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.

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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 A Study of Chlorine Incorporation in Amorphous In-Ga-Zn-O Thin Film Transistors by Soaking in NaCl Solution, ***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 TFT fabrication, 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 essential.

In this study, we immersed a-IGZO films in NaCl solution to incorporate chlorine. X-ray photoelectron spectroscopy (XPS) analysis revealed that chlorine formed bonds with metals, increasing both metal-oxygen (M-O) bonds and oxygen vacancies (Vo). Additionally, we observed a degradation in IGZO's electrical performance, attributed to structural bonding changes due to chlorine incorporation. Our initial findings indicated that the electrical properties deteriorated as the NaCl soaking time increased. To verify whether these effects were solely due to water exposure, we also examined the electrical properties of a-IGZO films soaked in deionized water. Compared to the pristine device, the saturation mobility and subthreshold slope of a-IGZO TFTs soaked in water for 1 hour decreased from 0.17 to 0.07 cm^2/Vs and increased from 0.79 to 1.11 V/decade, respectively. However, when soaked in NaCl solution, these values further degraded to 0.02 cm^2/Vs and 2.08 V/decade, respectively, confirming that chlorine penetration, rather than water exposure alone, caused the observed degradation. This degradation was associated with an increase in carrier concentration, corresponding with a widening bandgap from 3.46 eV to 4.29 eV. However, XRD analysis showed that soaking in NaCl solution did not alter the film's crystallinity. Furthermore, we examined 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

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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°C, 250°C, 300°C, and 400°C 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°C, 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.

Author Index

Bold page numbers indicate presenter