resistance became weak. Consequently, this study focuses on the characteristics of residual surface stress as a primary factor influencing plasma resistance. The residual stress in the coating was measured using X-ray diffraction (XRD) equipment and calculated based on the peak shift observed with varying psi angles. Comparing residual stress and plasma resistance in PVD Y_2O_3 coatings manufactured under identical conditions, we found that coatings with tensile surface stress exhibited approximately 25% better plasma etch resistance than those with compressive stress. Although both coatings displayed similar grain size and hardness, the superior plasma-resistant coating demonstrated a tensile surface stress of around 600 MPa, whereas the less resistant sample had a compressive stress of approximately 300 MPa. This enhanced resistance in tensile-stressed coatings can be attributed to channeling effects, where the increased atomic spacing prevents accelerated plasma ions from interacting directly with atoms, allowing them to pass through specific crystallographic directions without obstruction. This study aims to establish a better understanding of the correlation between surface residual stress and plasma etch resistance in PVD Y_2O_3 coatings and to propose new criteria for evaluating such coatings, ultimately contributing to enhanced performance in etching equipment.

MB-ThP-10 Electrical and Morphological Properties of Alloyed Al_2O_3 Thin Films at High Temperatures, ***Norma Salvadores Farran [norma.salvadores@tuwien.ac.at]****, Florentine Scholz, Tomasz Wojcik,* Christian Doppler Laboratory for Surface Engineering of high-performance Components, TU Wien, Austria*; Carmen Jerg, Astrid Gies, Jürgen Ramm,* Oerlikon Balzers, Oerlikon Surface Solutions AG, Liechtenstein*; Szilard Kolozsvári, Peter Polcik,* Plansee Composite Materials GmbH, Germany*; Jürgen Fleig, Tobias Huber,* Institute of Chemical Technologies and Analytics, TU Wien, Austria*; Balint Hajas,* Institute of Materials Science and Technology, TU Wien, Austria*; Helmut Riedl,* Christian Doppler Laboratory for Surface Engineering of high-performance Components, TU Wien, Austria

Aluminium oxide (Al_2O_3) is a well-known insulating material employed in a wide range of applications, both as structural component as well as in thin film form. Al_2O_3 can be stabilized in several polymorphs, in addition to an amorphous modification. Especially the amorphous state of Al_2O_3 exhibits interesting features, considering the absence of crystalline defects for diffusion of charge carriers paired with the difficulties in stabilizing crystalline Al_2O_3 during physical vapor deposition (PVD). Furthermore, amorphous materials are free of pinholes, which is favourable for a number of applications. Consequently, it is crucial to investigate economically and sustainably viable deposition techniques to grow insulating Al_2O_3 thin films.

Therefore, this study focuses on the effect of alloying elements such as silicon and yttrium-zirconium (YZr) on the thermal stability of amorphous Al_2O_3 based thin film materials up to 1200°C. The amorphous Al_2O_3 thin films have been synthesised via a reactive Modulate Pulse Power (MPP) sputtering processes. In all depositions, an in-house developed sputter system, equipped with a 3" Al target, was used in a mixed Ar/O_2 atmosphere. To this end, two types of targets were employed: an Al-Si target and Al-YZr target. The impact of the deposition parameters on the structure, morphology, and electrical resistivity at high temperatures was investigated using high-resolution characterization methods such as XRD, SEM, HR-TEM or in-situ set-ups for annealing treatments. The insulating behaviour of the coatings was analysed using in-situ impedance spectroscopy across a temperature range. Ti/Pt electrode pads were deposited on the thin films using a lithography process for the purpose of electrical characterization. In addition, the bonding type was investigated via XPS, which was also employed to determine the chemical composition across the thickness of the coating.

MB-ThP-11 Analysis of Four-Point Bending Test for Nb, Ta, and V-Doped CrYN Thin Films Deposited by Closed-Field Unbalanced Magnetron Sputtering*, Banu YAYLALI, Gokhan Gulten, Mustafa YESILYURT, Yasar TOTIK,* Atatürk University, Turkey*; Justyna Kulczyk Malecka, Peter Kelly,* Manchester Metropolitan University, U.K.*;* ***Ihsan Efeoglu [iefeoglu@atauni.edu.tr]****,* Atatürk University, Turkey

The increasing expectations and requirements for engineering materials are steadily compelling researchers to evolve and innovate further. Adding transition metals to coating architectures is becoming increasingly attractive as it improves structural and mechanical properties. In this work, CrYN thin films incorporating transition metals Nb, Ta, and V were deposited on a 316L stainless steel substrate using Closed Field Unbalanced Magnetron Sputtering (CFUBMS) with a DC and pulsed-DC power supply. The microstructural properties of the thin films were analyzed using scanning electron microscopy (SEM), while X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) provided a comprehensive understanding of the coating structure by providing information on crystallographic and surface chemical properties. Mechanical properties were evaluated using nanoindentation testing, which provided accurate measurements of hardness and elasticity, while scratch testing assessed critical load values. In addition, four-point bending tests were performed at room temperature to characterize the CrYN:Nb/Ta/V transition metal nitrides (TMNs), providing a more comprehensive analysis of the mechanical behavior (flexural strength and elastic modulus) and adhesion properties of the coating. The mechanisms of coating damage (crack formation and density, spalling, flaking, and separated coating particles) were analyzed as a result of four-point bending tests. The Taguchi approach was employed to investigate how deposition parameters—such as target current, duty cycle, and pulse frequency—affect elastic modulus and bending strength. Superior structural (homogeneous and dense film) and mechanical properties (CrYN:Nb/Ta/V high hardness values of 21.4, 18.2, 16.1 GPa, and bending strengths of 707, 711, and 697 MPa, respectively) were obtained. The positive correlation between hardness and bending strength points to an enhancement in the overall durability of the thin film.

MB-ThP-12 Halide-Treated ZnMgO Nanoparticles for Improving Stability of InP Based Quantum-Dot Light-Emitting Diodes, ***Kangsuk Yun [riverstone@kyonggi.ac.kr]****, Jaehyung Park, Jaehwi Choi, Jiwan Kim,* Kyonggi University, Republic of Korea

Quantum dots (QDs) are nanometer-sized semiconductor particles, and Quantum Dot Light Emitting Diodes (QLEDs) are electroluminescent devices that use QDs as an emitting layer. As QD size decreases, the quantum confinement effect enhances the discreteness of energy levels, leading to an increased bandgap. Consequently, by manipulating the size of QDs, it is possible to produce various colors of light and enhance color purity by narrow full width at half maximum. ZnMgO NPs, which are currently used as the electron transport layer (ETL) in QLEDs, are actively researched due to their high electron mobility and chemical stability. However, there are inevitable oxygen vacancies in thin films using ZnMgO NPs, which reduce the performance of QLEDs by exciton quenching. In this study, we used ZnMgO NPs as the ETL to fabricate InP QD-based QLEDs, which consisted of multilayers: ITO/ZnMgO/red InP QDs/CBP/MoO_3/Al. First, we formed ZnMgO NPs film on ITO glass and passivate halides on ZnMgO NPs to reduce oxygen vacancies. New Zn-halide and Mg-halide peaks were observed in the x-ray photoelectron spectroscopy. Additionally, photoluminescence (PL) measurements showed that halide-treated ZnMgO NPs exhibited a higher PL intensity compared to untreated ZnMgO NPs. These results indicate that the halide treatment effectively reduces oxygen vacancies in ZnMgO NPs, and its effect was verified with the inverted structured QLEDs. The maximum luminance of QLEDs with halide-treated ZnMgO NPs (h-QLEDs) showed 1,134 cd/m^2, compared to 696 cd/m^2 for the QLEDs with pristine ZnMgO NPs (p-QLEDs). After aging for 48 hours in a nitrogen atmosphere, h-QLEDs showed 1,290 cd/m^2, but the performance of p-QLEDs decreased dramatically to 64.67 cd/m^2. The experimental results indicated that the halide-treated ZnMgO NPs enhance the optical properties and stability of QLEDs, which can contribute QDs display commercialization.

MB-ThP-13 Inkjet Printing of Silver Film on Polydimethylsiloxane for Soft Electronics, ***Hsuan-Ling Kao [snoopy@mail.cgu.edu.tw]****,* Chang Gung University, Taiwan*; Li-Chun Chang,* Mingchi University of Technology, Taiwan*; Min-Hsuan Lu,* Chang Gung University, Taiwan

As the development of fifth-generation mobile communication technology expands into medical intelligence, the demand for flexible and wearable devices has increased significantly. The flexible polymer substrates are very promising for expansion into millimeter wave band applications. Among these polymers, Polydimethylsiloxane (PDMS) has recently gained much attention for the development of wearable antennas, sensors, and RF switch. PDMS is a transparent and colorless high molecular polymer with biocompatibility. Its mechanical properties are similar to human skin (elastic modulus ~2 MPa) and can be smoothly attached to the surface of object. Therefore, PDMS is like human skin and can be attached to various parts of the human body, making it an electronic skin for biological monitoring. In order to fabricate electronic devices on these flexible plastic materials, the interconnection using metal layers are essential. However, PDMS is softer than other flexible substrates, and its surface has poor wettability, making it difficult for the metal layer to adhere. Therefore, traditional production methods such as transfer printing or screen printing cannot be used to produce electrodes. Inkjet printing technology is used to deposit metal films on PDMS using non-contact material deposition and digital patterning. The inkjet printing technology can produce highly conductive films at a lower process temperature, without the need for etching steps and the process is simple. In this work, Inkjet-printed silver thin film on PDMS substrate process was established. First, the PDMS surface uses plasma technology to control its energy and time to convert hydrophobicity into hydrophilicity. Then, silver films were printed onto PDMS substrate, followed by curing in an oven to remove excess solvent and material impurities. Multi-pass printing is required to achieve good conductivity and enough thickness.The conditions for plasma treatment of PDMS were examined by water contact angle to optimize surface wettability. The conductivity, thickness and surface morphology of the printed metal film depend on the printing thickness and sintering temperature. The conductivity and surface morphology were measured using the four-probe method and SEM photos. The optimization of inkjet printing process and surface treatment study of inkjet-printed silver film were presented with details. Based on optimal conditions, inkjet-printed silver lines on PDMS substrate were implemented to study the RF performance. The results demonstrate that inkjet printing of metals on PDMS substrates offers the feasibility of soft electronics.

MB-ThP-14 Magnetoelectric Sensors for Flexible MEMS Applications*,*
Davinder Kaur [davinder.kaur@ph.iitr.ac.in]*,* Indian Institute of Technology Roorkee, India

Magnetoelectric Sensors (ME) have the potential to contribute to sustainable development because of their peculiar features such as lower power requirement, enhance energy efficiency, reduced environmental impact, applications in renewable energy, enable precision agriculture, infrastructure monitoring, health monitoring, optimize waste management, and contribution to overall resource conservation. The present study reports the fabrication of highly flexible, cost-effective, nano-structured magnetic field sensor comprising AlN/Ni-Mn-In ME heterostructure fabricated over magneto strictive Ni foil. The ultra-low magnetic field up to or less than ~1 µT has been easily detected from the fabricated sensor. Further the surface acoustic wave (SAW) delay line-based piezo resonator has been fabricated over highly flexible AlN/Ni-Mn-In/Kapton for flexible MEMS application. The fabricated device resonates at ~1.40 GHz. The effect of the external magnetic field on the resonance frequency (fR) of the device has been investigated and tunability (ΔfR/fR) ~9% was observed. The device displays high sensitivity of ~0.94 Hz/nT at room temperature. The alteration in the fR can be attributed to the ΔE-effect in the AlN/Ni-Mn-In heterostructure. The flexibility of the fabricated magnetic field sensors has been investigated in terms of the bending cycles and bending angle. The sensor characteristics remain unchanged up to ~ 2500 bending cycles. The integration of these novel ferromagnetic shape memory alloy (FSMA, i.e., Ni-Mn-In) based flexible piezo-resonator into various systems can enhance efficiency, reduces environmental impact, and contributes significantly to the overarching goal of sustainable development.

Keywords: Ferromagnetic shape memory alloys, flexible magnetic sensor, lead-free piezoelectric, magnetostrictive effect, surface acoustic waves (SAW).

MB-ThP-15 Flexible UV-Vis photodetectors based on NiOx thin film obtained by magnetron r.f. sputtering*,*
Eddue Osuna-Escalante [eddue.osuna@uabc.edu.mx]*, David Mateos-Anzaldo, Oscar Pérez-Landeros, Roumen Nedev, Ivan Cardoza-Navarro, Esteban Osorio-Urquizo, Mario Curiel-Álvarez, Nicola Nedev,* Universidad Autónoma de Baja California, Mexico

Flexible optoelectronic devices based on transparent substrates are attracting interest for potential applications in wearable sensors, flexible displays and transparent electronic devices. Among various fabrication techniques, magnetron r.f. sputtering stands out for preparation of high-quality films. The principal advantages of this technique are high adhesion, low density of defects, high compatibility with flexible substrates, and control over the deposited material composition.

Flexible photodetectors based on NiO_x deposited by magnetron r.f. sputtering at room temperature and 50°C, using powers in the range of 40-80W over ITO-PET and ITO-PEN substrates were fabricated. The obtained films were evaluated using ellipsometry to determine their thicknesses and optical constants. Thermal evaporation was used to deposit Au as top electrodes.

To assess the performance as photodetectors in the UV-visible spectrum, the fabricated devices were electrical characterized by current-voltage measurements in dark and under the incidence of different light emitting diodes. In addition, the fabricated flexible photodetectors were tested for mechanical and electrical stability after cyclic bending stress.

MB-ThP-16 Large Area Synthesis of Hexagonal Boron Nitride Layers on SiO2/Si Substrates*,*
Diego Lundquist Lundquist [dlundquist7949@sdsu.edu]*, Abinash Bhuyan, Mary Becker, Jennifer Brumley, Sanjay Behura,* San Diego State University, USA

__Diego Lundquist__,C. Abinash Bhuyan, Mary Becker, Jennifer Brumley, Sanjay K. Behura*

Department of Physics, San Diego State University, San Diego, CA 92182, United States

Hexagonal boron nitride (h-BN) is a two-dimensional material that has recently been the focus of research for hosting single photon emitters at room temperature. Its spin-optical properties make an ideal candidate for quantum technologies. Existing research relies on exfoliated hBN for its application which restricts its scalability for various practical applications. Also, the current synthesis of chemical vapor deposition grown hBN is on catalytic substrates such as Cu, Al, Ni, and Co. As a result, hBN film is transferred onto desired substrates for photonics applications. This study focuses on synthesizing large-scale hBN film on dielectric substrates, which allows for direct characterization of its high optical properties. Through the optimization of a two-zone, low-pressure chemical vapor deposition (LPCVD), hBN grown directly on SiO_2/Si substrates using the sublimation of ammonia borane complex as precursor and ultra-high pure H_2 as carrier gas. CVD-grown hBN films were characterized to confirm the large-area growth. Typical optical and scanning electron microscopic images reveal the uniform growth of hBN on SiO_2/Si substrate. Raman spectroscopic measurement reveals the signature peaks at 1368 cm^{-1} which corresponding to E^{2g} in-plane B-N vibrational modes in hBN.

MB-ThP-17 Influence of partial pressure of argon/oxygen and temperature on photosensors based on n-Si/NiO_x*,*
Esteban Osorio [esteban.osorio@uabc.edu.mx]*,* Autonomous University of Baja california, Mexico*; David Mateos-Anzaldo, Mario Curiel-Alvarez, Eddue Osuna Escalante,, Oscar Perez-Landeros, Ivan Cardoza-Navarro, Roumen Nedev, Benjamin Valdez-Salas, Nicola Nedev,* Autonomous University of Baja California, Mexico

This work reports photosensors based on non-stoichiometric nickel oxide obtained by radio-frequency magnetron sputtering on n-Si substrates in a mixed atmosphere of argon/oxygen. The amount of oxygen was varied from 0-4% of the total atmosphere. Also the deposition temperature was varied in the range of 0-100°C. Corning glass substrates were also used to determine the band gap and transparency of the obtained film. The photosensors were characterized by ellipsometry in a 350 to 1000 nm range. Au (~400nm) deposited by thermal evaporation was used as top and back contact for electrical characterization. Current-voltage measurements were performed in a dark chamber under red, green, blue and UV illumination.

MB-ThP-18 Topological Insulator, Reduced Graphene Oxide/Silicon Nanowire Arrays for Ultra-Broadband Photodetectors*,*
Hsu Hsun-Feng [hfhsu@dragon.nchu.edu.tw]*, Huang Tzu-Yun,* National Chung Hsing University, Taiwan

Topological insulator, such as bismuth telluride (Bi_2Te_3), has narrow bulk band gap and has a Dirac-type surface stat. Thus, it can absorb middle or long-wavelength infrared light and has low resistivity. Graphene, which is a 2D material, exhibits broadband light adsorption and a rapid response due to its Dirac cone structure. Therefore, graphene is an expected material for broadband photodetectors. Its drawbacks are the properties of a high electron-hole recombination rate and a low photoresponse. However, reduced graphene oxide (rGO) has lower electron-hole recombination rate comparing with graphene due to its functional group and edge defects. Silicon has become very popular for many applications because of the unique advantages of CMOS compatibility and high integrated density. Silicon nanowire (SiNW) array has low reflectivity that can raise light harvesting efficiency. Thus, in this study an ultra-broadband photodetector was fabricated by combining with the Bi_2Te_3, rGO and SiNW array.

The silicon substrate is etched using metal-assisted chemical etching to an obtain SiNW array. Then, Bi_2Te_3 was deposited on SiNW array by chemical vapor deposition (CVD). Using photocatalytic reduction to reduce graphene oxide on a SiNW array to form a thin film. Finally, silver electrodes are deposited on both sides of the specimen to create a device. Optical sensing is performed using 940 nm near-infrared light and 5500 nm mid-infrared light.

The results show that, under suitable process conditions using by CVD, Bi_2Te_3 and tellurium (Te) precipitates with a size of approximately 500 nm can be formed on the SiNW array. It can reduce the reflectance of the device in the near- to mid-infrared range (1200–2500 nm). For sensing 940 nm near-infrared light, the light is primarily absorbed by the SiNW array, generating electron-hole pairs that increase carrier concentration and produce photocurrent. The rGO coating can reduce the contact resistance between the electrode and the silicon nanowires, enhancing the responsivity and sensitivity of the photodetector. When irradiated with mid-wavelength infrared light at 5500 nm, the Bi_2Te_3/SiNW array device also exhibits a rapid response characteristic. The reason is that, upon illumination, electron-hole pairs are generated in the Bi_2Te_3 particles. Electrons are conducted through the SiNW to the electrodes, producing a photocurrent in the external circuit. Notably, the rGO/Bi_2Te_3/SiNW device with a mesh-like rGO film, compared to a fully covered rGO film, demonstrates superior responsivity and faster response times in sensing both 940 nm near-infrared light and 5500 nm mid-infrared light.

MB-ThP-19 Microstructural Evolution of Co-Sputtered Nanocrystalline Cu-Ag Alloy Thin Films During Annealing Process, ***Yu-Lin Liao* [20193eileen@gmail.com]**, College of Semiconductor Research, National Tsing Hua University, Taiwan; *Tsai-Shuan Kuo, Fan-Yi Ouyang,* Department of Engineering and System Science, National Tsing Hua University, Taiwan

Copper and silver films, known for excellent conductivity, are widely used as conductive layers in semiconductors. In 3D IC technology, direct bonding replaces solder balls to reduce RC delay and power consumption. To understand the potential of copper-silver alloys for direct bonding, it is very important to understand the properties and structure of copper-silver films. In the study, we investigate the microstructural evolution of the two-phase Cu-Ag alloy films during the annealing process with different doping concentrations and annealing temperatures for 1, 24 and 48 hours respectively. Oversaturated fine crystalline Cu-Ag alloy films with doping levels of 20 at.% and 40 at.% of Ag were fabricated using a magnetron sputtering system. The films were then annealed at four temperatures, i.e. 200℃, 250℃, 300℃, and 400℃ to understand their thermal stability and property evolution. The results show that Cu concentration on the surface slightly increases with rising annealing temperature after annealing for 1 and 24 hours. But when the annealing temperature increased to 400℃, the rich Ag, instead of Cu, was accumulated to the surface of the films. In addition, Oversaturated solid solution films were annealed at 3 different vacuum levels(1×10^{-6} torr, 5×10^{-3} torr, and 760 torr). The microstructural and property evolution during annealing and the corresponding mechanism will be discussed in detail.

MB-ThP-20 Multifunctionality in Frequency Tuning of PMN-PT/Ni-Mn-In Integrated Film Bulk Acoustic Wave Resonator for Flexible MEMS Applications, ***Diksha Arora* [diksha@ph.iitr.ac.in]**, *Davinder Kaur,* Indian Institute of Technology Roorkee, India

Flexible and tunable bulk acoustic wave (BAW) resonators are opening new possibilities in flexible MEMS, wireless devices, and wearable magnetic sensors. This work presents a highly adaptable thin-film BAW resonator constructed with a PMN-PT piezoelectric layer positioned between magnetostrictive Ni−Mn−In electrodes on a flexible Ni substrate. This device, operating at a resonance frequency (f_R) of 5.31 GHz, demonstrates significant tunability via both magnetic and electric fields. A magnetic field of 1200 Oe produces an f_R shift of approximately 450 MHz, achieving a sensitivity of around 3.75 Hz/nT and an impressive 9.6% tunability. Similarly, a 10 V DC bias yields an f_R downshift of roughly 360 MHz, with electric field sensitivity and tunability measured at about 36 Hz/μV and 6.8%, respectively. The device's resonance performance aligns with the modified Butterworth–Van Dyke model, and its quality and reliability remain intact through 3,000 bending cycles, underscoring its potential in advanced flexible electronics, tunable MEMS, and magnetic sensors.

MB-ThP-21 Fabrication and Properties of Zinc Oxide Thin Film Prepared by Thermal Evaporation Method, ***Bassel Abdel Samad* [bassel.abdel.samad@umoncton.ca]**, *Zackaria Kabore,* Université de Moncton, Canada

Thin films of ZnO were deposited with a thickness of 50 nm using the thermal evaporationtechnique at different substrate temperatures during the deposition process. Optical measurementsof transmittance and reflectance were performed using a spectrophotometer, andthe film thickness was characterized using spectroscopic ellipsometry. Based on these measurements,the bandgap was calculated: it is 3.68 eV for the sample at room temperature and4 eV for the other temperatures. Additionally, the electrical properties were characterized usingan electrometer and a four-point probe. The resistivity values for the sample were foundto be in the order of gigohms (GΩ), and conductivity increased with rising temperature.Finally, the activation energy was calculated for a metallic sample with a Zn phase.

MB-ThP-22 High-Performance Methyl Mercaptan Gas Sensor based on Tellurene Nanowires for Breath Analysis Application, ***Yeonjin Je* [jejinjin7@gmail.com]**, *Sang-Soo Chee,* Korea Institute of Ceramic Engineering & Technology, Republic of Korea

Tellurene, 2D semimetallic material composed of tellurium atoms, exhibits exceptional sulfur compound gas sensing capabilities due to its strong affinity and a high hole mobility of 2000 cm^2/Vs. These distinct properties enable a rapid gas response time even at room temperature, in contrast to metal oxide-based gas sensors operating above 300 ℃. Among sulfur compound gas molecules, methyl mercaptan (CH_3SH) is a representative odor gas molecule and a biomarker for diagnosing halitosis disease. However, its sensing detection properties have not yet reported.Here, we investigated CH_3SH sensing characteristics of the tellurene nanowire-based sensor at room temperature. These gas responses increased from 52% (RH 0%) to 179% (RH 80%), with a faster response time of 24.5 s even under humid conditions. Furthermore, a superior limit of detection (LOD) of 18 ppb was achieved even at RH 80% for the first time. These noticeable detection performances are attributed to the synergistic interaction between water molecules and the surface of tellurene. We finally demonstrated a breath analysis module incorporating our Tellurene-based sensor to prove the feasibility for breath analysis application.This sensing platform represents a significant step toward practical gas sensors for oral health monitoring, combining high sensitivity, fast response, and humidity-enhanced performance to ensure reliable operation in real-time breath analysis.

This research was supported by the Environmental Technology Development Project (No. RS-2023-00219117) from the Korea Environmental Industry and Technology Institute (KEITI) and the Strategic R&D program funded by the Korea Institute of Ceramic Engineering and Technology (KICET) (No. KPP 24004-0-01).

MB-ThP-23 Enhanced Electrochemical Performance and Stability of Zinc-Ion Batteries Using Tellurium Nanowires, ***Hyun Tae Kim* [qscft8536@gmail.com]**, Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea; *Gyeong Hee Ryu,* Gyeongsang National University, Republic of Korea; *Sang-Soo Chee,* Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea

Aqueous zinc-ion batteries (ZIBs) have attracted significant attention as a promising technology for next-generation energy storage systems due to their safety, environmental friendliness, and high cost-effectiveness. However, practical applications of ZIBs face critical issues including dendrite growth, corrosion, and dissolution of the metallic Zn anode. Additionally, MnO_2-based cathodes suffer from poor wettability and low electrical conductivity, leading to significant performance degradation.

1D tellurium (Te) nanowires exhibits a good electrical conductivity with a good chemical stability, enhancing ZIB performances. Furthermore, Te atoms can electrochemically interact with Zn ions, leading to improved energy storage performance.

Here, we introduce 1D Te nanowires as a conductive additive for MnO_2 cathodes and as an anode protective coating layer, aiming to enhance the energy storage performance in ZIB.

First, Electrochemical analysis revealed that the integration of Te nanowires into the MnO_2 cathode significantly reduced charge transfer resistance while simultaneously enhancing energy storage performane. This improvement originates from the intrinsic 1D structure of Te nanowires, which facilitates better electron pathways for faster charge transport.

Second, Te nanowire coating on anode surface effectively suppressed dendrite formation and promoted uniform nucleation, resulting in enhanced cycling stability. The modified Zn anode exhibited capacities ranging from 344 to 160 mAh/g at current densities ranging from 0.3 to 2.0 A/g, while maintaining excellent stability over 200 cycles.

This study demonstrates that Te nanowires in both the MnO_2 cathode and Zn anode systems significantly enhance the electrochemical performance of ZIBs. This approach makes it a promising approach for next-generation aqueous ZIBs.

Acknowledgement

This research was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (RS-2023-00303581).

MB-ThP-24 Development of Functional Insulation and Wear Protection Layers for Coating Sensors, ***Martin Welters* [welters@kcs-europe.com]**, *Rainer Cremer,* KCS Europe GmbH, Germany

The mobility sector is one of the main emitters of greenhouse gases. Therefore, providers of mobility services and systems in particular are facing a profound transformation process towards climate neutrality. An important driver on the way to emission-free production is circular production. It enables a significantly lower primary resource requirement and thus reduced environmental impact. The overarching aim of the project is to improve the CO_2 and environmental balance of structural and hybrid components by implementing a consistent increase in efficiency, the use of recyclates and a weight optimized component design.

One sub-project of the association is concerned with the development and design of sensory tool inserts for in-situ temperature measurement during the manufacture of automotive components from recycled materials. The sensory layer system consists of several individual layers (sensor layer, electrical insulation layer and wear protection layer) which are applied on top of each other as a layer stack. KCS Europe is responsible for producing the insulation and wear protection layers. Vacuum coating processes such as physical vapor deposition or plasma-assisted chemical vapor deposition are used for this purpose. An essential requirement is usually that the coatings must meet the durability criteria required for the application in addition to the sensory requirements, especially for the use of polymer melts with recycled material components. In cooperation with the partners, new layer systems are being tested and systems are being provided for large-scale implementation.

MB-ThP-25 Sub-10nm Superlattice HZO on CMP-Planarized Metal Surfaces Achieving High Remanent Polarization and Endurance, *Zefu Zhao, Dun-Bao Ruan,* FZU-Jinjiang Joint Institute of Microelectronics, College of Physics and Information Engineering, School of Advanced Manufacturing, Fuzhou University, China; ***Qian Cheng Yang [455783022@qq.com],*** FZU-Jinjiang Joint Institute of Microelectronics, College of Physics and Information Engineering, School of Advanced Manufacturing, Fuzhou University, Fuzhou University, China; *Kai-Jhih Gan,* FZU-Jinjiang Joint Institute of Microelectronics, College of Physics and Information Engineering, School of Advanced Manufacturing, Fuzhou University, China; *Kuei-Shu Chang-Liao,* Department of Engineering and System Science, National Tsing Hua University, Taiwan

This work presents a novel approach to fabricating high-performance ferroelectric capacitors through atomic layer deposition (ALD) of sub-10nm $Hf_{0.5}Zr_{0.5}O_2$ (HZO) superlattices on chemically-mechanically polished (CMP) metal electrodes. The ultra-flat electrode surface (RMS roughness = 0.3 nm) enables precise control of crystallographic orientation, as confirmed by electron diffraction patterns showing c-axis alignment of orthorhombic-phase HZO along the deposition direction.

The optimized flat electrode system demonstrates superior interface quality with HZO, achieving a high remanent polarization ($2P_r$ = 63 μC/cm^2) in the sub-10nm thickness regime.

The ALD-grown HZO superlattice architecture, combined with CMP planarization, enables uniform electric field distribution. This interfacial engineering strategy results in outstanding endurance characteristics, maintaining 90% of initial polarization (56 μC/cm^2) through 1×10^{12} switching cycles.

This study establishes a manufacturable pathway for implementing high-performance ferroelectric memories in advanced nodes, demonstrating the critical role of metal electrode engineering in achieving reliable ferroelectricity in ultrathin HZO films.

MB-ThP-26 The duality of Thermal and Magnetic Properties of Ni-Ta Thin Films: A New Generation of Sensing Devices, ***Armando Ferreira [armando.f@fisica.uminho.pt],*** *Filipe Vaz, Cláudia Lopes,* University of Minho, Portugal

Nickel-Tantalum (Ni-Ta) thin films have emerged as promising candidates for multi-sensing applications, combining electrical, magnetic, and thermoelectric functionalities. In this study, Ni-Ta nanostructures were synthesized via DC magnetron sputtering and integrated into a prototype to evaluate their dual capability: sensing temperature variations and generating an electrical potential under a constant magnetic field. By tuning the Ta content, three compositional groups were identified, significantly affecting their structural and functional properties. Ni-rich films exhibited the lowest sheet resistance (~14 Ω/sq), while increasing Ta content induced higher magnetic disorder and enhanced the temperature coefficient of resistance (TCR), reaching 5.43×10^{-1} K^{-1} for a Ta/Ni ratio of 0.48. These results highlight the potential of Ni-Ta thin films as functional surfaces for thermoelectric energy harvesting and multi-sensing applications, making them promising materials for next-generation sensor technologies.

MB-ThP-27 Electrical and Physical Properties of Dual-Active Channel TFTs Composed of Controlled Hf Doped InGaSnO Layer and an InGaSnO-Only Layer, ***Seungjin Kim [epicus87@naver.com],*** *Byoungdeog Choi,* Sungkyunkwan University (SKKU), Republic of Korea

In this study, a dual-channel layer TFT was fabricated using HfO_2 and IGTO co-sputtering, and its electrical and physical properties were analyzed. Enhancing the reliability of amorphous metal oxide(AOS) based TFTs by strengthening metal-oxygen bonds through doping to reduce oxygen vacancies has been extensively studied. However, some reliability improvements achieved through doping have also been observed to cause side effects, such as reduced mobility and decreased on-current. To address these issues, this study fabricated TFTs with a dual-layer structure consisting of a pure InGaSnO layer and a Hf-doped layer, and examined their electrical and physical properties. Through the dual-layer channel structure, we were able to achieve both the high mobility characteristics of IGTO-only TFTs and the reliability improvement effects of the Hf-doped layer. The reliability changes were evaluated by measuring bias stress (PBS, NBS, PBIS, NBIS) according to the Hf doping concentration in the doped layer, and physical property changes were analyzed through optical transmittance, XPS, UV-vis, and AFM measurements. This study suggests an optimal device fabrication method that can improve the reliability issues caused by stress, a persistent problem in oxide semiconductors, without performance degradation.

MB-ThP-28 3D Structured Local Thin Film Deposition by Direct Atomic Layer Deposition (DALP™), ***Mira Baraket [mbar@atlant3d.co],*** ATLANT 3D Nanosystems, Denmark

Advancements in chemical and physical deposition techniques for thin films and coatings are paramount for academic research and industrial applications in many technologies such as electronics, energy, and MEMS. Recent trends point to deposition technologies that combine flexibility, scalability, and material versatility. While traditional methods like Chemical Vapor Deposition (CVD) and Atomic Layer Deposition (ALD) offer high-quality film deposition, they often face challenges in patterning, complex structure fabrication, and process adaptability. Overcoming these limitations typically requires additional pre- or post-processing steps (such as lithography), which increase both processing time and cost, limiting their efficiency for next-generation applications.

Here, we introduce Micro Direct Atomic Layer Processing (μDALP™), a novel, atmospheric-pressure, direct-write deposition technology that expands ALD into localized, high-precision thin film printing (Figure 1). Unlike conventional ALD, μDALP™ enables complex structured coatings and seamless material transitions. Moreover, it allows deposition in ambient pressure, eliminating vacuum-related throughput limitations, and eliminates the need for lithography for some applications, significantly enhancing scalability for industrial applications. In particular, μDALP™ allows 3D designs with sub-nanometer control over the thickness profile of the film (Figure 2), making structures such as gradients, wells, and combs accessible easily.

μDALP™ adaptability and versatility open new possibilities for designing, developing, and producing next-generation thin film-based devices. By leveraging μDALP™'s capability for pre-programming the print shape and material transitions during deposition, we significantly accelerate device validation and optimization, dramatically reducing R&D costs.

In this talk, we will present the key advantages of μDALP™ for disruptive devices, multi-material integration, rapid material discovery, and direct-write patterning of functional thin film

MB-ThP-29 Effect of Amino Ligands of Aminosilane Precursors in Low-Temperature Silicon Nitride Plasma-Enhanced Atomic Layer Deposition (PEALD) for Moisture Barrier Films, ***Hyeonjin Choi [hyonjin0918@gmail.com],*** *Jinmyeong Kim, Youngju Ko, Heeyeop Chae,* Sungkyunkwan University (SKKU), Republic of Korea

In this work, the effect of amino ligands in aminosilane precursors on low-temperature plasma-enhanced atomic layer deposition (PEALD) of silicon nitride (SiN_x) for moisture barrier films was investigated. Silicon precursors including (tert-butylamino)dimethylsilane (TBADMS), bis(tert-butyl)aminosilane (BTBAS), and tris(dimethylaminosilane) (TDMAS) were compared in the PEALD process. TBADMS contains one tert-butylamine ligand, BTBAS contains two, and TDMAS contains three dimethylamine ligands. Quadrupole mass spectrometry (QMS) was used to analyze reactive species during the precursor dosing step.For TBADMS and BTBAS, the detected species included H, CH_x, SiH_x, tBu, and NHtBu, whereas for TDMAS, H, CH_x, and $[(CH_3)_xN]ySi$ were identified. The radicals CN, NH, N_2, and H were identified for all three precursors using optical emission spectroscopy (OES) during the NH_3 plasma process. TBADMS has fewer amino ligands than BTBAS and TDMAS, enabling efficient silicon delivery through rapid dissociation. This feature minimizes precursor adsorption issues caused by the larger molecular sizes of BTBAS and TDMAS, resulting in differences in growth per cycle (GPC) [1,2].TBADMS exhibits the highest GPC (0.7 Å/cycle), a high N/Si ratio (1.23), the lowest water vapor transmission rate (WVTR) of 5.695 x 10^{-3} g/m^{2}day. These results indicate that a lower number of amino ligands reduces steric hindrance, enhances the N/Si ratio, and lowers WVTR in SiN_x films. This work supports the development of high-quality thin-film silicon nitride for moisture barrier applications in flexible OLED encapsulation.

MB-ThP-30 Morphology Sustainable Synthesis of Calcium Phosphate 1d Nanostructures via Electrospinning for Advanced Functional Applications, *Yao Mawuena Tsekpo, Weronika Smok,* Department of Engineering Materials and Biomaterials, Faculty of Mechanical Engineering, Silesian University of Technology, Poland*; Adrian Radoń,* Łukasiewicz Research Network- Institute of Non-Ferrous Metals, Poland*; Paweł Jarka,* ***Tomasz Tanski [tomasz.tanski@polsl.pl]***, Department of Engineering Materials and Biomaterials, Faculty of Mechanical Engineering, Silesian University of Technology, Poland

Calcium phosphate compounds are a sustainable material with applications in biomedicine and environmental remediation. Among these compounds, calcium pyrophosphate can be prepared from biogenic materials; however, its fabrication into one-dimensional nanostructures via electrospinning remains understudied. This work presents a novel method for synthesizing calcium pyrophosphate nanowires using Galatea paradoxa clamshells as a calcium source. The process integrates electrospinning and sol-gel techniques to achieve 1D nano calcium pyrophosphate and aims to elucidate the influence of temperature on the process. Thermogravimetric analysis (TGA), Scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) were employed to characterize the nanostructures. Calcination at 600 ºC reveals the formation of wire-like structures at the nanoscale with diameters ranging from 96 – 296 nm. XRD analysis confirmed the presence of β-calcium diphosphate [1001556], corroborating the presence of calcium pyrophosphate and aligning with the Fast Fourier Transform (FFT) diffraction patterns obtained in TEM. These findings indicate the successful formation of 1D nanostructures of calcium pyrophosphate. The observed structure and morphology of the prepared nanostructure exhibit properties suitable for application in bone regeneration and biomedicine, adsorption of harmful heavy metals, and as a host material for semiconductors in creating sustainable catalysts.

MB-ThP-31 Investigation of Optical Constants in Nanostructured MoS_2, ws2, and MoS_2-WS_2 Thin Films by Spectroscopy Ellipsometry, ***Prachi Gurawal [prachi@ic.iitr.ac.in]***, Indian Institute of Technology Roorkee, India

The material structure-property relationships are crucial for the optimization and integration to enable the manipulation of material characteristics, such as electrical and optical properties. This work explored the synthesis and controlled growth of molybdenum disulfide (MoS_2), tungsten disulfide (WS_2), and the composite of both MoS_2-WS_2 as a thin film in a single step using pulsed laser deposition (PLD). The morphology of the thin films was analyzed using scanning electron microscopy (SEM), revealing distinct surface features for each film. The topography with surface roughness and elemental composition has been investigated employing atomic force microscopy and X-ray photoelectron microscopy, respectively. Spectroscopic ellipsometry (SE) has been used to determine optical dispersion, such as extinction coefficient k, refractive index n, and optical bandgap under wavelength range 246-1688 nm. The experimentally determined SE data were fitted with the theoretical Drude-Lorentz and Bruggeman effective approximation model.

MB-ThP-32 Optical and Protective Coatings Synthesized by Magnetron Sputtering, *Eric Aubry,* ***Pascal Briois [pascal.briois@utbm.fr]***, FEMTO-ST, France

The consortium of Opti-Reve project is composed by Surcotec and HE-Arc for the Swiss part and Gaggionne and UTBM for the French part. This project aims to develop a new technological solution (optical and protective coatings) in order to improve the quality of optical polymer components thanks to new functionalities brought to the surface by PVD technology, notably the corrosion resistance and the wear, as well as the brightness.

As part of this study, we first theoretically defined the material presenting the best reflection for the application and its thickness. The aluminium offers the best compromise between optical performance and cost production. With a thickness of about 50 nm, its reflection is only lowered by a few percent compared to that obtained with a silver mirror.. In order to protect it from external environmental aggressions, a transparent layer such as aluminum oxide or nitride and also silicon oxide or nitride is implemented.Optical modeling reveals that the a* and b* components are lowest for thicknesses of about 125 nm and 350 nm. The importance of thickness will be studied in terms of its protective properties and corrosion resistance.

From the experimental point of view, the films were sputtered by magnetron sputtering from metallic targets in a neutral argon atmosphere for the reflective layer, then in a reactive atmosphere for the protective layer. First, the stability of the Al-O, AL-N, Si-O and Si-N systems is studied for fixed conditions of plasma gas flow rate and current dissipated on the target. Once the reactive gas flow rates are determined for the synthesis of ceramics, the bilayer thin films is synthesized under specific substrate. The thin films are characterized by scanning electron microscopy, X-ray diffractionfor the morphological and structural properties, by spectrophotometry for the optical properties , and with a nanohardness test for the mechanical properties.

Funding:

This project is carried out within the framework of the INTERREG VI France-Switzerland 2021-2027 European territorial cooperation program. The total cost of the project amounts to €571 663.57. It benefits from financial support from the EU through the European Regional Development Fund (ERDF) for €186 634.06, from the Swiss Federal INTERREG for €105 547.65 and from Swiss cantonal funds for an amount of €105 547.65 (Canton of Geneva = €40 322.58 and canton of Neuchâtel = €65 225.07)

MB-ThP-33 Influence of Substrate Temperature on the Structural and Mechanical Properties of Ti-Zr Oxynitride Thin Films, ***Rogelio Ospina [rospinao@uis.edu.co]***, *Sergio Andres Rincon, Jorge Hernan Quintero,* Universidad Industrial de Santander, Colombia

Titanium and zirconium oxynitrides have garnered significant attention due to their unique physicochemical properties. Titanium oxynitrides are extensively utilized in the medical and chemical industries owing to their exceptional combination of mechanical strength and chemical stability. Meanwhile, zirconium oxynitrides have attracted considerable interest in the electronics industry due to their promising electrical properties. These materials exhibit the advantageous characteristics of nitrides, such as high hardness and wear resistance, as well as those of metallic oxides, including tunable optical properties, chemical stability, and coloration effects. Given these attributes, the development of Ti-Zr oxynitride thin films is of particular scientific interest, especially in understanding how substrate temperature influences their structural and mechanical properties.

This study aims to investigate the effect of substrate temperature on the structural and mechanical characteristics of Ti-Zr-O-N thin films deposited via pulsed laser deposition (PLD). The deposition process was performed on commercial titanium substrates using an Nd:YAG excimer laser with a wavelength of 355 nm, a pulse duration of 8 ns, and a source energy of 150 mJ. The samples were subjected to controlled temperature variations in an oxidative atmosphere within a high-pressure chamber integrated with the X-ray Photoelectron Spectroscopy (XPS) system to assess surface chemical modifications. Furthermore, variations in the hardness of the substrate-coating system were evaluated using microindentation testing before and after oxidative treatment.

The microstructural evolution of the coatings was characterized using X-ray diffraction (XRD), while the surface morphology of the processed films was analyzed via Atomic Force Microscopy (AFM). The findings of this study provide valuable insights into the correlation between deposition parameters and the physicomechanical properties of Ti-Zr oxynitride coatings, contributing to the optimization of their applications in advanced engineering fields.

MB-ThP-34 Functionalization of SnO2 Electron Transport Layer with Phosphonic Acid Derivative for Enhanced Perovskite Solar Cell Performance, ***Biplav Dahal [biplav.dahal@udc.edu]***, *Akhil Prio Chakma, Hongmei Dang,* University of the District of Columbia, USA

Interfacial engineering is critical in optimizing charge transport, mitigating recombination losses, and improving the long-term stability of perovskite solar cells (PSCs). In this work, we explore the functionalization of the SnO_2 electron transport layer (ETL) with (2-chloro-2-phenyl-vinyl)-phosphonic acid (CPVPA), a phosphonic acid derivative, to enhance interfacial properties and device performance. CPVPA contains key functional groups that contribute to interface engineering: the $–PO_3H_2$ group facilitates strong chemical bonding with SnO_2, potentially passivating defect sites and tuning energy levels; the phenyl group may aid in charge transport and surface energy alignment; and the chlorine atom could introduce dipole effects or modulate the electronic environment, thereby improving band alignment with the perovskite absorber. Additionally, the structural stability provided by the phenyl group may further contribute to enhanced device stability. The impact of CPVPA modification was examined through structural and morphological characterization using X-ray diffraction (XRD), scanning electron microscopy (SEM), and atomic force microscopy (AFM), which revealed improved perovskite crystallinity, enlarged grain sizes, and a more uniform film morphology with reduced surface roughness and pinholes. To further probe the chemical interactions and electronic structure changes at the SnO_2 interface, X-ray photoelectron spectroscopy (XPS) and Fourier-transform infrared spectroscopy (FTIR) are planned. Photovoltaic performance evaluations have demonstrated improved power conversion efficiency (PCE) for CPVPA-modified devices compared to unmodified controls. Additionally, preliminary stability studies suggest that CPVPA-modified perovskite film exhibits enhanced moisture resistance. This study highlights the potential of phosphonic acid-based interfacial engineering to improve efficiency and enhance the stability of PSCs. The findings contribute to ongoing efforts toward developing more reliable and scalable perovskite photovoltaics.

Author Index

Bold page numbers indicate presenter