Functional Thin Films and Surfaces
Room Palm 5-6 - Session MB3-MoM

Low-dimensional Materials and Structures

Moderator: Kostas Sarakinos, University of Helsinki, Finland

10:00am **MB3-MoM-1 Shape and Symmetry Engineering in Transition Metal Dichalcogenide Nanoribbons for Light Harvesting**, *Ganesh Ghimire, **Stela Canulescu [stec@dtu.dk]**,* Technical University of Denmark, Denmark **INVITED**

In this talk, I will discuss how controlling shape and symmetry at the nanoscale can fundamentally change how transition-metal dichalcogenides (TMDs) interact with light. By tailoring these materials into nanoribbon architectures, we can induce local symmetry breaking, tune excitonic behavior, and open new pathways for light harvesting and nonlinear optical response.

I will begin by introducing our alkali-assisted CVD approach for growing highly crystalline MoS_2 nanoribbons.[1,2] These nanoribbons can extend to tens of microns in length and naturally form monolayer–multilayer junctions within a single structure. This built-in structural gradient creates regions that either preserve or break inversion symmetry. As a result, we observe strong second harmonic generation and distinct excitonic emission localized at the nanoribbon edges. These symmetry-driven optical characteristics directly translate into improved device performance: individual nanoribbon photodetectors exhibit responsivities among the highest reported for TMD-based nanoscale photodetectors.

I will then expand the discussion to the bulk photovoltaic effect (BPVE), a mechanism that enables photocurrent generation in non-centrosymmetric crystals without the need for p–n junctions. I will show how engineered asymmetry in 3R-stacked MoS_2 and lithographically defined WS_2 nanoribbons leads to strong nonlinear optical response and shift-current generation. The resulting devices display large short-circuit current densities and measurable open-circuit voltages, underscoring the potential of symmetry-driven photovoltaic operation.

Overall, I will highlight how **nanoscale shape and symmetry engineering** serve as powerful design principles for next-generation optoelectronic and energy-conversion technologies. By deliberately breaking symmetry—through strain, stacking control, and dimensional confinement—we can create TMD architectures that harvest light more efficiently and exhibit enhanced nonlinear optical behavior. These findings position TMD nanoribbons as versatile building blocks for future light conversion, sensing, and photovoltaic applications.

References:

1. Ghimire, G. *et al.* Molybdenum Disulfide Nanoribbons with Enhanced Edge Nonlinear Response and Photoresponsivity. *Adv. Mat.* 35, (2023).

2. Miakota, D. I., Ghimire, G., Ulaganathan, R., Rodriguez, M. & Canulescu, S. A novel two-step route to unidirectional growth of multilayer MoS_2 nanoribbons. *Appl Surf Sci*. 619, (2023)

10:40am **MB3-MoM-3 Discovery of Goldene Comprising Single-atom Layer Gold; Prospects for Novel Noble Metallenes**, ***Lars Hultman [lars.hultman@strategiska.se]**,* Linköping University, IFM, Thin Film Physics Division, Sweden **INVITED**

The quest to make monolayer gold has hitherto been limited to a few atomic layers stabilized on or inside another material. The bonding nature of metals is the root cause to gold's tendency to take 3D shapes during all kinds of synthesis, like vapor-phase deposition or precipitation from solutions.

Through an innovative scheme, single-atom-thick 2D gold[1)], named *goldene*, has been exfoliated by wet-chemically etching away Ti_3C_2 layers from Ti_3AuC_2 nano-laminated MAX-phase[2), 3)] ceramic initially formed by substituting the Si layer in Ti_3SiC_2thin films with Au[3)]. The driving force for such exchange substitution lies in the eutectic nature of the Au-Si phase diagram. Etching-free the goldene sheets is made using a diluted form of the Murakami's reagent[5)]. Surfactant schemes are applied to hinder *goldene* sheets from coalescing with each other in water suspension.

Goldene is observed by scanning transmission electron microscopy. A tendency for curling and agglomeration of*goldene* is observed, whereas *ab initio* molecular dynamics simulation shows that flat atomic layers are inherently stable. X-ray photoelectron spectroscopy reveals an Au 4f binding energy increase of 0.88 eV. Prospects for preparing *goldene* from a series of carbide and nitride MAX phases are also presented.Proposed applications for *goldene* include sensors and photocatalyst for water splitting during solar energy harvesting. The use of Au resources would be minimized due to the ultimate surface-area-to-volume ratio for *goldene*.

Isolated three-atomic-layer Au sheets – trilayer *goldene* – was recently reported by us by selectively removing the Ti_4C_3 sheets from $Ti_4Au_3C_3$, formed by Au-intercalated Ti_4SiC_3 thin films.[6)] Finally, this presentation will discuss ways to realize other noble-metal *metallenes*[7)] from thin-film or bulk-powder templates.

1. *Nature Synthesis*, **3** (April 16, 2024) 744-751

2. *MAX phases* are inherently nanolaminated hexagonal ternary metal carbides and/or nitrides with a general formula $M_{n+1}AX_n$, where M is a transition metal, A is a group 13-16 element, X is carbon and/or nitrogen, and n = 1, 2, 3,...

3. Review: M. Dahlqvist, M.W. Barsoum, J. Rosen, *Materials Today* **72** (2024) Jan/Feb, p. 1 https://doi.org/10.1016/j.mattod.2023.11.010

4. H. Fashandi, M. Dahlqvist, J. Lu, J. Palisaitis, S. Simak, I. Abrikosov, J. Rosen, L. Hultman, M.Andersson, A.Lloyd-Spetz, P.Eklund *Nature Materials* **16** (2017) 814

5. Potassium ferricyanide is combined with potassium hydroxide (or sodium hydroxide) and water to formulate Murakami's etchant.

6. Y. Shi, [...], L. Hultman*Sci. Advances***11**, eadt7999 (2025) 28 March 2025

S. Kashiwaya, Y. Shi, J. Rosen, L, Hultman, *2D Materials* **12** (2025) 033001

11:20am **MB3-MoM-5 Nanoporous TiO2 Thin Films by Helium-Assisted Sputtering for Noble-Metal-Free Hydrogen Sensing**, ***Stanislav Haviar [haviar@ntis.zcu.cz]**, Akash Kumar, Tomáš Kozák, Petr Zeman,* University of West Bohemia in Pilsen, Czechia

A large portion of magnetron-sputtered film applications targets the fabrication of highly compact, dense films. Textbook knowledge of thin-film growth delineates process windows that lead to "low-quality," non-compact morphologies. However, there are use cases where higher porosity or other forms of nanostructuring are advantageous—for example, when a large reactive surface area is desired. In this work, we discuss a modification of classical reactive sputtering in an Ar/O_2 mixture by introducing helium gas. Subsequently, we evaluate the resulting materials assembled as conductometric hydrogen gas sensors.

Titanium oxide films were deposited by conventional DC reactive sputtering, where helium replaced part of the Ar/O_2 working-gas mixture. The substoichiometric as-deposited films were post-annealed to achieve stable TiO_2. The introduction of helium promotes the formation of distinctive morphological features, which increase film porosity, as observed by electron microscopy.

We analyze the mechanisms involving reflected fast neutrals underpinning the emergence of nanoporous structures, supported by SEM imaging as well as structural characterization via XRD and Raman spectroscopy. We describe the evolution of the microstructure with annealing temperature and identify key processing parameters required to obtain porous yet stable films.

The application potential is then assessed by employing the films as conductometric hydrogen sensors. Films prepared by He-assisted sputtering show a several-fold increase in sensitivity to hydrogen without the addition of any noble metals.

Overall, controlled nanostructuring of thin films represents a promising route to engineer novel materials for gas sensing, and He-assisted deposition is one such approach.

Functional Thin Films and Surfaces
Room Palm 5-6 - Session MB2-1-MoA

Thin Films for Emerging Electronic and Quantum Photonic Devices I

Moderators: Shirly Espinoza, ELI Beamlines, ELI ERIC, Czechia, **Jaroslav Vlcek**, University of West Bohemia, Czechia

1:40pm **MB2-1-MoA-1 AlScN Thin Films and Heterostructures for High Temperature Non-volatile Memory**, ***Nicholas Glavin [nicholas.glavin.1@us.af.mil]***, Air Force Research Laboratory, Materials and Manufacturing Directorate, USA **INVITED**

In recent years, strong demand for digital electronics operating in extreme conditions has driven a surge of research and development in new materials and processes. Of particular importance is the development of nonvolatile memory (NVM) capable of operating at temperatures in excess of 500°C. In this talk, scandium-doped aluminum nitride (AlScN) ferroelectric diodes (FEDs) are discussed as a promising solution for NVM operating at high temperatures because of their fast switching speed, high coercive field, high remnant polarization, and temperature resilience. With optimized scandium concentration (30%–40%) and fabrication processes (reactive magnetron sputtering), AlScN FEDs have been demonstrated with on–off ratios as high as 50000, remnant polarizations of >100μC/cm2, and reliable operation at 1000°C with over a million read cycles and 60hours of retention. Additionally, integration of high-k dielectric oxide thin films have shown to improve endurance cycling and performance for future device integration in extreme environments.

2:00pm **MB2-1-MoA-2 Optical and Electrical Properties of Nitrogen-doped p-type Cu_2O Thin Films Prepared by Reactive HiPIMS**, ***Jan Koloros [koloros@ntis.cz]***, *Jiří Rezek, Pavel Baroch,* University of West Bohemia in Pilsen, Czechia

One of today's challenging scientific topics is finding a suitable p-type TCO that would at least approach the optoelectronic properties of the n-type counterpart [1]. Finding such p-type material is a necessary condition for further sustainable technological development of society. The realization of p-n junctions using transparent conductive materials will enable the development of a new generation of invisible electronics, contribute to reducing the energy requirements of various optoelectronic devices or lead to the production of more efficient solar cells. Transparent conductive materials based on Cu_2O appear to be among the most promising. This is mainly due to the abundance of elements used, their non-toxicity and interesting optoelectronic properties. One of the limiting factors in Cu_2O layers is the low mobility of holes. In our previous work [2], we demonstrated that post-deposition laser annealing can effectively enhance hole mobility.

In our work, we systematically investigated the role of nitrogen incorporated into Cu_2O thin films, with a primary focus on their optical and electrical properties, including the optical band gap and electrical resistivity. The Cu_2O:N films were prepared by reactive HiPIMS of Cu circular target (100 mm in diameter) in $Ar+O_2+N_2$ atmosphere. The pulse-averaged target power density (S_{da}) was varied from ≈ 100-1300 Wcm^{-2}, and the fraction of N_2 in ($Ar+N_2$) mass flow was 0–90 %. A decreasing trend in resistivity has been observed with increasing nitrogen content. The prepared p-type Cu_2O:N films with the highest value of a nitrogen fraction of 90% exhibited a very low resistivity about $5x10^{-2}$ Ωcm exceeding the current state of the art [3].

[1] J. Singh, P. Bhardwaj, R. Kumar, V. Verma, Progress in Developing Highly Efficient p-type TCOs for Transparent Electronics: A Comprehensive Review, J Electron Mater (2024).

[2] J. Rezek, M. Kučera, T. Kozák, R. Čerstvý, A. Franc, P. Baroch, Enhancement of hole mobility in high-rate reactively sputtered Cu_2O thin films induced by laser thermal annealing, Applied Surface Science, (2024).

[3] J. Rezek, J. Koloros, J. Houška, R. Čerstvý, S. Haviar, D. Kolenatý, J. Y. Damte, P. Baroch, Ultra-low-resistivity nitrogen-doped p-type Cu_2O thin films fabricated by reactive HiPIMS, Applied Surface Science, (2025).

2:20pm **MB2-1-MoA-3 Fabrication and Manipulation of Weakly-Interacting Interfaces for Optoelectronic Applications**, ***Kostas Sarakinos [kostas.sarakinos@helsinki.fi]***, University of Helsinki, Finland **INVITED**

A key challenge in the materials science community is to understand the correlation among nanoscale atomic arrangement, structure-forming mechanisms, and mesoscale morphology during material synthesis. Addressing this challenge will herald a new epoch in which tailor-made materials and devices with unprecedented macroscopic behavior will be created by controlling mesoscale structure via nanoscale manipulation. The present talk demonstrates the implementation of the above-outlined concept of multiscale materials design during the vapor-based synthesis of thin noble-metal films (and nanostructures) on weakly-interacting substrates, including oxides and van der Waals crystals. Such film/substrate systems exhibit a pronounced and uncontrolled three-dimensional (3D) morphology, which is a major obstacle toward fabricating high-quality multifunctional metal contacts in a wide array of devices. Using growth of sliver (Ag) on silicon dioxide (SiO2) as a model system—along with a combination of in situ film growth monitoring, ex situ microstructure and chemical characterization, and modelling—it is shown that the tendency for 3D growth morphology can be effectively reversed, without compromising key physical properties of the film and the substrate, when miniscule amounts of minority gaseous [1,2,3] and metal species [4,5] (surfactants) are deployed with high temporal precision at the film growth front, such that atomic-scale processes that govern key film-formation stages are selectively targeted and affected. The talk concludes with a discussion with regards to the implications and possibilities that this strategy opens for tuning macroscopic performance of devices in the areas of energy saving and generation.

[1] A. Jamnig *et al.*, "*3D-to-2D morphology manipulation of sputter-deposited nanoscale silver films on weakly-interacting substrates via selective nitrogen deployment for multifunctional metal contacts*", ACS Applied Nano Materials 3 (2020) 4728.

[2] N. Pliatsikas *et al.*, "*Manipulation of thin silver film growth on weakly-interacting silicon dioxide substrates using oxygen as a surfactant*", J. Vac. Sci. Technol. A 38 (2020) 043406.

[3] K. Sarakinos *et al.*, "*Unravelling the effect of nitrogen on the morphological evolution of thinsilver films on weakly-interacting substrates*", App. Surf. Sci. 649 (2021) 159209.

[4] A. Jamnig *et al.* "*On the effect of copper as wetting agent during growth of thin silver films on silicon dioxide substrates*", App. Surf. Sci. 538 (2021) 148056.

[5] A. Jamnig *et al.*, "*Manipulation of thin metal film morphology on weakly-interacting substrates via selective surfactant deployment*", J. Vac. Sci. Technol. A. 40 (2022) 033407.

3:00pm **MB2-1-MoA-5 Investigation of High-temperature Morphology and Electrical Performance of YZr-alloyed Amorphous Al_2O_3 Thin Films**, ***Norma Salvadores Farran [norma.salvadores@tuwien.ac.at]***, *Florentine Scholz, Tomasz Wojcik,* TU Wien, Austria*; Astrid Gies, Jürgen Ramm, Klaus Böbel,* Oerlikon Balzers, Liechtenstein*; Szilard Kolozsvári, Peter Polcik,* Plansee Composite Materials, Austria*; Tobias Huber, Jürgen Fleig, Helmut Riedl,* TU Wien, Austria

Aluminium oxide (Al_2O_3) is a widely used insulating material, particularly in thin-film applications. In addition to its various polymorphs, Al_2O_3 can also exist in an amorphous phase, which is characterized by excellent oxidation resistance and high thermal conductivity. A key advantage of the amorphous form is its uniform structure, free from pinholes. Owing to these properties, amorphous Al_2O_3 being investigated as a dielectric material in electronic and semiconductor devices, as well as in energy storage technologies. Therefore, identifying cost-effective and sustainable deposition methods for the fabrication of high-quality Al_2O_3 insulating thin films is of great importance.

Amorphous Al_2O_3 films were synthesized using a reactive Modulated Pulse Power (MPP) sputtering process. All depositions were carried out in an in-house developed sputtering system equipped with a 3-inch aluminium target and operated in a mixed Ar/O_2 atmosphere. The primary aim of this study was to examine the influence of yttrium–zirconium (YZr) alloying on the thermal stability of the amorphous Al_2O_3 phase, with the goal of preventing phase transitions into crystalline states up to 1200 °C. To achieve this, varying amounts of YZr were incorporated into the aluminium targets. The effects of these YZr additions and their concentrations on process stability, as well as on the resulting film properties – including morphology, structure, and electrical resistivity – were analysed using advanced high-resolution characterization techniques.

Phase formation and evolution were investigated using X-ray diffraction (XRD) over a temperature range from room temperature up to 1200 °C. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) were employed to assess the deposition rate and surface

morphology of the coatings. The chemical composition of the films was analysed using X-ray photoelectron spectroscopy (XPS), which was also utilized to examine the bonding states of the constituent elements. Additionally, in-situ impedance spectroscopy was used to study variations in the electrical properties as a function of temperature. For electrical characterization, Ti/Pt electrode pads were fabricated via photolithography.

4:00pm **MB2-1-MoA-8 Ion-Beam Assisted Deposition of P-Type Oxide Semiconductor Thin Films in Room Temperature**, ***Tsung-Yu Huang [huang.tsungyu@mail.mcut.edu.tw]***, Ming Chi University of Technology, Taiwan **INVITED**

Transparent semiconductor oxides are an important class of materials in materials science, including SnO_2, In_2O_3, ZnO, and dozens of doped transparent semiconductor oxides. These materials have been widely used in various electronic and optoelectronic devices. Tin monoxide (SnO), due to the overlap between its 5s orbital and the oxygen 2p orbital, exhibits unique characteristics that enable hole transport. This makes it one of the most promising candidates for p-type oxide semiconductors. In this study, our p-type SnO thin film achieved a mobility of 4.52 $cm^2 V^{-1} s^{-1}$.

4:40pm **MB2-1-MoA-10 Influence of Bonding Temperature on Electromigration Suppression in Cu-Doped Ag Bumps**, ***Chien-Cheng Chiang [johnson10678@gmail.com]***, *Peng-Hsiang Hsu, Fan-Yi Ouyang,* National Tsing Hua University, Taiwan

The continuous advancement of technology has driven the demand for higher-performance electronic devices, leading to progressive miniaturization of device dimensions. However, further device scaling is fundamentally constrained by physical limits. To overcome these challenges, three-dimensional integrated circuits (3D ICs) have emerged as a promising alternative for enhancing device performance. Compared with conventional flip-chip solder joints, direct metal bonding (DMB) provides higher interconnect density, lower electrical resistance, and improved reliability, making it an attractive technique for advanced packaging. Nevertheless, as interconnect dimensions decrease, reliability issues become increasingly critical, with electromigration (EM) being one of the primary failure mechanisms.

In this study, Ag alloyed with 3.2 at.% Cu was employed as the interconnect material, and a nanotwinned structure was introduced to enhance EM resistance. Thermal compression bonding was performed at various temperatures to investigate the influence of bonding temperature on electromigration behavior and microstructural evolution.Compared with pure silver, Ag doped with 3.2 at.% Cu exhibits not only a better bonding interface at higher bonding temperatures but also retains a larger amount of twin structures, thereby achieving superior electromigration resistance. The results provide valuable insights into the relationship between bonding parameters and EM performance, offering practical strategies to improve the reliability of next-generation advanced packaging technologies.

5:00pm **MB2-1-MoA-11 Piezoelectric MEMS – from Advanced Material Systems to Novel Device Architectures**, ***Ulrich Schmid [ulrich.e366.schmid@tuwien.ac.at]***, *Daniel Platz, Michael Schneider,* TU Wien, Austria **INVITED**

In a compact introduction, I will motivate the benefits of piezoelectric thin films for MEMS and will give a short overview to state of art device applications.

Next, I will highlight latest results on the electrical, mechanical and piezoelectrical characterization of sputter-deposited aluminium nitride (AlN) including the impact of *e.g.,* substrate pre-conditioning. I will present test structures for determining piezoelectric coefficients (d_{33}, d_{31}) down to an accuracy of about 0.1 pm/V on wafer level. The impact of AlN doping with yttrium which leads to an increase of the moderate piezoelectric coefficient of pure AlN, as known with scandium, will complete the material-related part of my talk.

Next, these films are integrated into fabrication processes of silicon MEMS devices. In combination with a tailored electrode design, cantilever-type resonators are realized featuring Q-factors up to about 350 in water (@1-2 MHz). This enables the precise determination of the viscosity and density of fluids up to dynamic viscosity values of about 300 mPas. Besides this application, such high Q-factors are most essential when targeting mass-sensitive sensors, thus paving the way to *e.g.,* nanosized particle detection even in such highly viscous media like oil. In addition, the characterization of bitumen with dynamic viscosities up to the 10.000 mPas range is demonstrated with these piezoelectric MEMS resonators.

Besides sensing, the field of MEMS actuators is covered. I will present some selected results on buckled, bistable plate-type MEMS devices that allow continuous switching between the two stable states by integrated piezoelectric thin film actuators for realizing *e.g.,* compact ultrasound emitters. Specific features of this device architecture will be discussed**.**

Functional Thin Films and Surfaces
Room Palm 5-6 - Session MB2-2-TuM

Thin Films for Emerging Electronic and Quantum Photonic Devices II

Moderators: Ufuk Kilic, University of Nebraska - Lincoln, USA, **Ulrich Schmid**, TU Wien, Austria

8:00am **MB2-2-TuM-1 Polyoxometalate Thin Film Heterostructures and Blends with Neuromorphic Computing Capabilities**, ***Dimitra Georgiadou [D.Georgiadou@soton.ac.uk]***, University of Southampton, UK **INVITED**

Neuromorphic computing holds promise for lowering power consumption and increasing the computation speed of Artificial Intelligence (AI) applications, as it is emulating the parallel manner of memorising and processing information in the brain. Although machine learning algorithms inspired by the spiking neural networks in the brain have recently made gigantic leaps into the field of neuromorphic computing, scalability and power efficiency remain a challenge. There is, therefore, a clear need for redesigning the neuromorphic hardware systems using radically novel materials and architectures that can better emulate the chemical processes in the mammalian brain and lead to efficient computation with added functionalities.

Polyoxometalates (POMs), a class of redox active molecular metal oxides, have emerged as promising candidates for next generation neuromorphic devices. Their discrete molecular structure, tunable electronic properties, and compatibility with silicon-based platforms have made them attractive materials for advanced memory applications with tunable long- and short-term memory characteristics. POMs can accept multiple electrons without compromising their structural integrity, notably acting as “electron reservoirs” or “electron sponges”, while the highly tunable surface chemistry of these metal oxide clusters offers many routes for electronic device optimisation.

In this talk, I will present a two-terminal redox-based resistive switching memory using the Keggin phosphomolybdate POM $H_3PMo_{12}O_{40}$. By combining this Mo-POM with nanogap coplanar metal electrodes, we create nanoelectronic devices that offer significant advantages, such as low power consumption and fast switching times. Emphasis will be placed on the diverse strategies used to integrate POMs with different metal substrates and functional layers, such as dielectric and conjugated polymers. I will also discuss the influence of counterions and encapsulating layers in resistive switching mechanisms.

This combination of redox active nanomaterials and nanogap architecture holds great potential for advancing electronic technologies, while being also fully compatible with large area manufacturing and flexible substrates. Overall, this work introduces POM-based systems as a viable alternative to the limitations of conventional CMOS memory, offering a blueprint for future developments in molecular electronics.

8:40am **MB2-2-TuM-3 Yttrium-Doped Aluminum Nitride Memristors to Enhance the Pattern Recognition Accuracy of Unsupervised Spiking Neural Network**, ***Jer-Chyi Wang [jcwang@mail.cgu.edu.tw]***, Chang Gung University, Taiwan **INVITED**

Recently, an increasing requirement for pattern recognition and decision-making in computing systems has led to the development of artificial neural network (ANN). Although ANN is inspired by the working principle of the biological nervous system, the learning rule and computing architecture are still inconsistent with nervous behaviors, making it difficult to realize the functionalities of the human brain. To overcome these issues, spiking neural network (SNN) with high biological plausibility has been proposed for next-generation neuromorphic computing systems. SNN performed with the spike-timing-dependent plasticity (STDP) learning rule can mimic the learning behaviors of living beings. Hence, the design of electronic devices with STDP behavior, such as synaptic transistors, memristors, and ferroelectric memories, has become a crucial task. Among them, memristors have been considered as the most promising candidates because of their synapse-like morphology, high scaling ability, and low power consumption. Nitride-based memristors, such as AlN, Si_3N_4, WN, and CuN memristors, have been reported to exhibit superior memory characteristics; however, most of the devices require specific operation methodologies to mimic the synaptic properties. Thus far, no studies have focused on the process-related influences on the STDP behavior of memristors and further implementation of the devices in the SNN system. In this study, yttrium (Y)-doped AlN memristors are proposed to investigate the dependence between the Y-doping concentration and SNN performance. With an increase in the Y-doping concentration, both the memory characteristics and synaptic behaviors of the AlN memristors significantly improved. In addition, the STDP parameters of the memristors were extracted and fed into the SNN to simulate the pattern recognition capability. The optimized pattern recognition accuracies of 75.89 and 60.21% for the MNIST and ETH-80 datasets, respectively, were achieved for the AlN memristors with a Y-doping concentration of 3.4%, which is promising for implementation in future neuromorphic computing system and artificial intelligence.

9:20am **MB2-2-TuM-5 Impact of Interlayers on the Electrical and Microstructural Stability of Cu Films Deposited on SiC Substrates**, ***Jui-Wei Hsu [michaelhsu33@gmail.com]***, College of Semiconductor Research, National Tsing Hua University, Hsinchu, Taiwan; *Fan-Yi Ouyang,* Department of Engineering and System Science, National Tsing Hua University, Hsinchu, Taiwan

Silicon carbide (SiC) has become a key substrate material for high-voltage and high-temperature power devices due to its wide bandgap, high breakdown field, and excellent thermal conductivity. However, its distinct surface chemistry and higher thermal budget pose challenges for metallization. In conventional Si-based systems, interlayers such as TiN, Ta, and TaN are widely used as Cu diffusion barriers and adhesion layers. Yet, their effectiveness on SiC substrates remains insufficiently understood. Establishing a stable, low-resistance Cu film stack on SiC is therefore critical for ensuring both electrical performance and reliability under high-temperature operation.

In this study, TiN, Ta, and TaN interlayers were deposited on SiC substrates using a sputtering system, followed by a 5000 Å Cu overlayer. This configuration enables direct comparison of how each interlayer affects Cu texture, interfacial stability, and diffusion behavior during subsequent thermal processing. The as-deposited Cu/TiN structure exhibited the lowest sheet resistance, followed by Cu/TaN and Cu/Ta. After annealing at 200–300 °C, the Cu/Ta stack demonstrated the best stability, while Cu/TaN maintained a slightly higher but stable value around 2.0 Ω/sq. TiN showed more pronounced resistance variation with temperature. The temperature-dependent evolution of resistivity and interfacial structure, along with the underlying diffusion mechanisms, will be discussed in detail. These findings contribute to a deeper understanding of Cu/interlayer/SiC interfaces, providing design guidance for reliable metallization schemes in next-generation power electronics.

Keywords: SiC, TiN/Ta/TaN interlayer, diffusion barrier, Cu metallization, thermal stability

9:40am **MB2-2-TuM-6 Ternary-Blending Energetics and 3d Packing in Thin Films Enable Ultralow-Noise Nir Opds and Thermally Durable All-Polymer Opvs**, ***Chih-Ping Chen [cpchen@mail.mcut.edu.tw]***, Ming Chi University of Technology, Taiwan **INVITED**

We report complementary molecular- and ternary blend-control thin-film strategies that concurrently suppress non-radiative loss and dark current in near-infrared (NIR) organic photodetectors (OPDs) and deliver record-level thermal durability in all-polymer organic photovoltaics (OPVs). (i) In OPDs, introducing PTQ10 into PM6:PY-IT forms a ternary film that suppresses unfavorable molecular packing and tunes interfacial energetics, thereby mitigating thermally activated carrier generation/leakage. A ternary OPD incorporating PTQ10 into PM6:PY-IT suppresses unfavorable packing and optimizes energy-level alignment, thereby mitigating thermally activated carrier generation and leakage. The devices achieve $J_d < 1.0 \times 10^{-9}$ A cm^{-2} at −2 V and shot-noise-limited detectivity $D^*\_shot \approx 5.0 \times 10^{13}$ Jones (830 nm, −2 V) without sacrificing responsivity. In the case of donor D18 paired with Y-series acceptors of varied surface energies and frontier orbitals identifies D18:Y18 blends with optimized 3D packing (GIWAXS), reduced trap density, and minimized non-radiative recombination, yielding $D^*\_shot = 4.2 \times 10^{13}$ Jones at −2 V, with superior linear dynamic range, cutoff frequency, and response time. For OPVs, blending the polymer donor PBQx-TF with high-crystallinity D18 followed by sequential deposition of PY-IT tunes morphology and balances carrier mobilities while minimizing energy losses. The ternary all-polymer OPV attains PCE = 16.07%, surpassing the corresponding binaries (15.26% for PBQx-TF:PY-IT; 14.39% for D18:PY-IT), and exhibits outstanding durability, retaining 80% of its initial PCE after 1500 h at 120 °C, with intact layer structure. Together, these results

establish clear design rules—ternary-blend energetics and controlled 3D packing—for achieving ultralow dark current in NIR OPDs and unprecedented thermal stability in all-polymer OPVs.

Functional Thin Films and Surfaces
Room Palm 1-2 - Session MB1-WeA

Optical Materials and Thin Films

Moderators: Jiri Houska, University of West Bohemia, Czechia, **Juan Antonio Zapien**, City University of Hong Kong

2:00pm **MB1-WeA-1 Ultrafast Phenomena in Optical Materials with fs–ns Time-Resolved Spectroscopic Ellipsometry**, ***Shirly Espinoza [shirly.espinoza@eli-beams.eu]***, ELI Beamlines. ELI ERIC, Czechia **INVITED**

Static, imaging, and time-resolved ellipsometry link microstructure and optical function in thin films. Using time-resolved spectroscopic ellipsometry (TRSE), we access amplitude and phase simultaneously (angles Ψ and Δ) to recover the complex dielectric function (ε) with femtosecond resolution, a capability that conventional transient probes do not provide directly and that is key to disentangling overlapping ultrafast processes. As complementary techniques, time-resolved X-ray diffraction (TR-XRD) correlates lattice strain and structural pathways with the optical response, while imaging ellipsometry maps, with spatial resolution, thickness and optical constants (n, k), assessing uniformity and device-level variability.

In ZnO thin films, TRSE separates bleaching by Pauli blocking, band-gap renormalization, and intra-valence-band absorption, together with the evolution of excitonic features under strong photoexcitation; this yields the full-time evolution (real and imaginary parts) of ε(ω,t) and clarifies electron–electron and electron–phonon coupling on sub-ps time scales.

In $LaCoO_3$ thin films, TRSE reveals a photoinduced insulator-to-metal transition with spectral-weight transfer to low energies, followed by an ultrafast relaxation and, between 1–30 ps, a second maximum whose kinetics and thickness dependence evidence coherent acoustic phonons that transiently modulate the optical constants.

Complementarily, imaging ellipsometry applied to spin-coated oxides demonstrates its utility for metrology and function: thickness/optical-constant mapping and fabrication of Co_3O_4/CeO_2 diodes with reproducible rectification, all within a low-cost deposition platform.

Finally, for layered chalcogenides, recent results obtained outside our TRSE setup show that GaS acts as a reconfigurable optical material: laser-induced structural modification persistently tunes the band structure and refractive index with low loss, enabling sub-wavelength patterning and programmable optical elements.

Taken together, TRSE, TR-XRD, and imaging ellipsometry form a quantitative toolbox to read and design ultrafast optical functionalities in oxides and chalcogenides, from fundamental dynamics to scalable device integration.

2:40pm **MB1-WeA-3 The Role of Contaminants in the Microstructural Evolution of Defects in Low-Emissivity Glazing at High Temperatures**, ***Phillip Rumsby [phillip.rumsby@etud.polymtl.ca]***, *Bill Baloukas, Oleg Zabeida, Ludvik Martinu,* Polytechnique Montréal, Canada

Silver-based coatings present exceptional optical and electrical properties, garnering them significant interest in applications requiring multifunctional optical filters. Amongst these are low-emissivity (low-E) windows. These dramatically reduce radiative heat transfer, improving the energy efficiency of window units while simultaneously providing highly transparent and aesthetically pleasing glass facades. However, Ag films present specific challenges in terms of their chemical and high-temperature stability, which must be managed with an appropriate combination of protective layers (hard coatings, diffusion barriers, metallic interface layers).

In this work, we investigate the processes by which minor mechanical defects in said protective layers evolve during glass tempering. This process, in which coated glass is heated at temperatures in excess of 650 °C, can cause small, practically invisible scratches, formed during glass cutting and handling, to develop into highly visible features. This can lead to entire panes of glass being rejected late in the fabrication process.

First, the multiple mechanisms participating in coating degradation are isolated and their interplay is analyzed: indeed, in addition to purely microstructural changes, disruption of the protective films allows diffusion of both atmospheric and substrate contaminants to the Ag layer, such as O_2, H_2O, and Na. The effect of different combinations of contaminants is thus evaluated by annealing partial stacks with various barrier layer configurations in controlled environments and on substrates of different composition, allowing one to control contaminant availability. Subsequent optical, electrical and microstructural analyses reveal key differences in the Ag dewetting behavior induced by O_2 and Na exposure.

Defects with repeatable morphological features are then generated using a microscratch tester with a diamond tip indenter. The effect of defect types and tempering conditions on scratch visibility is then compared quantitatively by image analysis of dark-field photographs. This reveals that atmospheric contaminants play a dominant role in scratch intensification. Investigation of the coating microstructural features leading to this increase in visibility is performed by both scanning and transmission electron microscopies; this indicates that large Ag particles (≈ 1 µm) formed at the scratched surfaces are not the main contributor. Rather, particles formed inside the coating, with restricted sizes (≈ 100 nm) contribute to scattering much more strongly, as evidenced by Mie scattering calculations.

3:00pm **MB1-WeA-4 Thermochromic VO_2-Based Coating for Energy-Saving Smart Windows: Design and Scalable Synthesis**, ***Jaroslav Vlcek [vlcek@kfy.zcu.cz]***, University of West Bohemia, Czechia **INVITED**

Vanadium dioxide (VO_2) exhibits a reversible phase transition from a low-temperature monoclinic VO_2(M1) semiconducting phase to a high-temperature tetragonal VO_2(R) metallic phase at a transition temperature of approximately 68 °C for the bulk material. The automatic response to temperature and the abrupt decrease of infrared transmittance with almost the same luminous transmittance at the transition into the metallic state make VO_2-based coatings a promising candidate for thermochromic smart windows reducing the energy consumption of buildings.

We report two different types of high-performance thermochromic coatings synthesized on standard soda-lime glass at a low substrate temperature of 320-350 °C: three-layer $YSZ/V_{0.855}W_{0.018}Sr_{0.127}O_2/SiO_2$ coatings, where YSZ is yttria-stabilized zirconia, prepared using a scalable (proved by a successful transfer to a large-scale roll-to-roll deposition device with ultrathin flexible glass substrate) sputter deposition technique, and even higher-performing coatings with four layers of subwavelength W-doped VO_2 nanoparticles dispersed in SiO_2 matrix prepared using a two-step process, combining magnetron sputter deposition and postannealing in oxygen. The coatings exhibit a transition temperature of 22-33 °C with an integral luminous transmittance T_{lum} > 60% and a modulation of the solar energy transmittance ΔT_{sol} > 10%. Such a combination of properties, together with the low substrate temperature in both cases, fulfill the requirements for large-scale implementation on building glass (glass panes, or flexible glass and polymer foils laminated to glass panes) and have not yet been reported in the literature.

We present and explain the fundamental principles of both developed low-temperature (usually used temperatures are higher than 450 °C) preparation techniques and the design of these thermochromic coatings. Moreover, we explain the effect of Sr in the W and Sr co-doped VO_2 on the electronic structure and the enhanced thermochromic properties of the three-layer $YSZ/V_{0.855}W_{0.018}Sr_{0.127}O_2/SiO_2$ coatings, and the effect of the discontinuous W-doped VO_2 microstructure on the very promising thermochromic properties (ΔT_{sol} > 15%) of the coatings with four layers of W-doped VO_2 nanoparticles dispersed in SiO_2 matrix.

3:40pm **MB1-WeA-6 Designing Light-Active Thin Film Heterojunctions: Band Alignment and Layer Engineering for Efficient Photocatalysis**, ***Monserrat Bizarro [monserrat@materiales.unam.mx]***, UNAM, Mexico **INVITED**

The design of functional thin films capable of harvesting visible light for photocatalytic processes relies critically on controlling charge transport and interfacial phenomena. While the formation of semiconductor heterojunctions in nanoparticles or powdered materials has proven to be a powerful approach to improve carrier separation and extend light absorption, the actual mechanisms that govern the performance of *thin-film* heterostructures—where photocatalysis is inherently surface-dominated—remain poorly understood.

In this work, we explore how stacking order and interfacial electric fields define the photocatalytic response in two representative systems: ZnO/Bi_2O_3 and BiOBr/BiOI thin-film heterojunctions prepared by spray pyrolysis. Each semiconductor was first deposited as an individual layer to establish its structural, optical, and electronic properties, and then combined in two configurations (A/B and B/A) to evaluate the influence of layer sequence. Detailed microstructural analyses confirmed the formation of well-defined physical junctions and excluded the presence of new ternary phases. Band positions, carrier concentrations, mobilities, and Fermi levels were determined to construct energy band diagrams that explain the observed photocatalytic trends.

Under blue or simulated sunlight irradiation, the heterostructures exhibited a pronounced dependence of activity on stacking order. Configurations in

which the semiconductor with the wider band gap and less negative conduction band (ZnO or BiOBr) occupied the surface achieved superior photocatalytic efficiency toward dye degradation, attributed to favorable band alignment, internal electric fields that drive charge migration, and reduced recombination at the interface. Conversely, reversing the stacking sequence quenched the photocatalytic response, highlighting the delicate interplay between layer order, thickness, and interfacial charge transfer.

These findings demonstrate that thin-film heterojunctions can be rationally designed to enhance surface photocatalytic activity through precise control of band alignment and interface fields. Beyond their relevance for environmental photodegradation, such insights are broadly applicable to solar energy conversion, photoelectrochemical devices, and other light-assisted surface reactions, positioning thin-film heterostructures as a versatile platform for functional materials engineering.

Functional Thin Films and Surfaces
Room Palm 3-4 - Session MB2-3-ThM

Thin Films for Emerging Electronic and Quantum Photonic Devices III

Moderators: Jiri Capek, University of West Bohemia, Czechia, **Spyros Kassavetis**, Aristotle University of Thessaloniki, Greece

8:40am **MB2-3-ThM-3 From Passive to Active Structurally Controlled Optical Coatings for Energy, Eyewear and Sensor Applications**, *Bill Baloukas, Martin Crouan, Brandon Faceira, Aleksandra Pajak,* ***Phillip Rumsby [phillip.rumsby@polymtl.ca]****, Oleg Zabeida, Jolanta Klemberg-Sapieha, Ludvik Martinu,* Polytechnique Montréal, Canada

Control of energetic interactions at the surface of the growing thin films allows one to selectively adjust their micro- and nanostructure. This is particularly important when synthesizing optical films by vapor-based techniques such as reactive sputtering (including HiPIMS), evaporation (including Glancing Angle Deposition), Plasma-Enhanced Chemical Vapor Deposition, Atomic Layer Deposition, Ion Beam Assisted Chemical Vapor Deposition, and Gas Agglomeration Cluster formation. As a result, this has become increasingly attractive for judicious fabrication of nanostructured optical filters with controlled film porosity, crystallinity, anisotropy, plasmonic effects, thermo-mechanical properties and other features of both passive as well as active (dynamic – e.g., electrochromic or thermochromic) coating materials with new functionalities.

This presentation will illustrate the progress and new opportunities in structurally controlled passive and active optical coating systems using a holistic approach from design to fabrication and device performance. This will specifically be highlighted by our work on high-performance low-emissivity and smart windows for energy saving in the building sector, energy control in micro/nanosatellites, hybrid (organic-inorganic) coatings and switchable electrochromic systems for ophthalmic lenses including novel transparent flexible electrodes, plasmonic optical filters for gas sensing, and other advanced optical coating devices.

References:

1. M. Crouan, B. Baloukas, O. Zabeida, J.E. Klemberg-Sapieha, L. Martinu, "Antireflective-to-mirror-like all-solid-state electrochromic devices", Optical Materials **168** (2025) 117464.

2. Z. Krtous, O. Polonskyi, P. Pleskunov, M. Cieslar, B. Baloukas, L. Martinu, J. Kousal, "Sensing of Organic Vapors with Plasmonic Distributed Bragg Reflectors", *ACS Appl. Mater. Interfaces* **17** (18) (2025) 27126–27135.

3. M.-A. Dionne, B. Baloukas, O. Zabeida, J. Klemberg-Sapieha, L. Martinu, "Fabrication and Performance of Randomly Patterned Tri-Layer Flexible and Transparent Electrodes", Optical Materials **166** (2025) 117200.

4. P. Rumsby, B. Baloukas, O. Zabeida, and L. Martinu, "Enhanced Durability and Antireflective Performance of Ag-Based Transparent Conductors Achieved via Controlled N-Doping", ACS Applied Materials & Interfaces **16** (2024) 24039–24051.

5. A. Shelemin, Z. Krtous, B Baloukas, O. Zabeida, J.E. Klemberg-Sapieha, L. Martinu," Fabrication of Plasmonic Indium Tin Oxide Nanoparticles by Means of a Gas Aggregation Cluster Source", ACS Omega **8** (2023) 6052−6058.

9:00am **MB2-3-ThM-4 Glancing Angle Deposition of WOx and Cu-doped TiO2 Thin Films for Improved Conductometric Gas Sensing**, ***Akash Kumar [akashkumarneutronics@gmail.com]****,* University of West Bohemia, NTIS, India*; Stanislav Haviar,* University of West Bohemia, NTIS, Czechia*; Nirmal Kumar,* University of West Bohemia, NTIS, India

The emerging hydrogen industry is stimulating efforts in developing new materials for various purposes, including the quest for efficient, sustainable, and low-power hydrogen detectors. Many such devices rely on metal oxide semiconductor materials, which are easily integrable into devices and relatively cheap but suffer from some challenges, such as low sensitivity and selectivity.

This study explores the possibility of exploiting a Glancing Angle (GLAD) sputter deposition of Cu-doped TiO_2 and WO_x films, targeting the enhancement of active surface area and, therefore, sensor sensitivity improvements.

Cu-doped TiO_2 and WO_3 films were deposited using conventional reactive DC magnetron sputtering, employing circular titanium and tungsten targets in a mixture of argon and oxygen. Cu-doping was achieved by using a composite target.Films were post-annealed prior to sensing characterization. The Glancing Angle Deposition (GLAD) technique was employed to induce a characteristic columnar nanostructure, thereby increasing the films' porosity and so leading to a desired increase in active surface area. Multiple parameters were tuned to enhance the sensing response, including the angle of deposition (80°, 85°, 88°), thickness (50–300 nm), and reactive sputtering parameters.

Synthesized films were thoroughly analyzed by SEM and XRD. Sensing response measurements revealed an interesting fact: that neither the surface roughness nor the surface area improves the response to the sensing gas monotonically. In the presented paper, we discuss the geometrical reasons as well as the synthesis parameters that influence the sensing characteristic. The comparison of the two materials, WO_3 and TiO_2, is also given.

9:20am **MB2-3-ThM-5 Sputter Coating of High-Quality Vo2 Metal-Insulator Transition Films for Flexible Electronics**, ***Juan Andres Hofer [juhofer@ucsd.edu]****,* University of California San Diego, USA*; Ali C. Basaran,* General Atomics, USA*; Tianxing Damir Wang, Ivan K. Schuller,* University of California San Diego, USA

The metal-insulator transition (MIT) in vanadium dioxide (VO_2) thin films is a topic of great interest for applications in smart windows, memristors, and neuromorphic computing applications. VO_2 thin films are accompanied by substantial changes in the electronic and optical properties across the MIT, and these changes can be induced by external stimuli such as voltage, strain, or temperature. While several studies have shown that flexible and freestanding VO_2 films can be achieved, complex pre- or post-growth processing is required. In this work, we show that direct sputter deposition of VO_2 on flexible Kapton substrates results in a straightforward methodology to achieve flexible MIT films. A pre-deposited Al_2O_3 layer on Kapton enhances film adhesion, and the resulting flexible VO_2 films show up to 4 decades of change in resistance across the MIT. Temperature and substrate-induced strain during growth affect substantially the quality of the films. The resulting VO_2 flexible devices show ultra-low power consumption for resistive switching, up to two orders of magnitude lower than in samples grown on traditional substrates. We also demonstrate that the VO_2 MIT characteristics can be governed by mechanical deformation, resulting in a novel method to induce resistive switching and decrease power consumption. This study reveals a straightforward approach for direct growth of high-quality flexible VO_2 films exhibiting robust MIT, with promising applications in tactile sensors and electromechanical devices.

Funding Acknowledgment: This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-22-1-0135.

10:20am **MB2-3-ThM-8 - In Situ Electron-Beam-Induced Selective-Area Growth of Tellurium Films by Molecular Beam Epitaxy**, ***Ossie Douglas [dro3@usf.edu]****,* University of South Florida, USA*; Peter Snapp,* NASA Goddard Space Flight Center, USA*; Ali Ashraf,* University of South Florida, USA

Recently, thin films of elemental tellurium (Te) have gained increasing attention due to their intrinsically anisotropic crystal structure and morphology-dependent semiconducting properties. Molecular beam epitaxy (MBE) is an established technique for producing chemically pure, wafer-scale Te films with high morphological precision. However, post-processing of Te films for device fabrication typically relies on masked lithographic techniques, which can inadvertently degrade film quality and electrical performance. While selective-area growth approaches have been explored to mitigate these effects, mask-based methods introduce additional pre-processing complexity and crystallographic constraints. An in situ selective-area growth technique offers a pathway to reduce fabrication complexity while preserving intrinsic film properties.

Here, we demonstrate an in situ process for selective-area growth of Te thin films on muscovite mica (MuM) dielectric substrates using an electron beam generated by a reflection high-energy electron diffraction (RHEED) gun integrated within an MBE system. Spatially selective growth is achieved without physical masking, resulting in millimeter-scale lateral patterning of nanometer-thick Te films, confirmed by optical characterization. Directional control of film growth is realized through azimuthal alignment of the substrate relative to the incident electron beam. The resulting feature dimensions are found to depend strongly on electron beam voltage, exposure duration, and substrate temperature. This approach demonstrates

controllable Te film shape and thickness during growth, highlighting new opportunities for direct-write epitaxial patterning within MBE systems.

10:40am **MB2-3-ThM-9 High Tunability in Crystallographic Design of Thin Films Enabled by Atomic Imprint Crystallization***, **Koichi Tanaka [ktanaka@anl.gov]***, Argonne National Laboratory, USA*; Xella Doi, Connor Horn, Chloe Tsang, Supratik Guha,* University of Chicago, USA

In general, properties of thin films are dependent on their crystal orientation, and the most common approach to control the crystal orientation of thin films is to utilize epitaxial growth on single-crystalline substrates. Although a variety of materials have been synthesized on single-crystalline substrates using chemical and physical vapor deposition (CVD, PVD), epitaxial growth methods allow us to grow materials into only one fixed orientation predetermined by the substrate orientation, and typically with limited tunability in terms of area or orientation.

In this talk, we report area-selective, orientation-tunable crystallization processes of amorphous Si utilizing atomic imprint crystallization (AIC), where an amorphous Si layer is crystallized by solid phase epitaxy from an external single-crystal Si template. Using a flat template, the top surface of an amorphous Si is crystallized following the crystal orientation of the template wafer up to 5 mm diameter, indicating that the crystallization of the amorphous Si can be initiated by an external template wafer. Using micro-patterned single-crystalline Si templates, limited areas (~50 μm diameter) of an amorphous Si film, where the film surface and patterned template surface are in contact, are crystallized via SPE to create an array of crystallographically aligned dots embedded in amorphous matrix. Combining the AIC from the top surface and conventional SPE from the substrate, we developed new crystallization processes to fabricate unique microstructures such as a twisted interface with a tunable twist angle and an array of crystalline dots embedded in single-crystalline matrix with tunable in-plane rotation angle. The results demonstrate the area-selective, orientation-tunable crystallization process enabled by AIC, controlling crystallographic properties of thin films, which can open up new materials design capabilities for variety of applications in materials science including but not limited to electronics and quantum device applications.

11:00am **MB2-3-ThM-10 Thin Film Processing Strategies for High-Throughput Autonomous Materials Discovery and Development***, **Christopher Muratore [cmuratore1@udayton.edu]***, University of Dayton, USA*; Brian Everhart, Drake Austin, Nicholas Glavin,* US Air Force Research Laboratory, USA

The talk highlights automated experimental tools enabling synthesis and characterization of hundreds of samples per day. This approach, where experimentation is much faster than simulation has the potential to flip the traditional ‘order of operations’ for materials discovery where experiment feeds model during initial iterations.One high-throughput format relies on scanning lasers with broad ranges of power, scan rates, and focal positions to induce physical and chemical transformations within materials. Laser heating parameters may be set to approximate quasi-equilibrium heating as in a furnace, or induce extreme heating and cooling rates, thereby broadening the range of accessible compositions and crystal structures dictated by kinetics of both chemical reactions and crystallization. Deposition tools may also be used to create a broad range of compositions on the sample surface. Once a combinatorial sample with a desired range compositions and laser illumination conditions is processed, it can be manually or autonomously subjected to the combination of high-throughput characterization tools required for evaluation of the properties specified by the user. Autonomous systems enable users to specify a desired property and the system iterates processing and characterization data to ‘make decisions’ about optimization of conditions to realize the user-specified input.For example, an automated Raman spectroscopy system enables rapid collection of key data points (grain size, defect density, thickness, etc.) for technologically important optical, electronic, and energy materials.Some specific case studies include fundamental kinetics studies showing migration-limited crystallization kinetics amorphous materials can be directly observed.Pre-cursor materials for downstream processing can be converted directly into reaction intermediates with the appropriate non-equilibrium laser energy input to reduce process activation energy and process temperature required for high-quality materials. For photocatalysis materials rapid, non-equilibrium process conditions were identified demonstrating optimized performance with mixtures of phases.

11:20am **MB2-3-ThM-11 Designing Porosity for Function: Polymer-Templated Metal Oxides for Catalysis and Broadband, Wide-Angle Optics***, **Elena V. Shevchenko [eshevchenko@anl.gov]***, University of Chicago, Argonne National Laboratory, USA*; Diana Berman,* University of North Texas, USA **INVITED**

Nanostructuring metal oxides through controlled porosity provides a powerful route to simultaneously enhance surface reactivity and tailor optical response. By introducing interconnected nanoscale voids into inorganic frameworks, it becomes possible to maximize accessible surface area while engineering light propagation, scattering, and refractive index profiles. Such materials are increasingly important for catalytic, electrocatalytic, sensing, and photonic technologies. This talk will present polymer-directed strategies for fabricating nanoporous metal oxide coatings with precisely controlled architecture and composition. In this approach, sacrificial polymer scaffolds define pore morphology prior to oxide formation. Inorganic precursors infiltrate the template from solution or vapor phases, yielding conformal oxide networks that preserve structural integrity after template removal. The method is compatible with single- and multicomponent systems, enabling the formation of hierarchical structures and functional heterointerfaces.

By tuning pore size, connectivity, and composition, we demonstrate how nanoscale architecture directly governs catalytic activity, charge transport, and light–matter interactions. In particular, controlled refractive index gradients and tailored pore distributions enable broadband antireflective coatings that maintain excellent optical performance across a wide range of incident angles. The resulting materials combine high catalytic efficiency with angularly robust optical functionality, illustrating how rational porosity design transforms metal oxides into multifunctional platforms for energy and photonic applications.

Functional Thin Films and Surfaces
Room Town & Country A - Session MB-ThP

Functional Thin Films and Surfaces Poster Session

MB-ThP-2 Scalable Surface Engineering of PDMS for Uniform Inkjet-Printed Silver Patterns, ***Hsuan-Ling Kao [snoopy@mail.cgu.edu.tw]***, Chang Gung University, Taiwan; *Li-Chun Chang,* Ming Chi University of Technology, Taiwan; *Min-Hsuan Lu,* Chang Gung University, Taiwan

The advancement of flexible and wearable electronics has increased the demand for materials compatible with the human body. Polydimethylsiloxane (PDMS) stands out due to its biocompatibility, transparency, chemical stability, and skin-like mechanical properties, making it suitable for bio-integrated devices. Its elastomeric nature also allows conformal contact with curved surfaces, making it suitable for epidermal and implantable electronics. Despite these advantages, achieving reliable inkjet printing of conductive traces on PDMS remains challenging due to poor ink adhesion and inconsistent droplet behavior. This study introduces a scalable surface modification approach using dielectric barrier discharge (DBD) plasma to improve PDMS wettability for inkjet printing of silver nanoparticle films. The DBD plasma treatment was performed under ambient conditions, and the discharge parameters were tuned to ensure uniform activation across the entire surface. The optimized argon flow rate and electrode gap facilitated consistent plasma exposure, resulting in reproducible surface energy enhancement. By optimizing argon flow and electrode-substrate distance, the treated area was expanded to 5 × 5 cm^2. Water contact angle (WCA) measurements across nine points confirmed uniformity, averaging 50° ± 1.8°, and white-light interferometry verified the surface remained undamaged. Substrate temperature was also found to play a role comparable to WCA in determining film quality, particularly in relation to printed pattern dimensions. At 50 °C, 200 µm-wide lines printed with three layers exhibited slight wrinkling or cracking, while 300 µm-wide lines showed minor edge spreading. Four-layer prints at this temperature led to bulging. At 60 °C, three- and four-layer 200 µm-wide lines suffered from severe wrinkling and cracking, while 300 µm-wide lines showed edge drying or bulging in three layers, and slight bulging in four layers. An appropriate substrate temperature was identified as essential, enabling both 200 µm and 300 µm-wide silver lines to maintain structural integrity and electrical performance across three to four printed layers. Under these optimized conditions, 300 µm-wide, 4 cm-long silver transmission lines exhibited excellent conductivity with low insertion loss. These results demonstrate the effectiveness of the proposed surface engineering and printing strategy for enabling high-quality, large-area conductive patterns on PDMS, supporting the development of next-generation bio-integrated electronic systems.

MB-ThP-4 Spatially Resolved Molecular Arrangement on the Surface of PEDOT:PSS Film via Laser Scanning, *Chanwoo Kim,* ***Habeom Lee [hblee@pusan.ac.kr]***, Pusan National University, Republic of Korea

Conjugated polymers, particularly poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS), are extensively studied for their intriguing electronic and optical properties, making them promising candidates for various functional applications. Precise and spatially resolved control over their molecular organization and morphology is one of challenging things for the tailored innovations. Here, we present a comprehensive investigation into the localized and spatially precise surface structural reorganization of PEDOT:PSS films, achieved through Laser-induced photo thermal effect without any chemical agents. Our focus is on delineating the intricate morphological and molecular changes and understanding the underlying mechanism that enables this spatial control.

Our study delineates the morphological evolution on surface of PEDOT:PSS films (~ 10 µm thickness) under varying laser doses (wavelength: 532 nm, spot size: 7 µm, continuous wave). Notably, a moderate laser dose induces significant morphological transformations, including undulating and dome-like micro-scale surface features with color change. Critically, the moving continuous laser induces a localized thermal distribution. This consistent thermal propagation, coupled with the kinetic state of the laser, induces a rearrangement within the PEDOT:PSS molecular system. The evidenced AFM phase images exhibit a distinct geometry, providing direct visual evidence of spatially controlled molecular reorganization on the surface. These observations promise a powerful approach for achieving spatially resolved control over molecular arrangement, enabling precise patterning and local property tuning.

Further characterization using XPS, UV-Vis, AFM, XRD, Raman, and FT-IR spectroscopy provides insights into the mechanisms driving these changes. This comprehensive study not only significantly elucidates fundamental understanding of laser-PEDOT:PSS interactions for functional film design but also suggests the intricate potential of this technique for creating advanced functional surfaces with tailored properties through precisely engineered molecular architectures.

MB-ThP-5 Influence of the Si Alloying on the Growth Stability and Electrical Properties of AlN Thin Films, ***Norma Salvadores Farran [norma.salvadores@tuwien.ac.at]***, *Tomasz Wojcik,* TU Wien, Austria; *Astrid Gies, Jürgen Ramm, Klaus Böbel,* Oerlikon Balzers, Liechtenstein; *Szilard Kolozsvári, Peter Polcik,* Plansee Composite Materials, Austria; *Tobias Huber, Jürgen Fleig, Helmut Riedl,* TU Wien, Austria

Aluminum nitride-based ceramics are well known for their insulating properties combined with high thermal conductivity. Their range of applications is wide, in both structural components and thin films. However, the electrical conductivity of these materials is highly temperature-dependent. As the temperature increases, the mobility of charge carriers also rises, which poses significant challenges to their insulating performance.

This study investigates the growth of insulating AlSiN thin films using physical vapor deposition (PVD) and evaluates their electrical insulation at temperatures up to 750 °C. Various reactive PVD techniques were explored, including high-power impulse magnetron sputtering (HiPIMS) and bipolar pulsed sputtering. All depositions utilized a 3-inch aluminum target with varying silicon concentrations in an Argon/Nitrogen (Ar/N_2) atmosphere. Depending on the silicon content, either hexagonal AlN films containing an amorphous Si_3N_4 phase or fully amorphous AlSiN films were produced. The target's alloying concept was designed to enhance deposition stability during sputtering. Within this framework, we also investigated the formation of a fully nitride film at lower reactive gas ratios while maintaining excellent electrical insulating properties.

Phase formation has been examined using X-ray diffraction (XRD), while the deposition rate and film morphology were characterized by scanning electron microscopy (SEM). The insulating behavior of the coatings was evaluated via in-situ impedance spectroscopy across a temperature range from 300°C to 750°C, using Ti/Pt lithography pads as electrodes.

The electrical properties are related to the morphology of the films, particularly whether the films were crystalline or amorphous. Additionally, the influence of impurities, such as O_2, plays a significant role in reducing the insulating properties of the films.

MB-ThP-8 Different Morphologies of Gallium Oxide Thin Films Fabricated by Liquid-Target Reactive DC-Pulsed Magnetron Sputtering, ***Jan Koloros [koloros@ntis.zcu.cz]***, *Petr Novák, Sayed Alireza Ataie, Jiří Rezek, Radomír Čerstvý, Pavel Baroch,* University of West Bohemia in Pilsen, Czechia

Gallium oxide (Ga_2O_3) remains a focus of research due to its outstanding optoelectronic properties, including an ultra-wide bandgap of approximately 4.8 eV, a high electron saturation velocity, and its ability to withstand a high breakdown electric field of about 8 MV/cm. Although Ga_2O_3 is typically prepared using methods such as MBE, MOCVD, or ALD, it would be advantageous to find a viable method for preparing this material using magnetron sputtering as well. This is because this method is known for its high deposition and ease of up-scaling the process. Despite some published work in this area, it has not yet been possible to find conditions that lead to layers with satisfactory electrical properties.

In this work, we focus on reactive magnetron sputtering of Ga_2O_3 films using a liquid gallium metal target on different substrates and under various conditions (oxygen and argon partial pressures, substrate temperature, and pulse-averaged target power density). The resulting films exhibit a broad range of morphologies, from compact solid thin films to wire-like microstructures. We present the optical, electrical, and microstructural properties of the films and suggest their correlations with the discharge parameters as well as the substrate used. We found that the crystalline quality of Ga_2O_3 films and their preferential orientation play a crucial role in achieving improved electrical properties. The optimal crystal structure can be obtained primarily by selecting an appropriate temperature and substrate that promotes the crystalline growth of the film.

MB-ThP-11 Plasma-Polymer Fluorocarbon Based High Sensitivity Surface Enhanced Raman Spectroscopy Application, ***Jimin Han [jimin7479@chungbuk.ac.kr]***, *Sang-Jin Lee,* Chungbuk National University, Republic of Korea

Surface-enhanced Raman spectroscopy (SERS) provides a powerful analytical tool for molecular identification through the amplification of Raman scattering signals from target analytes on plasmonic nanostructures. In this study, we present a plasma–polymer–fluorocarbon (PPFC)-based nanocomposite thin-film platform designed to achieve high SERS sensitivity via controlled nanoparticle formation. By tuning the sputtering power density during mid-frequency magnetron sputtering, the distribution and ratio of Ag and Cu nanoparticles embedded in the PPFC matrix were precisely modulated, as confirmed by X-ray photoelectron spectroscopy (XPS) and ultraviolet–visible–near infrared (UV–Vis–NIR) spectroscopy. The optimized Ag–Cu PPFC (CAP) thin films exhibited distinct localized surface plasmon resonance (LSPR) absorption peaks and demonstrated an enhancement factor (EF) of up to 10^8 for rhodamine 6G, supported by finite-difference time-domain (FDTD) simulations showing strong electromagnetic localization at the metal–metal nanogaps. Furthermore, a simplified fabrication approach employing a single composite target of Cu, carbon nanotube (CNT), and PTFE powders (5:60–80:35–15 wt.%) was developed to produce Cu–PPFC nanocomposite films with moderate SERS sensitivity (EF ≈ 2.18×10^4). The prepared CAP and Cu–PPFC nanocomposite films successfully detected rhodamine 6G on flexible polyethylene terephthalate substrates, maintaining distinguishable Raman signals even with reduced optical transmittance. These results demonstrate that plasma–polymer fluorocarbon nanocomposites incorporating Cu and Ag nanoparticles offer a scalable, flexible, and cost-effective route toward high-performance SERS-active substrates suitable for on-site and point-of-care molecular detection applications.

MB-ThP-12 Radio Frequency Magnetron Sputtered CdS-Plasma Polymerized Fluorocarbon Nanocomposite Thin Films : Structural Properties and Electrochemical Performance for Lithium-Ion Battery Anodes, ***Joowon Lee [ljw0821@chungbuk.ac.kr]***, *Sang-Jin Lee,* Chungbuk National University School of Semiconductor Engineering, Republic of Korea

Radio Frequency (RF) magnetron sputtering was employed to synthesize CdS–plasma polymerized fluorocarbon (PPFC) nanocomposite thin films. This work presents a comprehensive analysis of the structural, chemical, and morphological characteristics of these films, followed by an evaluation of their potential as anode materials for lithium-ion batteries.

Advanced characterization techniques, including Transmission electron microscopy (TEM), X-ray diffraction (XRD), grazing incidence small-angle X-ray scattering (GISAXS), and X-ray photoelectron spectroscopy (XPS), were utilized to elucidate the film properties. These analyses confirmed the successful incorporation of CdS nanoparticles within the polymeric matrix as shown in **Figure 1**.

Electrochemical testing demonstrated that the CdS–PPFC nanocomposite thin films exhibit stable performance as battery anodes. Notably, thinner films displayed superior battery performance compared to thicker electrodes. This enhancement is attributed to the evolution of surface morphology; specifically, a reduction in film thickness leads to increased surface roughness, which in turn provides a larger surface area for electrochemical reactions.

Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government(MSIT) (RS-2025-00516639)

MB-ThP-13 Synthesis of Bismuth Molybdate Photocatalytic Films by Reactive Magnetron Sputtering for the Photo-Discoloration of Carmine Indigo Dye, *Ricardo González-Campuzano,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México*; David E. Martínez-Lara,* Escuela Nacional Preparatoria No.7 "Ezequiel A. Chávez", Universidad Nacional Autónoma de México*; Agileo Hernández-Gordillo,* ***Monserrat Bizarro-Sordo [monserrat@materiales.unam.mx]***, *Sandra E. Rodil-Posada,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México

Water pollution has increased significantly due to rapid industrial growth. A significant issue arises from dyes produced by various industries, including the chemical, medical, leather, and other sectors, which pose significant environmental impacts due to their difficult disposal. Photocatalysis has recently attracted considerable attention and demonstrates significant promise for the degradation of diverse organic and inorganic contaminants. It is considered one of the most sophisticated advanced oxidation methods for removing an extensive variety of organic and inorganic pollutants. Bismuth molybdates (BMO) are photocatalytic semiconductors employed in potential applications including water pollutant degradation, air purification, and carbon dioxide reduction, among others.In this work, we report on the synthesis, morphological, structural, compositional, and optical characterization, as well as the evaluation of the photocatalytic response of BMO in thin-film form. The films were produced through co-deposition by sputtering from two independent targets: bismuth oxide (α-Bi_2O_3) and molybdenum (Mo). This approach allows precise control over composition and the attainment of various phases without the need to fabricate targets with different compositions. The deposits were produced by maintaining a constant power of 30 W on the α-Bi_2O_3 target while varying the power on the Mo target from 20 to 100 W. The substrates were heated to 150 °C during deposition, followed by a 1-hour heat treatment at 500 °C in air to induce crystallization. The phases observed were determined by X-ray diffraction and Raman spectroscopy, while their optical properties, specifically the band gap, were estimated using UV-Vis reflectance spectroscopy.The photocatalytic response of the films was evaluated by photodecolorization of indigo carmine (IC) dye solutions at five ppm and pH 3.5 under irradiation from a 385 nm light source. The results showed a decrease in the intensity of the 610 nm absorption band of the IC solution with increasing irradiation time, achieving almost 100% photodecolorization in approximately 2 hours. Subsequent tests for reuse and stabilization were performed for practical applications, repeating the IC blue photodegradation experiments ten times using the sample that showed the best photocatalytic performance. No significant reduction in photocatalytic activity was observed after 10 cycles of testing.

MB-ThP-14 Microstructure and Electrochemical Behavior of Aps Coatings Deposited on Agricultural Plows, *Corneliu Munteanu,* ***Bogdan Istrate [bogdan.istrate@academic.tuiasi.ro]***, "Gheorghe Asachi" Technical University of Iasi, Romania*; Boris Nazar,* Technical University of Moldova*; Fabian Cezar Lupu, Ramona Cimpoesu, Gelu Ianus,* "Gheorghe Asachi" Technical University of Iasi, Romania*; Teodor Marian,* Technical University of Moldova

This research focuses on the application of thermal spray technologies aimed at optimizing the functional properties of agricultural components intended for soil tillage. The investigation is based on thermal coatings obtained through Atmospheric Plasma Spray (APS) technology applied to the constructive elements of agricultural ploughs, which are subjected to aggressive operating conditions. The specific properties of these components—microstructural analysis and corrosion resistance—constitute determining parameters for ensuring enhanced durability of agricultural equipment (mainshare and foreshare).

Within the experimental investigation, protective coatings were deposited through thermal spray technology using metallic powders based on WC12%Co (commercial designation WOKA 3101). Characterization of the microstructural properties and electrochemical behavior of the deposited layers was evaluated on laboratory specimens in specific corrosion environments. The obtained results demonstrated that thermal spray coatings presents an optimal method for enhancement and potential reconditioning of components.

The deposited layers exhibited satisfactory adhesion and characteristic microstructure, composed of successive splats with reduced porosity. Analysis of electrochemical behavior revealed superior corrosion resistance compared to the base material, an aspect indicating significant improvement of functional properties and enhanced functional capacity of the coated components.

Acknowledgment: This work was supported by a grant from the Ministry of Education and Research, CCCDI–UEFISCDI, project number PN-IV-PCB-RO-MD-2024-0336, within PNCDI IV

MB-ThP-15 Influence of Microstructure on Dealloying Kinetics of Nanoporous Thin Films, *Ezgi Hatipoğlu,* Max Planck Institute for Sustainable Materials, Germany*; Ayman El-Zoka,* Imperial College London, UK, Germany*; Yujun Zhao,* Max Planck Institute for Sustainable Materials, Germany*; Stanislav Mraz, Jochen Schneider,* RWTH Aachen University, Germany*; Baptiste Gault,* ***Aparna Saksena [a.saksena@mpi-susmat.de]***, Max Planck Institute for Sustainable Materials, Germany

Nanoporous metals offer an important platform for tailoring composition and surface-to-volume ratio, both aspects critical for applications in catalysis where nanoporous thin films can offer further ease of handling. These films are however prone to intergranular cracking during dealloying, limiting their stability and potential applications. Here, we set out to systematically investigate the grain boundaries (GBs) in Au28Ag72 (± 2

at.%) thin films. We observe that sample synthesized at 400 °C is at least 2.5 times less prone to cracking compared to sample synthesized at RT. This correlates with a higher density of coincident site lattice (CSL) GBs, especially the density of Σ3, increased, which appear resistant against cracking. Atom probe tomography (APT) of random high-angle GBs reveals prominent Ag enrichment of up to 77at.%, whereas Σ3 coherent twin boundaries show Au enrichment of up to 30at.%. APT also reveals a strong texture dependence on the dealloying kinetics where the (111)-textured film retains a higher Ag concentration within the nano-ligaments and the untextured film already exhibits coarsening, indicating a faster reaction kinetics, and a lower Ag content. Our study highlights the potential of microstructure engineering in tailoring the properties of nanoporous metals for possible future catalytic and electrochemical applications.

MB-ThP-18 Ion-Beam Assisted Deposition of Oxide Semiconductor Thin Films for Optical Devices, ***Pin Yao Hsiang [hsiangpy@gmail.com]***, Chang Gung University, Taiwan; *Tsung Yu Huang,* Ming Chi University of Technology, Taiwan, Republic of China

This study investigated the use of a tin-based oxide (SnOx) semiconductor layer as the active layer for a light-addressable potentiometric sensor (LAPS) on a commercial indium tin oxide (ITO)/glass substrate. We characterized the optical absorption properties of the SnOx layer, as well as changes in Hall mobility and Raman spectroscopy, using ion beam assisted discharge (IBAD) and varying argon/oxygen flow ratios. The experimental results demonstrate the potential of SnOx as an active layer for LAPS, but the stability and lifetime performance of SnOx LAPS require further process optimization.

MB-ThP-19 Insulation Coatings for Temperature Sensors in Molding Tools, ***Martin Welters [welters@kcs-europe.com]***, *Rainer Cremer,* KCS Europe GmbH, Germany

The mobility sector is one of the largest emitters of greenhouse gases. Consequently, providers of mobility services and systems are facing a profound transformation towards climate neutrality. A key lever on the path to emission-free production is circular value creation, which significantly reduces the use of primary raw materials and thus lowers environmental impact. The overarching goal of the project is to improve the CO_2 and environmental performance of structural and hybrid components by consistently increasing efficiency, using recyclates, and implementing an ecologically optimized component design.

One sub-project focuses on the development and design of sensor-equipped tool inserts for **in-situ temperature measurement**during the production of automotive components made from recycled materials. The sensor layer system consists of multiple layers - sensor layers and an electrical insulation and a wear-protection layer - applied on top of each other to form a layer stack. A key requirement is that the coatings must meet not only the sensory specifications but also the durability criteria necessary for their application - particularly when used with polymer melts containing recyclate components. For the development of the insulating layer, special sensor dummies as well as fixturing for PVD processes were developed to enable the investigation of local differences in the properties of the insulating layer. In this way, the aluminum-based insulation layers used could be iteratively improved with regard to the application, eliminating the need to coat numerous elaborately manufactured sensors.

MB-ThP-20 Corrosion-Inhibiting, Antibacterial Coatings for Soft Tissue Anchors, ***Simon Cremer [simon.cremer@kcs-europe.com]***, *Rainer Cremer,* KCS Europe GmbH, Germany

Conventional biodegradable soft tissue anchors are exposed to severe corrosion due to their contact with blood, causing them to lose their integrity after only 8-12 weeks. PVD coatings are aimed at specifically influencing this corrosion. PVD coatings have long been studied for their corrosion protection properties. Although layers deposited by magnetron sputtering or arc evaporation nowadays have a dense microstructure. However, contact with corrosive media such as blood usually leads to pitting corrosion very quickly, which severely attacks the substrate materials underlying the coating. Such attacks occur primarily at layer growth defects.

In order to prevent controlled degradation of the implants and the negative effects of pitting corrosion, which manifests itself in excessively rapid corrosion, round samples of an Fe-Mn alloy were polished and coated with a thin titanium layer by KCS Europe using a sputtering process. To obtain an antibacterial surface, the samples were coated with a silver layer of 3, 10, and 30 nm in a second coating process. The thickness of the silver layer is decisive for the antibacterial effect of the surface. If the silver layer is too thin, the antibacterial properties of the surface can be lost because individual areas of the surface are not coated. A continuous silver layer, on the other hand, prevents the desired controlled degradation of the implants. A surface on which individual silver cells were deposited locally in island-like formations, but did not completely cover the substrate, proved to be optimal for controlled decomposition and the antibacterial effect of the coatings.

MB-ThP-21 Partial Laser Ablation in PVD Multilayers for Multicolored and Nanostructured Surfaces, *Raphael André,* Berner Fach Hochschule, Switzerland; *Christian Petitot,* Université Marie et Louis Pasteur, UTBM, CNRS, Institut FEMTO-ST (UMR 6174), France; *Rainer Kling, Sylvain Le coultre,* Berner Fach Hochschule (BFH), Switzerland; ***Pascal briois [pascal.briois@utbm.fr]***, Université Marie et Louis Pasteur, UTBM, CNRS, Institut FEMTO-ST (UMR 6174), France

The APLM (*Ablation Partielle par Laser dans des Multicouches PVD pour des surfaces Multicolores et nanostructurées in french*) project is supported by the INTERREG VI France–Switzerland 2021–2027 program. The project consortium consists of two universities, namely the Bern University of Applied Sciences (BFH) and the University of Technology of Belfort-Montbéliard (UTBM), as well as four industrial partners (Plasmadiam and Gravity for Switzerland, and SILSEF and SAIREM for France).

The objective of APLM is to develop all the technical expertise required to industrialize a process invented and patented by BFH and Plasmadiam in May 2024. The invention combines vacuum deposition technologies for ultrathin coatings using PVD and PECVD, together with partial ablation by means of nanosecond, picosecond, and femtosecond pulsed lasers, enabling the generation of cavities within multilayers with nanometric control and precision. Prototypes of multicolored watch dials, as well as molds for nanoimprint lithography (NIL), embossing, and plastic injection molding, will be produced. These prototypes will help promote the technology and enhance the value of the invention, generating economic benefits for all industrial partners of the consortium within the regions and beyond.

The main actions of the project consist in developing various robust processes for depositing brightly colored layers or layers with specific optical properties by combinatorial PVD sputtering, with or without the use of MW-PECVD plasma, while meeting the mechanical specifications required for the targeted applications. Subsequently, a database of laser ablation thresholds (in J/cm^2) will be established for the different colored or functional PVD layers produced (20–500 nm thickness range) at different wavelengths. A predictive model will also be designed to estimate the ablation threshold of a material based on its physical properties. Finally, flagship prototypes demonstrating the patented technology will be developed in the fields of multicolored watch dials and nanostructured molds for NIL, embossing, and plastic injection, through the ablation of nanometric cavities structured on three or four levels.

During this poster presentation, a general overview of the project will be provided, along with a presentation of the first colored coatings obtained by BFH and UTBM. These coatings were produced by reactive magnetron sputtering.

MB-ThP-23 Numerical Modelling for Optimized Experimental Design in Vernier Ellipsometry Sensing, *Kawshik Shikder, Zhang Yun, Md Rashedul Huqe, Yishu Foo, May Thawda Phoo, Yee Man Kwong,* ***Juan Antonio Zapien [apjazs@cityu.edu.hk]***, City University of Hong Kong

In Vernier Ellipsometry Sensing (VES) two zero-reflection points (ZRPs) in p-pol and s-act in synergy to enable a refinement optical measuring scale akin to a Vernier scale. These new class of sensors are enabled by: i) strong coupling between p-pol surface plasmon polariton and p-pol photonic waveguide leading to Rabi splitting with phase singularities of the resulting hybrid resonances; ii) spectrally overlap between the s-pol photonic modes and the hybrid p-pol resonances; and, importantly, iii) the ellipsometric sensing strategy where the s-pol ZRPs provide a stable reference to boost the sensor performance in terms of the amplitude ratio and phase difference of both ZRPs.

In VES fine angle of incidence (AoI) tuning enables resetting the sensor to its optimal sensing point.We will present new numerical simulations that are able to track the performance of this VES with high efficiency to determine the optimum operation conditions in terms of (AoI) and spectral overlap resonance for la large dynamic range in changes of refractive index unit (RIU) in the sensing media. We discuss the implications of these results for the design of a dedicated AoI- and wavelength- resolved ellipsometer system capable to instantaneously track the best-point sensitivity and achieve lowest limit of detection (LoD) and large dynamic range.

MB-ThP-24 Selective Etching of Boron Doped Si1-XGeX Epitaxial Layers for Vertically Stacked Memory Device, ***Joosung Kang [jws1204@yonsei.ac.kr]***, *Dongmin Yoon, Seonwoong Jung, Dae-hong Ko,* Yonsei University, Republic of Korea

Dynamic random access memory (DRAM) devices have continuously increased their integration density through aggressive device scaling and have progressively evolved toward three-dimensional (3D) architectures to overcome the limitations of planar designs. Among various approaches, 3D DRAM structures employing highly stacked Si channels and SiGe sacrificial layers are regarded as promising candidates for cell designs beyond the $4F^2$ node. In such vertically stacked channel architectures, the selective removal of SiGe sacrificial layers from epitaxial Si/SiGe multilayers represents a critical process requirement.

In this study, the selective etching behavior of boron-doped SiGe epitaxial layers—introduced to compensate for strain arising from lattice mismatch between Si and SiGe—was systematically examined as a function of boron concentration. Dopant-dependent variations in etching behavior were observed in both blanket films and Si/SiGe multi-stack structures. To gain insight into the underlying mechanisms, the chemical bonding states of etched SiGe surfaces were analyzed using X-ray photoelectron spectroscopy (XPS), with a focus on dopant-induced modifications of oxide-related surface chemistry. The results reveal that boron incorporation significantly alters the etching response of SiGe layers through changes in surface oxide chemistry, leading to distinct dopant-dependent trends. These findings provide fundamental insight into dopant-mediated surface reactions during selective etching and offer useful considerations for process optimization in vertically stacked semiconductor device fabrication.

Acknowledgment

This work was supported by the Technology Innovation Programs (RS-2024-00434624 & RS-2025-02306457) and the K-CHIPS program (25065-15FC) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).

Author Index

Bold page numbers indicate presenter