

# Monday Morning, October 25, 2021

## Live Session

### Room Live - Session LI-MoM

#### AVS Plenary & Awards Session

**Moderators:** Timothy Gessert, Gessert Consulting, Dan Killelea, Loyola University Chicago, Amy Walker, University of Texas at Dallas

10:00am **LI-MoM-1 Welcome from the AVS President, Susan Burkett**, University of Alabama

Welcome to the AVS 67 Virtual Symposium! We hope you will enjoy our Exciting Live and On Demand Sessions this week!

10:05am **LI-MoM-2 Welcome from the AVS 67 Program Chair, Dan Killelea**, Loyola University Chicago

Welcome to the AVS 67 Virtual Symposium. I will review the structure of this week's program. We hope you will enjoy the event!

10:15am **LI-MoM-4 AVS Plenary Lecture: Pump-Probe Experiments with Neutral Matter: A New Approach to the Kinetics of Surface Reactions, Alec M. Wodtke**, Georg-August University of Göttingen and The Max Planck Institute for Biophysical Chemistry, Germany **INVITED**

Knowledge of the rates of elementary gas phase reactions has contributed decisively to our understanding of important societal problems, for example stratospheric ozone chemistry. Growing our knowledge of rates of elementary chemical reactions at surfaces is crucially important to improving heterogeneous catalysis. In comparison to gas phase reactions, there are surprisingly few known activation energies of elementary surface reactions, nor knowledge of the energies and entropies of the reactions' transition states. This situation is a result of limitations on our methods for measuring rate constants of elementary surface reactions. Furthermore, first principles theories to predict surface reaction rates remain largely unvalidated. In this talk, I will present recent experimental advances yielding the rates of elementary reactions at surfaces, which rely on a stroboscopic pump-probe concept designed for neutral matter. This method is also capable of revealing surface-site-specific kinetics information. Not only is site specific reactivity an essential aspect of surface reaction mechanisms, it is essential to provide benchmarks for testing first principles methods for calculating reaction rates, another potentially powerful tool with which to investigate heterogeneous catalysis.

11:00am **LI-MoM-13 2021 Dorothy M. and Earl S. Hoffman Award Scholarship Talk: Formation and Stability of Oxygen Structures on Ag(111) Surfaces, Marie Turano**<sup>1</sup>, Loyola University Chicago; *L. Juurlink*, Leiden University, The Netherlands; *E. Jamka, M. Gillum, D. Killelea*, Loyola University Chicago

We have studied oxidized Ag(111) surfaces after exposure to gas-phase O atoms using a combination of surface science techniques to determine the resultant surface structure. The total oxygen incorporation was determined with temperature programmed desorption (TPD) and the surface structures were determined with low energy electron diffraction (LEED) and scanning tunneling microscopy (STM). A long-standing challenge in the study of heterogeneously catalyzed oxidation reactions on silver surfaces is the determination of what surface species are of greatest chemical importance. This is due to the coexistence of several different oxygen reconstructions on oxidized silver surfaces. A further complication is subsurface oxygen (O<sub>sub</sub>) or O atoms dissolved into the near surface region of a metal, which alters the surface structure and reactivity of the metal. However, the effects of O<sub>sub</sub> have yet to be well characterized. Using a curved Ag(111) single crystal with two step types, we investigated the influence of terrace width and step geometry on oxidation and reconstruction formation on a well characterized Ag surface. Upon exposure of a curved Ag(111) crystal to gas-phase O atoms at 525 K, we observed a non-uniform oxygen accumulation over the crystal surface. Quantitatively, O desorption was identical to planar Ag(111) as verified by TPD. However, through STM images, we determined that A-type steps massively reconstruct with reconstruction forming at the bottom edge of steps and spreading outward. B-type steps exhibit a different growth mechanism where steps are originally pinned by initial oxidation and thus hinder the formation of reconstruction.

In addition, after oxygen exposures at low temperatures (T = 450 K) resulting in O<sub>sub</sub> formation, the surface showed the coexistence of a previously characterized stripe structure as well as an amorphous pattern. Annealing this exposure resulted in familiar surface reconstructions implying that the O<sub>sub</sub> changes the surface structure on curved Ag(111).

Based on these findings, we demonstrate the complexity of the silver surface under oxidizing conditions and the importance of O<sub>sub</sub> in resultant surface structures.

11:15am **LI-MoM-16 AVS 2021 Graduate Research Award Talk: Molecular Interactions with Frozen Ice Films: Adsorption, Oxidative Reactivity, and Isotopic Enrichment, Michelle Brann**<sup>2</sup>, *S. Sibener*, University of Chicago

My research seeks to experimentally model surface-mediated processes occurring on icy-dust grains to develop a more complete understanding of the formation of planetary atmospheres, complex organic molecules, and origin of life in the universe. I use a state-of-the-art ultra-high vacuum (UHV) chamber that mimics the low-pressure conditions seen in astrophysical environments with optics for *in-situ* Reflection Absorption Infrared Spectroscopy (RAIRS). This chamber is connected to a molecular beam line that produces reactant gases with highly customizable energies for exposure onto the desired substrate. My goal is to understand how impinging molecules adsorb, react, or diffuse into frozen ice films as this is often a first step for reactions to occur resulting in new organic molecules essential for life. This talk is split into three sub-projects: (1) initial sticking probability of methane on ice films with varying porosities and crystalline structures, (2) oxidative reactivity of frozen propene films, and (3) differential condensation of methane isotopologues. For each study, changes on the surface were monitored in real time with RAIRS and mass spectrometry techniques.

I determined that more methane ended up sticking onto the porous amorphous water films, compared to the crystalline films suggesting that porous are more efficient at dissipating energy. Similarly, when examining propene oxidation, I also found that film structure was important for reactivity. In this case, I identified, through careful analysis of RAIR spectra, that I could form both an ordered as well as an amorphous propene film depending on the deposition temperature; yet, oxygen was only able to react with the ordered propene film. Lastly, I observed preferential increased sticking and condensation for CD<sub>4</sub> on a CH<sub>4</sub> film compared to CH<sub>4</sub>, confirming an isotopic enrichment. These results suggest that there is more efficacious gas-surface energy transfer involving multiphoton excitations for the heavier isotopologue. Overall, these results are important to create accurate models of surface mediated astrophysical and terrestrial processes and understand formation of the universe.

11:30am **LI-MoM-19 2021 AVS Russell and Sigurd Varian Award Talk: Chemically Resolving Metal Supported Regioisomeric Assemblies at the Angstrom Scale using Ultrahigh Vacuum Tip-Enhanced Raman Spectroscopy: Conformations & Interactions, Sayantan Mahapatra**<sup>3</sup>, *J. Schultz, L. Li, N. Jiang*, University of Illinois at Chicago

Conventional spectroscopic techniques are limited by the optical diffraction limit to about half wavelength and therefore offers about 200 nm x 200 nm microscopic zone for working in the visible light range. Tip-enhanced Raman spectroscopy (TERS) emerges as an advanced analytical technique, where the plasmonically active probe is not only used to detect the tunneling current but also to interrogate the local chemical environment of surface adsorbed molecules with angstrom scale precision. In this work, we report a topological and chemical analysis of two regioisomers (positional isomers), trans- and cis-tetrakis(pentafluorophenyl)porphodilactone (trans- and cis-H<sub>2</sub>F<sub>20</sub>TPPDL) by scanning tunneling microscopy (STM), ultrahigh vacuum (UHV) TERS on Ag(100) with the spatial resolution down to 8 Å, which has wide range of applications in various field of surface science & nanotechnology such as regioselective catalysis reaction, chemical reactions, molecular electronics etc. We have shown, it is possible to distinguish these two structurally very similar forms with high accuracy & precision. The two-component molecular junction has been identified using high resolution two-dimensional (2D) Raman mapping. In addition, the molecule-substrate interactions have been addressed at the single-molecule level by employing three different single-crystals i.e., Ag(100), Cu(100), and Au(100). Strong surface interactions at Cu(100) surface converted the flexible porphodilactone structure inverted, which was further verified by STM. Expanding upon this work, the chemical information available through STM-TERS allows me to track a complete chemical reaction, from reactant to product, with single chemical bond sensitivity. Angstrom scale chemical analysis using TERS is shown here as a broad and versatile technique in surface characterization.

<sup>1</sup> National Student Award Finalist

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<sup>2</sup> National Student Award Finalist

<sup>3</sup> National Student Award Finalist

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11:45am LI-MoM-22 2021 AVS Graduate Research Award Talk: **Investigating Surfaces, Interfaces, and their Impact on Degradation of Polymer Electrolyte Membrane Water Electrolyzers**, Sarah F. Zaccarine<sup>2</sup>, Colorado School of Mines; M. Shviro, Forschungszentrum Jülich GmbH, Germany; M. Dzara, Colorado School of Mines; M. Carmo, Forschungszentrum Jülich GmbH, Germany; S. Pilypenko, Colorado School of Mines

Hydrogen is an attractive option for renewable energy applications due to its ability for large quantities to be stored over a long period of time, but current H<sub>2</sub> production from fossil fuels is a major CO<sub>2</sub> emitter; consequently, there is a need for efficient, renewable H<sub>2</sub> production.<sup>1</sup> Polymer electrolyte membrane water electrolysis (PEMWE) is a promising strategy, but major degradation issues and the slow kinetics of the anodic oxygen evolution reaction (OER) limit commercialization. Ir has been shown to be the most active metal towards the OER, while IrO<sub>2</sub> is typically more stable in the harsh oxidizing conditions of this reaction. Both materials face high costs and limited availability, motivating studies of PEM electrolyzers with low loadings.

Commercial Ir and IrO<sub>2</sub> black catalysts were obtained and studied as catalyst powders, fresh membrane electrode assemblies (MEAs), and tested MEAs following durability cycling at different conditions. A variety of surface and bulk characterization techniques were employed to evaluate changes in the catalyst morphology and composition, electrode composition and structure, and various interfaces that exist in this system in order to understand their respective contributions towards degradation. Information about catalyst composition was obtained with surface-sensitive x-ray photoelectron spectroscopy (XPS) and bulk x-ray absorption spectroscopy (XAS). Scanning electron microscopy (SEM) and scanning transmission electron microscopy (STEM) combined with energy-dispersive x-ray spectroscopy (EDS) mapping of the electrode cross-sections were used to elucidate morphological and structural information as well as elemental distribution as a function of various durability conditions. Further, transmission x-ray microscopy (TXM) was used to visualize electrode structure at a larger scale than possible with electron microscopy methods. Results demonstrate that a systematic, multi-scale, multi-technique characterization approach is necessary to isolate contributions of the catalyst, ionomer, and overall CL morphology, composition, and structure on degradation of the PEM electrolyzer. These findings advance fundamental understanding towards development of more efficient electrodes, highlighting the importance of optimizing uniformity of the electrodes.

(1) Ayers, K. E. The Potential of Proton Exchange Membrane-Based Electrolysis Technology. *Curr. Opin. Electrochem.* **2019**, *18*, 9–15.

(2) Spöri, C.; Kwan, J. T. H.; Bonakdarpour, A.; Wilkinson, D. P.; Strasser, P. *Angew. Chemie Int. Ed.* **2017**, *56* (22), 5994–6021.

(3) Alia, S. M.; Stariha, S.; Borup, R. L. *J. Electrochem. Soc.* **2019**, *166* (15), F1164–F1172.

12:15pm LI-MoM-28 AVS 2021 Peter Mark Memorial Award Lecture: **Novel MBE Approaches for Atomically Precise Synthesis of “Stubborn” Metal Oxides**, Bharat Jalan<sup>2</sup>, University of Minnesota, USA **INVITED**

Our ability to synthesize atomically-precise materials has continued to drive modern technology and fundamental study. Consider an element that is hard to oxidize and also difficult to evaporate, how do we create an atomically precise thin films of such metals, metal oxides or their heterostructures? This has been a key question in the synthesis science for many decades.

In this talk, I will present my group's effort to address this question. We have recently shown that both the low vapor pressure and difficulty in oxidizing a “stubborn” element can be addressed by using a *solid* metal-organic compound with significantly higher vapor pressure, and with the added benefits of being in a pre-oxidized oxidation state along with excellent thermal and air stability. Using this approach, we show, for the first time, the synthesis of Pt, RuO<sub>2</sub> and SrRuO<sub>3</sub> films with the *same ease and control* as afforded by III-V MBE. I will present a detailed MBE growth study combined with structural and transport characterizations. The effect of film thickness, orientation, strain, and defects such as cation vacancies on electronic properties will be discussed. In second part of my talk, I will present our work on the development of radical-based MBE approach for wide band gap alkaline stannates (BaSnO<sub>3</sub> and SrSnO<sub>3</sub>) growth combined with their detailed structure and transport study.

<sup>1</sup> National Student Award Finalist

<sup>2</sup> Peter Mark Memorial Award Winner

12:45pm LI-MoM-34 2021 AVS Nellie Yeoh Whetten Award Talk: **Efficient Near-Infrared Emission from Lead-Free Ytterbium-Doped Cesium Bismuth Halide Perovskite Thin Films**, Minh Tran<sup>3</sup>, I. Cleveland, G. Pustorino, E. Aydil, New York University

All-inorganic metal halide perovskites have attracted significant attention for applications as solar cells, light-emitting diodes, and photodetectors because they have strong and tunable absorptions and emissions. Lead-based perovskites have been the focus of many studies because they perform well in these applications, but lead is toxic. Bismuth-based halide perovskites are non-toxic alternatives to widely researched lead-containing halide perovskites for optoelectronics. Cesium bismuth bromide, in particular, may have suitable optical properties, but optical absorption and photoluminescence (PL) data reported to date are contradictory. We resolved these literature discrepancies and showed that Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> thin films deposited by physical vapor deposition (PVD) via coevaporation of CsBr and BiBr<sub>3</sub> show absorption and emission peaks at 433 and 472 nm, respectively. Peak location and lineshapes of blue-shifted absorption and emission previously reported and attributed to quantum confinement in Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> nanocrystals could be reproduced in BiBr<sub>3</sub> solutions in different solvents even without any Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub>. This suggests that high photoluminescence quantum yield (PLQY) and blue-shifted emissions reported below 472 nm may be originating from unreacted precursors and impurities in nanocrystal dispersions rather than from Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub>. We also doped Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> films with Yb to investigate the possibility of quantum cutting, generation of two near-infrared (NIR) photons (1.25 eV) from each ultraviolet or blue photon absorbed at energies >2.5 eV. Coating silicon solar cells with a material that can achieve quantum cutting with PLQY approaching 200% (2 photons for every high energy photon) has the potential to increase the silicon solar cell efficiencies above the Queisser limit, 33%. The addition of Yb that can substitute up to 50% of the Bi in Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> leaves the Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> structure unchanged and results in NIR Yb<sup>3+</sup>F<sub>5/2</sub> → <sup>2</sup>F<sub>7/2</sub> emission (1.25 eV) with 14.5% quantum yield. A PLQY of 14.5% from Yb-doped Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> is promising because undoped Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> is otherwise not emissive due to rapid nonradiative recombination: the highest reliably measured visible PLQY in the literature is only 0.2%. Despite this, energy transfer from Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> to Yb appears to compete efficiently with nonradiative recombination and results in a 14.5% quantum yield. Moreover, NIR emission decreases sharply when the perovskite host's bandgap is reduced below 2.5 eV, twice the Yb<sup>3+</sup> emission energy, by substituting bromine with iodine, raising the possibility that the emission mechanism may involve quantum cutting. This also raises the tantalizing possibility that Cs<sub>3</sub>Bi<sub>2</sub>Br<sub>9</sub> could be a potential lead-free quantum cutting material for solar spectrum shaping to increase solar cell efficiency.

1:00pm LI-MoM-37 AVS 2021 John Thornton Memorial Award Lecture: **Oxide MBE Rocks! Reflections on 35+ Years of Oxide MBE**, Darrell Schlom<sup>4</sup>, Cornell University **INVITED**

Molecular-beam epitaxy (MBE) is the “gold standard” synthesis technique for preparing semiconductor heterostructures with high purity, high mobility, and exquisite control of layer thickness at the atomic-layer level. Its use for the growth of multicomponent oxides got off to a rocky start 36 years ago, but in the ensuing decades, it has become the definitive method for the preparation of oxide heterostructures too, particularly when it is desired to access metastable polymorphs of oxides and the novel properties they possess. In this talk I will highlight a few examples from our\* work over the past >30 years demonstrating how the atomic-layer control made possible by oxide MBE can be used to break synthesis rules and create metastable compounds and heterostructures with intriguing properties. Many important growth tricks, first developed for the growth of compound semiconductors by MBE, are equally applicable to the growth of oxides. Examples include the use of strain engineering, interface engineering, epitaxial stabilization, or dimensional confinement. These can be used to transmute oxides that are usually “vegetables” into metastable polymorphs that are ferroelectric, ferromagnetic, both at the same time (multiferroic), or superconducting. A key element of this modern alchemy is the availability of substrates with appropriate structural motifs to strain these complex oxide thin films by several percent—far beyond where they would crack or plastically deform in bulk—or to stabilize metastable polymorphs. I will also discuss some of the technical challenges to the controlled synthesis of oxides in thin film form that have been overcome. The ability of MBE to customize oxide structures with atomic-level control and impart controlled strain have made oxide MBE the technique of choice

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<sup>4</sup> John A. Thornton Memorial Award Winner

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for precisely preparing epitaxial oxide heterostructures to understand and exploit their novel properties.

\*The work reported was performed in collaboration with superb students, postdocs, colleagues, and collaborators from around the world. Although it is only possible to acknowledge a small fraction, I celebrate the achievements being honored by this award with the pioneering contributions of Jim Eckstein and Ivan Bozovic—with whom I began this journey and continue to work—together with the contributions and advice from leading collaborators: Long-Qing Chen, Chang-Beom Eom, Craig J. Fennie, Venkat Gopalan, Stanislav Kamba, Lena F. Kourkoutis, Jeremy Levy, Jochen Mannhart, David A. Muller, Nate Orloff, Xiaoqing Pan, Karin M. Rabe, Ramamoorthy Ramesh, Kyle M. Shen, Dmitri A. Tenne, Susan Trolrier-McKinstry, Nicola A. Spaldin, Reinhart Uecker, and Xiaoxing Xi.

**1:45pm LI-MoM-46 2021 AVS Graduate Research Award Talk: Versatile Polymer Nanoparticle Synthesis Using Initiated Chemical Vapor Deposition (iCVD), Trevor Donadt<sup>1</sup>, D. Streever, R. Yang, Cornell University**  
Polymerization of monomers to form nanoparticles (i.e. bottom-up synthesis) is commonly performed in liquid environments which confers restrictions to monomer chemistries and particle shape based on solubility and procedures that are commonly driven by surface tension. Here we report the synthesis of polymer nanoparticles (PNPs) through a technique performed in a chemical vapor deposition apparatus that traditionally forms thin film polymer coatings. By utilizing an initiated chemical vapor deposition (iCVD) reactor, the synthesis process is afforded the advantages of an all-dry process, enabling PNPs made of insoluble polymers (e.g., hydrophobic and heavily cross-linked) and a variety of chemistries (zwitterionic, fluorinated, functionalizable, etc.) using the same technique. Furthermore, the solvent-free process enables control of the PNP diameters across an impressively broad range, from below 10 nm to above 1  $\mu\text{m}$ . This approach delivers unprecedented synthetic capability for PNPs with nanoscale control over particle size without relying on laborious nanofabrication of templates, which are commonly required for particle size control in existing procedures. The approach is also substrate-independent, such that it can be performed on any type of material, turning PNPs into nanostructured thin films in situ. This technique is compatible with a library of over 70 functional monomers developed to date for iCVD. The chemical versatility, combined with the broad yet precise control of particle sizes, renders this approach a promising route to generating PNPs from materials inaccessible in liquid-based methods, thus opening new avenues for PNP applications.

**2:00pm LI-MoM-49 2021 Dorothy M. and Earl S. Hoffman Award Scholarship Talk: Tunable Photonics Based on Thin-Film Vanadium Dioxide, Chenghao Wan<sup>2</sup>, University of Wisconsin - Madison; Z. Zhang, Purdue University; D. Woolf, Physical Sciences Inc.; J. Rensberg, M. Hafermann, Friedrich Schiller University Jena, Germany; J. Salman, Y. Xiao, University of Wisconsin - Madison; M. Park, Purdue University; C. Ronning, Friedrich Schiller University Jena, Germany; S. Ramanathan, Purdue University; M. Kats, University of Wisconsin - Madison**

Vanadium dioxide ( $\text{VO}_2$ ) is a prototype strongly correlated material that undergoes a first-order insulator-to-metal transition (IMT) at  $\sim 70^\circ\text{C}$ . This reversible IMT in  $\text{VO}_2$  has drawn decades-long research attention because it can result in orders-of-magnitude changes in carrier density accompanied by a dramatic change in the refractive index, which has advanced various applications in electronics and optics. Recently, improvements in deposition techniques have enabled synthesis of high-quality  $\text{VO}_2$  thin films (with thickness of tens of nanometers), boosting the utilization of thin-film  $\text{VO}_2$  in nanophotonics.

In this talk, we will first present our characterization and analysis of optical properties of thin-film  $\text{VO}_2$  for wavelengths from the ultraviolet to the far infrared. Both ellipsometry data and effective-medium modeling will be presented, for  $\text{VO}_2$  films grown using different methods, on different substrates, and with different thicknesses. Based on ellipsometry measurements, we have concluded that  $\text{VO}_2$  films synthesized via different conditions generally feature consistent and large refractive-index contrast in the mid-infrared, but distinguishable (or even significantly different) optical properties in the visible and far infrared. Our data is freely available for anyone to use in their own design and simulations.

In the second part of the talk, we will give specific illustrations of tunable photonic devices by incorporating thin-film  $\text{VO}_2$  into two kinds of

nanophotonic geometries—metasurfaces and thin-film assemblies. For the metasurface-based design, we demonstrated an ultrathin reflective optical limiter comprising a  $\text{VO}_2$  thin film and metallic aperture antennas. Our design can feature intensity-dependent modulation of transmission for a broad wavelength range ( $>2\ \mu\text{m}$  at  $10\ \mu\text{m}$ ) and angle of incidence (up to  $50^\circ$  away from the normal, for all polarizations). For the thin-film design, we demonstrated a tunable broad-to-narrow bandpass filter by introducing a  $\text{VO}_2$  film into a dielectric stack of alternating Ge and ZnSe layers. The fabricated filter can switch between a broadband transmission window in the long-wave infrared (8 – 12  $\mu\text{m}$ ) and a narrow passband centered around 8.8  $\mu\text{m}$ , which has potential uses for thermal-imaging enhancement.

In the end, we will also briefly discuss our engineering of the IMT temperature in  $\text{VO}_2$  films by defect engineering via ion implantation, which can enable applications close to room temperature.

**2:15pm LI-MoM-52 2021 AVS Dorothy M. and Earl S. Hoffman Award Talk: Strain Engineering of Magnetism and Topological States in Rippled Heusler Membranes, Dongxue Du<sup>3</sup>, S. Manzo, C. Zhang, V. Saraswat, University of Wisconsin - Madison; K. Genser, K. Rabe, Rutgers, The State University of New Jersey; P. Voyles, M. Arnold, J. Kawasaki, University of Wisconsin - Madison**

Single-Crystalline Membranes of Functional Materials Enable the Tuning of Properties via Extreme Strain States; However, Conventional Routes for Producing Membranes Require the Use of Sacrificial Layers and Chemical Etchants, Which Can Both Damage the Membrane and Limit the Ability to Make Them Ultrathin. Here We Demonstrate the Epitaxial Growth of the Cubic Heusler Compound  $\text{GdPtSb}$  on Graphene-Terminated  $\text{Al}_2\text{O}_3$  Substrate. Despite the Presence of the Graphene Interlayer, the Heusler Films Have Epitaxial Registry to the Underlying Sapphire, as Revealed by X-Ray Diffraction, Reflection High Energy Electron Diffraction, and Transmission Electron Microscopy. The Weak Van Der Waals Interactions of Graphene Enable Mechanical Exfoliation to Yield Free-Standing  $\text{GdPtSb}$  Membranes, Which Form Ripples When Transferred to a Flexible Polymer Handle. Whereas Unstrained  $\text{GdPtSb}$  Is Antiferromagnetic, Measurements on Rippled Membranes Show a Spontaneous Magnetic Moment at Room Temperature, With a Saturation Magnetization of 5.2 Bohr Magnetons Per Gd. First-Principles Calculations Show That the Coupling to Homogeneous Strain Is Too Small to Induce Ferromagnetism, Suggesting a Dominant Role for Strain Gradients. We Will Also Describe Preliminary Magnetotransport Measurements Aimed at Tuning the Topological Properties of  $\text{GdPtSb}$ , Since This Compound Shares a Similar Electronic Structure as the Weyl Semimetal  $\text{GdPtBi}$ . Together, Our Results Point to Strained Membranes as a Powerful Platform for Tuning Magnetism and Topological States in Quantum Materials.

**2:30pm LI-MoM-55 AVS 2021 Medard W. Welch Award Lecture: Probing and Controlling Excitons in 2D Semiconductors, Tony Heinz<sup>4</sup>, Stanford University and SLAC National Accelerator Laboratory INVITED**

One of the key features of the optical response of 2D semiconductors is the dominant role of excitonic interactions. The strong influence of these many-body effects reflects the reduced dimensionality combined with the reduced dielectric screening of atomically thin crystals. In this paper, we will review progress in understanding the nature of optically excited states in 2D monolayers and heterostructures. We will describe how excitonic states can be tuned and probed by altering the Coulomb interaction within the layer by various approaches, including through changes in the external dielectric environment. We will particularly emphasize recent advances in applying time-resolved ARPES (angularly resolved photoemission spectroscopy) to examine the momentum-space character and dynamics of excitons in transition metal dichalcogenide semiconductors. In these studies, carried out in collaboration with the group of Keshav Dani, we have been able not only to determine the valley characteristics of both bright and dark excitons, but also to image directly the wavefunction of excitonic states in momentum space. Examples of this approach will be presented both for monolayers and for vertical heterostructures.

**3:00pm LI-MoM-61 Closing Remarks and Thank You's, Amy V. Walker, University of Texas at Dallas**

Thank you for attending the AVS 67 Plenary and Awards Session. We look forward to seeing you tomorrow at 10:00 am EDT for a full day of Live Parallel Sessions. Remember to check out the AVS 67 On Demand Sessions which are now available in the mobile app and online scheduler.

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<sup>4</sup> Medard W. Welch Award Winner

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