Advanced Surface Engineering
Room Ballroom A - Session SE-ThP

Advanced Surface Engineering Poster Session

SE-ThP-1 PLD or Magnetron Sputtering: Which to Choose for Functional Coatings?, ***Esteban Broitman***, *Sven Kelling, Rickmer Kose,* SENTYS

This review evaluates pulsed–laser deposition (PLD) and magnetron sputtering (MS) through a practical, application–oriented lens to help researchers and engineers select the most appropriate route for functional thin films (oxides, nitrides, chalcogenides, carbon-based). Drawing on head–to–head studies that deposit identical materials with both techniques, the paper traces how differences in deposition physics translate into film composition, microstructure, defect populations, mechanical properties and device performance.

PLD is highlighted for its reliable stoichiometric transfer from complex targets, its ability to produce high bonding density and elevated sp^3 fractions in carbon films, and its suitability for epitaxial growth and high–hardness coatings; its principal drawback is the tendency to generate particulates from the energetic plume unless droplet–mitigation strategies are employed. Magnetron sputtering (DC/RF) is shown to excel at large–area uniformity, conformal coverage and low macroscopic droplet density; pulsed modes and HiPIMS further boost ionization and substrate bombardment, yielding dense films that can rival PLD in many functional metrics while offering established industrial throughput.

The review also surveys hybrid PLD+MS approaches that leverage PLD's compositional fidelity together with sputtering's smoother deposition to reduce defects and increase density. Advances in ultra–high vacuum (UHV) platforms enhance both methods: UHV PLD improves cleanliness and epitaxial control, and UHV MS reduces impurity uptake and tightens reproducibility. Manufacturers of scientific research equipment such as **PREVAC** exemplify systems that enable in–situ diagnostics and clean sample transfer. Finally, the paper places cost and scalability in context: bench–scale sputter tools are typically less costly to acquire and run than PLD benches, whereas at production scale capital expenditures for high–end HiPIMS sputter systems and wafer–scale PLD platforms converge.

The review closes with a concise decision matrix and actionable guidelines to match deposition choice to stoichiometry, surface quality, throughput and budget constraints.

SE-ThP-2 Surface Engineering of Ni-Based Alloy Thin-Film Catalysts for Enhanced Hydrogen Evolution Reaction, *Zhe-Yu Liu, Jhih-Siang Yang, Fan-Bean Wu,* ***Wan-Yu Wu***, National United University, Taiwan

Nickel-based thin-film catalysts have attracted increasing interest as cost-effective alternatives to noble-metal electrocatalysts for water electrolysis. In this study, Ni-Cu and Ni-Mo alloy thin films were prepared by magnetron co-sputtering as a surface engineering strategy to tune composition, morphology, and electrocatalytic performance for the hydrogen evolution reaction (HER). The sputtering process enables the fabrication of dense, adherent, and composition-controlled thin films, providing a useful platform for clarifying the relationship between alloy composition and catalytic activity.For the Ni-Cu system, Cu was incorporated into Ni to balance hydrogen adsorption behavior and improve charge-transfer properties. Pure Ni tends to bind hydrogen too strongly, whereas Cu has weaker hydrogen adsorption and high electrical conductivity. Therefore, the Ni-Cu alloy design is expected to provide a synergistic effect for HER. Electrochemical measurements in 1 M KOH showed that the Ni-Cu thin film with a near-equiatomic composition of approximately Ni:Cu = 55:45 exhibited the best HER performance, achieving overpotentials of 76 mV at 10 mA cm^{-2} and 180 mV at 100 mA cm^{-2}. This film also showed the lowest charge-transfer resistance of 0.71 Ω, indicating enhanced interfacial reaction kinetics.For the Ni-Mo system, Mo-Ni alloy thin films with different Ni contents were deposited by DC co-sputtering on silicon and carbon-paper substrates. Structural and surface analyses indicated that co-sputtering promoted composition-dependent thin-film structures with hydrophilic surfaces. In 0.5 M H_2SO_4, the Mo-Ni catalysts exhibited a volcano-type dependence of HER activity on Ni content. The catalyst with 72.8 at% Ni showed the optimal performance, with an overpotential of 149.0 mV at 10 mA cm^{-2} and a Tafel slope of 77.5 mV dec^{-1}. In 1 M KOH, HER activity generally improved with increasing Ni content, suggesting the important role of Ni in alkaline HER kinetics.Overall, these results demonstrate that magnetron co-sputtering is an effective approach for tailoring the composition and surface properties of Ni-based alloy thin-film catalysts. The Ni-Cu system highlights the importance of balancing hydrogen adsorption and charge transfer, while the Ni-Mo system shows that composition-dependent structural modification strongly influences HER kinetics.

SE-ThP-3 Mechanochemically-Driven Formation of Zero-Friction and Zero-Wear Lubricating Carbon Films, ***Diana Berman,*** University of North Texas

Mechanically-induced surface degradation creates a significant problem for currently-used mechanical assemblies and is the major cause for their loss of usefulness. Meanwhile, high-contact pressure and shear during relative movement of the sliding interfaces provide the unique capability for local heating and shear- and load-induced compression of the sliding surfaces. For a correct combination of materials in sliding contact, these conditions may induce tribochemical reactions that lead to the formation of a protective damage-suppressing tribofilm directly at the contact. In this presentation, we overview recent advances in establishing the fundamental understanding of materials interactions at sliding interfaces and use this knowledge as a guide to developing nanomaterials solutions that enhance reliability and efficiency of tribological systems. We demonstrate tribochemically-driven self-replenishment of materials inside the contact interfaces, thus enabling a zero-wear sliding regime.

Overall, the findings could open a new avenue for the development of new concepts and design strategies for next generation of tribologically efficient materials systems.

SE-ThP-4 Friction and Wear of Composite MXene/MoS_2 Coating Under Low-Viscosity Fuels, ***Ali Zayaan Macknojia***, *Diana Berman, Andrey Voevodin, Samir Aouadi,* University of North Texas*; Stephen Berkebile,* Army Research Laboratory

Friction and wear-related failures remain major challenges in moving mechanical assemblies operating under various conditions. For example, the components of fuel systems made of AISI 52100 steel are susceptible to scuffing-induced wear when operated in a fuel environment. This study demonstrates the decreased friction and wear characteristics achieved by spray-coating 52100-grade steel surfaces with solution-processed multilayer Ti_3C_2Tx-MoS_2 blends. The study analyzed the performance of the coating under high contact stresses and sliding speeds in different fuels. Raman spectroscopy, scanning electron microscopy, and transmission electron microscopy results revealed the formation of a robust in situ tribolayer responsible for the outstanding performance observed at high contact pressures and sliding speeds. This study has broad implications for the development of solid lubricants that can operate under extreme conditions and low-viscosity fuel environments, inspiring further research and development in this field.

SE-ThP-5 Synthesis and Dehydrogenation of Thin Film Metal Hydride for Hydrogen Storage, ***Vladimir Gorokhovsky***, *Grace Owens,* University of Colorado at Boulder*; Paul Smith,* Plasma Kinetics Corporation

Magnesium hydride (MgH_2) is solid-state hydrogen storage material, with a theoretical hydrogen storage capacity of 7.6 wt%, making it an attractive candidate due to its high hydrogen affinity, low cost and abundance. But high enthalpy of formation and high decomposition energy of MgH_2 requiring about 76 kJ/mol of heat for each mole of H_2 released lead to increase of hydrogenation temperature, slow hydrogenation and dehydrogenation kinetics. Ni is often used as a catalyst to improve the kinetics of MgH_2 formation in H_2-contained atmosphere due to reduced enthalpy of formation of Mg-Ni alloys (<65 kJ/mol) and also has a reduced activation energy of dissociation of molecular hydrogen in comparison to Mg, suggesting that Ni mainly catalyzes the dissociation/recombination reaction barrier for H_2 solid-state hydrogen storage material reducing the hydrogenation/dehydrogenation temperatures. MgNi thin film coatings were prepared via vacuum cathodic arc deposition on sapphire wafer, aluminum foil, and aluminized polyamide tape. The cathodic arc process conditions for deposition of MgNi coatings were chosen to keep the substrate temperature low for which the arc current was selected from 50 to 70 A, and substrates (both sapphire and metal foil) were installed in a free-standing position at floating potential. The coating architecture consisted of the bottom supporting NiTiCu sublayer having large open columnar microstructure promotes the formation of the columnar microstructure with open voids in the MgNi layer. The Pd top layer deposited by e-beam evaporation improves hydrogen absorbance capability. The films were hydrogenated in Ar/5%H_2 atmosphere at 300°C in atmospheric pressure. The hydrogenation changed the color of the coating surface from silver metal to dark color accompanied by reduced electrical conductivity and increased transparency of the film indicating shift from metallic to insulative ceramic The dehydrogenation of the magnesium

hydride containing films was made via laser irradiation at room temperature using 808 nm wavelength CW laser. The hydrogen flow, consisting of both molecular and atomic hydrogen, generated by laser irradiation of one hydrogenated coating spot 1mm x 10mm during 1s ranging from 0.5 to 1 SCCM. It was demonstrated that almost 90% of hydrogen contained in hydrogenated NiTiCu/MgNi/Pd coating can be released by CW laser irradiation from the 1" x 1.25" sample. The partial light transparency and increased light absorbance of MgH_2 improved by columnar microstructure with open voids provide a basis for using amplified light beam to release hydrogen from the thin film, contributing to safe and efficient hydrogen storage.

SE-ThP-6 Photodegradable Thin Films for Dust Mitigation, ***Kira Sand***, *David Allred,* Brigham Young University

High-contrast optical systems for space applications require effective dust mitigation strategies to maintain low-scatter surfaces and edges. A novel approach would be to use photodegradable thin films that can remove any dust particles after launch, thereby reducing the likelihood of further particulate accumulation.

In this work, we investigate the photodegradation behavior of polymers such as poly(olefin sulfone) (PMPS) and poly(1-hexene sulfone) (PHS) under space-like conditions, specifically in vacuum under UVC irradiation (254 nm and 172 nm). We demonstrate that these materials undergo efficient dissociative degradation, enabling the removal of dust from coated optical surfaces. Our results show a significant reduction in particle coverage following irradiation of dust-coated films.

Additionally, we report the use of more energetic thin-film materials, including ammonium nitrate, which exhibit similar photodegradation behavior. These materials may provide enhanced dust removal efficiency due to the higher energy stored in their chemical bonds.

Overall, this study highlights the potential of photodegradable thin films as an effective strategy for in situ dust mitigation in space-based optical systems.

SE-ThP-7 Surface Patterning with Unconventional Self-Assemblies by an *m*-Terphenyl Isocyanide Ligand, ***Liya Bi***, *Zhiyuan Yin, Krista Balto, Joshua Figueroa, Shaowei Li,* University of California San Diego

Self-assembled monolayers (SAMs) refer to spontaneously formed single-layer molecular sheets on surfaces, which have found applications in corrosion protection, catalysis, drug delivery, molecular sensing, etc. The assembling behaviors of a given molecule on the surface depend on both the molecule-surface interactions and the intermolecular interactions which include covalent bonding, van der Waals interaction, hydrogen bonding or a combination of these forces. Consequently, there are various tuning knobs towards controllable molecular self-assemblies by modifying either the surfaces or the molecules. Here, we report the unconventional self-assembled patterns of a rationally designed *m*-terphenyl isocyanide ligand, $CNAr^{Mes2}$, on Ag surfaces. This molecular ligand binds to metal atoms via its isocyanide group and experiences rich intermolecular interactions upon surface adsorption because of its *m*-terphenyl skeleton. We anticipated it to form a dimerized linear molecular chain on metal surfaces based on its profile, as confirmed on Cu(100) and Cu(111) surface. Surprisingly, $CNAr^{Mes2}$ self-assembles into a few unexpected structures on Ag(111) surface including ribbons, rings and hexagons at low surface coverage and forms closely packed monolayers at high molecule density. A detailed study on these unconventional patterns suggests that $CNAr^{Mes2}$ trimer other than the dimer is the building block and that the surface chemistry of Ag plays a vital role in this assembling mechanism change. These observations inspire us to engineer the metal-binding isocyanide group and/or the steric bulks of $CNAr^{Mes2}$ to achieve programmed SAMs with on-demand shapes, lattice constants and functionalities on metal surfaces.

SE-ThP-8 ASSD Student Award Finalist Poster: In-Situ Tribo-Sintering and Atomic Structure of 2D Silicate Interfacial Films derived from Sustainable Oleogels, ***Mohammad Eskandari***, *Diana Berman, Ali Zayaan Macknojia,* University of North Texas

Designing stimuli-responsive interfacial materials capable of adapting to extreme thermomechanical stresses remains a profound challenge in surface science. Conventional liquid lubricants typically exhibit catastrophic boundary film failure at elevated temperatures. Here, we report a paradoxical friction-reversing phenomenon in sustainable bio-oleogels thickened with organically modified montmorillonite nanoclay: an autonomous transition to a macroscopic superlubricity regime (COF <0.01) initiated solely by high contact pressures (500 N) and thermal activation (150°C).

To unravel the structural mechanisms underlying the observed superlubricity phenomena, we first performed a post-tribology Raman spectroscopy analysis that confirmed the formation of a clay-based tribofilm. The 3D topographical maps acquired with ultra-high-resolution confocal laser scanning microscopy (~140 nm) confirmed the contiguous nature of it. Electron diffraction and lattice fringe imaging using high-resolution transmission electron microscopy (HR-XTEM) revealed the in-situ self-assembly of ordered layers, sintered at the plastically deformed metallic asperities. Through the combined multi-scale microscopy approach, this research provides direct evidence of a shear-induced sol-to-solid phase transition at the sliding interfaces, revealing a new class of intelligent, bio-derived, adaptive liquid interfaces for extreme environments.

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