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2026 Spring Meeting
Hudson Mohawk AVS Chapter
Wednesday, April 29, 2026
2:50 – 7:20 PM

Rensselaer Polytechnic Institute (RPI), 110 8th St, Troy, NY 12180
Building: Center for Biotechnology and Interdisciplinary Studies (CBIS)
Conference Room: CBIS Auditorium

Meeting Agenda

1:30 - 2:50 Lab tour at RPI Facilities *(optional, but confirm attendance)*

2:50 - 3:20 Reception *(coffee and cookies served)*

3:20 - 3:30 Welcoming Remarks by Vincent Smentkowski

Keynote Presentation

3:30 - 4:00 *"Understanding Glass-Organic Interactions with ToF-SIMS"*
Dr. Christine Mahoney, Corning Research and Development

Oral Presentations

4:00 - 4:15 *"Image Processing Applications Using CMOS-Integrated Packaged 1T-1R Resistive Random-Access Memory Arrays"*
Jeelka Solanki (UAlbany, Graduate Student)

4:15 - 4:30 "*StrataPHI via XPS for Thin Film Surface & Interface Engineering: Depth-Resolved, Non-Destructive Analysis of Layered Materials"*
Norb Biderman (Physical Electronics)

4:30 - 4:45 *"Epitaxial Growth of the Topological Semimetal NbAs"*
Ariful Islam (RPI, Graduate Student)

4:45 - 5:00 *"Grating-Coupled Fluorescence Plasmonics (GC-FP) Biosensor: Expanding from Protein to Nucleic Acid Detection"*
Dwiti Krushna Das (UAlbany, Graduate Student)

5:00 - 5:15 *"Advancements in XPS Depth Profiling Using Femtosecond Laser Ablation (fs-LA) for Thin Film and Metal Oxide Surfaces"*
James Lallo (Thermo Fisher Scientific)

5:15 - 5:30 *"Molecularly Manipulating Growth Morphology and Thermal Transport in Inorganic Nanofilms and Multilayers"*
Ankit Kashyap, Jonas Kendra (RPI, Joint: Graduate Students)

5:30 - 7:00 **Poster Presentations** *(pizza and refreshments served)*

7:00 - 7:20 **Student Awards Ceremony**

Poster Presentations

P01. **RESISTIVITY SIZE EFFECT IN EPITAXIAL MAX-PHASE $Ti_2AlN(0001)/Al_2O_3(0001)$ FILMS**
Mehedi Hasan Prince (RPI, Graduate Student)

P02. **ELLIPSOMETRIC FINGERPRINTS OF PHASE TRANSITIONS IN β-W THIN FILMS**
Raid Bader (UAlbany, Graduate Student)

P03. **PROBING THERMAL-INDUCED STRAIN AT ATOMIC INTERFACES VIA RAMAN SPECTROSCOPY**
Zixiu Cai (RPI, Graduate Student)

P04. **CHARACTERIZATION OF PEPTIDE FRAGMENTATION PROCESSES WITHIN AN ATMOSPHERIC-PRESSURE SOLUTION-CATHODE GLOW DISCHARGE VIA MASS SPECTROMETRY**
Jared Viggers (RPI, Graduate Student)

P05. **IMPACT OF IONS IN PLASMA ENHANCED ATOMIC LAYER DEPOSITION CONFORMALITY**
Nicholas Oktyabrsky (UAlbany, Undergraduate Student)

P06. **HIGH SENSITIVITY NONDESTRUCTIVE THIN FILM THERMAL CHARACTERIZATION VIA IMMERSION SCANNING THERMAL MICROSCOPY**
Jonas Kendra (RPI, Graduate Student)

P07. **EFFECT OF TUNGSTEN NUCLEATION LAYER ON MOLYBDENUM FILM PROPERTIES**
Ethan Hendrix (RPI, Graduate Student)

P08. **IMPROVEMENT OF TANTALUM OXIDE BASED ReRAM VIA OPTIMIZATION OF THE SWITCHING LAYER**
Jinam Modasiya (UAlbany, Graduate Student)

P09. **INTERFACE EFFECTS IN TEMPERATURE DEPENDENT EFFECTIVE THERMAL CONDUCTIVITY AND THERMAL RESISTANCE MEASUREMENTS OF THIN FILMS WITH 3W METHOD**
Kazi Masuk Elahi (RPI, Graduate Student)

P10. **PLATFORM FOR PLASMA SPECTROCHEMICAL ANALYSIS OF LEVITATED PARTICLES THROUGH LASER-BASED SPECTROSCOPIES**
Carlos Nogales-Herrera (RPI, Graduate Student)

P11. **AN OVERVIEW OF NORTHEAST REGIONAL DEFENSE TECHNOLOGY HUB (NORDTECH)**
David Fobare, Darrilyn Di Nardo (NORDTECH, RPI)

P12. **VISCOELASTIC RESPONSE OF TWO INDEPENDENT POLYMER NETWORKS VIA REACTIVE COARSE-GRAINED MOLECULAR DYNAMICS**
Yashdi Saif Autul (RPI, Graduate Student)

P13. **IMPACT OF SILICA SURFACE CHEMISTRY ON NUCLEATION OF RUTHENIUM AREA-SELECTIVE ATOMIC LAYER DEPOSITION**
Shixian Ha (Stony Brook University, Graduate Student)

P14. **ENHANCEMENT OF EXPERIMENTAL REPEATABILITY AND THERMAL UNIFORMITY IN TCR CHARACTERIZATION VIA BOTTOM-UP HEATING AND AUTOMATED STEADY-STATE DETECTION**
S M A Mohaiminur Rahman (RPI, Graduate Student)

P15. **BREAKING DOWN FOREVER CHEMICALS: PLASMA DRIVEN MODIFICATION OF PFAS**
Jonathan Graham (RPI, Undergraduate Student)

P16. **IN-SITU ELECTRON MICROSCOPY OF CONDUCTION FILAMENT DYNAMICS IN ASYMMETRIC METAL-INSULATOR-METAL BASED RESISTIVE SWITCHING DEVICES**
Subhangshu Sen (RPI, Graduate Student)

P17. **ELECTRON VISION: E-BEAM GLANCING ANGLE SCATTERING FOR HYBRID BONDING SURFACE PLANARITY MEASUREMENT**
Weichang Lin (RPI, Graduate Student)

P18. **DEPENDENCE OF TEMPERATURE AND PRESSURE ON RESONANT FREQUENCY AND DAMPENING OF MEMS DEVICES**
Alvar Garza*, Meghan Herbert (UAlbany, Graduate Student*)

P19. **INTER-CODE VALIDATION OF PHOTON TRANSPORT THROUGH PROGRESSIVELY DEGRADED SHIELDING MATERIALS: OpenMC VERSUS MULASSIS/Geant4**
Md. Marjanul Haque (RPI, Graduate Student)

P20. **EPITAXIAL TaP(001) FORMATION BY PHOSPHORIZATION OF EPITAXIAL Ta(001)/MgO(001)**
Emma Sponga (RPI, Graduate Student)

P21. **THE SHARED SILICON FRAMEWORK**
Alexander McDougall (UAlbany, Undergraduate)

HM AVS Spring 2026 Meeting Location

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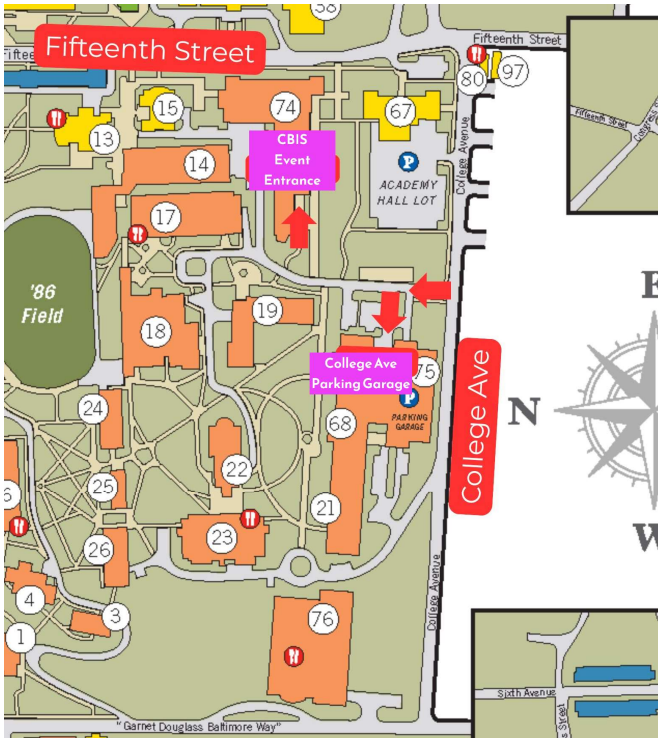

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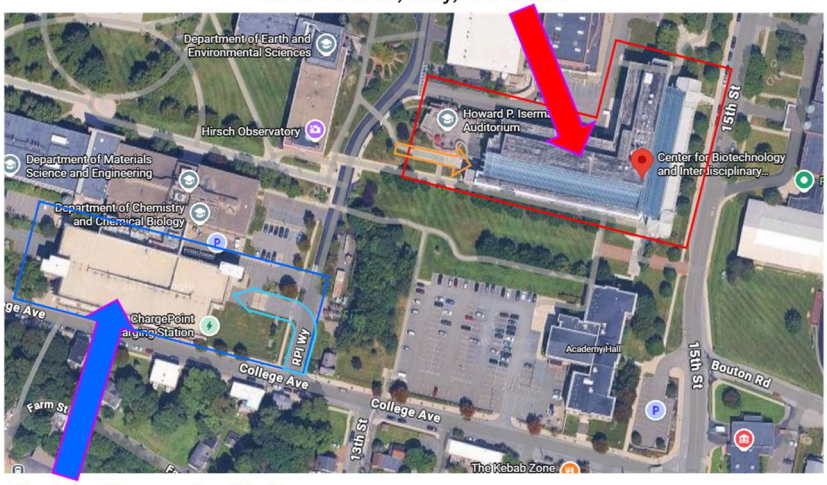

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USING TOF-SIMS TO UNDERSTAND ORGANIC/GLASS INTERACTIONS AND RELEVANCE TO ADHESION

Dr. Christine M. Mahoney

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Why do organic coatings adhere well to some glasses but fail catastrophically on others? This work uses time-of-flight secondary ion mass spectrometry (ToF-SIMS) to reveal how glass chemistry fundamentally governs organic–glass adhesion through chemical and structural evolution of the interphase. A model ink coating was applied to glasses spanning a range of compositions, including soda-lime, high-purity fused silica, and aluminosilicate substrates, and examined before and after aggressive aging at 85 °C and 85% relative humidity. ToF-SIMS depth profiling shows that alkali mobility — particularly sodium — drives dramatic changes during aging both in the glass, and in the coating as well. These chemical changes correlate directly with degraded adhesion. We also briefly investigate the impact of glass chemistry on adhesion of polyethylene laminate films, which show opposite trends in adhesion. Together, these results demonstrate that practical adhesion failures originate not at an ideal interface, but within a chemically dynamic interphase controlled by glass composition and environmental exposure — and highlight ToF-SIMS as a powerful tool for directly linking molecular-scale chemistry to macroscopic adhesion behavior.

Keynote Presentation

IMAGE PROCESSING APPLICATIONS USING CMOS-INTEGRATED PACKAGED 1T-1R RESISTIVE RANDOM-ACCESS MEMORY ARRAYS

Jeelka Solanki[1], Minhaz Abedin[1], Maximilian Liehr[1,2], Karsten Beckmann[1,2], Nathaniel Cady[1]

1 Department of Nanoscale Science and Engineering, University at Albany, Albany, NY.
2 NY CREATES, Albany, NY,12203.

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Modern computing architectures face increasing performance and energy challenges when executing AI, ML, and large-scale data workloads due to the inherent bottlenecks of the von Neumann model. In-memory computing using non-volatile RRAM offers an effective solution by enabling analog, high-speed vector–matrix operations within crossbar arrays. RRAM, with its analog programmability, fast switching, and dense crossbar structure, is well suited for AI-centric vector–matrix operations. Computing directly in memory improves energy efficiency and throughput for AI workloads.

To demonstrate the potential of this approach, we fabricated custom 64 x 64 hafnium oxide-based RRAM arrays with CMOS decoder interface using a 65nm CMOS technology in a 1-transistor 1-RRAM (1T1R) configuration at the NY Creates Albany NanoTech complex 300mm wafer-scale fabrication facility. To enable real-time in memory compute applications beyond wafer-level testing we developed a custom printed circuit board /microcontroller interface to support read/write communication and in-memory computing applications with our packaged 1T1R arrays. To program the arrays, a Nuvoton M032 microcontroller shown in Figure 1 was implemented on custom PCB. Using this microcontroller / RRAM array demonstration board, in memory compute operations were performed on greyscale images directly programmed into the RRAM array. Eight different analog resistance levels were used to program 3-bit greyscale images into the RRAM array followed by thresholding operations and application of an edge detection kernel directly in memory demonstrated in Figure 2. This work demonstrates the potential of CMOS-integrated RRAM for combined data storage and in-memory compute operations, and future NVM-based non-Von Neumann computing applications.

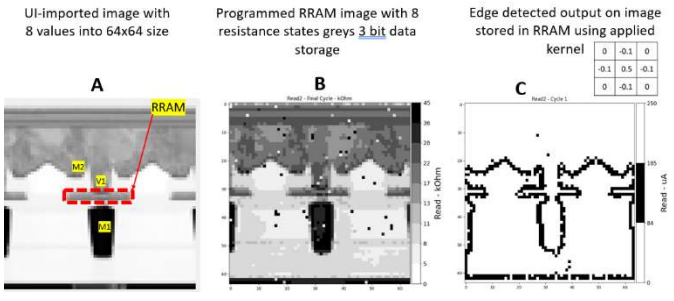

Figure 1: A) 64 x 64-pixel image of an individual RRAM device to be programmed into the 1T1R RRAM using 8 analog-resistance states. B) Heat-map representation of the RRAM array after programming. (C) Edge-detected output obtained by applying a 3×3 filter to the greyscale image programmed into the 1T1R array (in panel B).

Graduate Student
Oral Presentation #01

*Strata*PHI VIA XPS FOR THIN FILM SURFACE & INTERFACE ENGINEERING: DEPTH-RESOLVED, NON-DESTRUCTIVE ANALYSIS OF LAYERED MATERIALS

Norb Biderman and Kent Brown

Physical Electronics USA

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Next-generation engineered materials demand new approaches as insights into ultra-thin films, surfaces, and interfaces are often obscured by the limitations of even traditional surface analysis techniques. *Strata*PHI introduces a next-generation characterization platform designed for non-destructive, depth-resolved analysis of multi-layer films composed of ultra-thin layers.

*Strata*PHI leverages X-ray photoelectron spectroscopy (XPS) and hard X-ray photoelectron spectroscopy (HAXPES) data, extracting key processing-dependent material parameters, such as thickness and composition across multiple layers in a thin-film stack up to 30 nm below the surface.

The newest *Strata*PHI platform introduces an integrated analyzer acceptance angle mode that builds on the traditional model of a single photoelectron escape angle from the surface by including all escape angles as detected by the analyzer. This strengthens *Strata*PHI's application in metrology, delivering rapid and reliable thickness measurement of individual layers in a multi-layer thin film, equivalent to thicknesses traditionally obtained via angle-resolved XPS.

*Strata*PHI also quantifies fractional coverage for individual layers, enabling detection of partial film formation and interface quality, such as incomplete Al_2O_3 growth, critical for optimizing atomic layer deposition (ALD) and other advanced semiconductor processes.

This presentation will demonstrate how *Strata*PHI enables scientists and engineers to model complex ultra-thin film stacks and extract insights into new technologies. With automated batch analysis, *Strata*PHI also links processing conditions to thin-film properties, providing a comprehensive characterization suite for tighter control over performance and reliability of new materials and devices.

Oral Presentation #02

EPITAXIAL GROWTH OF THE TOPOLOGICAL SEMIMETAL NbAs

Ariful Islam, Sadiq Shahriar Nishat, Rui Shu, Daniel Gall

Materials Science and Engineering, Rensselaer Polytechnic Institute, Troy, 12180

islama8@rpi.edu

NbAs thin film growth is explored because NbAs is a promising topological semimetal for nanoscale interconnect applications[1]. In a first step, a 26-nm-thick epitaxial Nb(001) film is sputter deposited on $Al_2O_3(1\bar{1}02)$ at T_s = 550 °C. Subsequently, As is deposited onto the Nb film at T_a = 900 °C for 1 h, causing arsenization that results in the formation of a 38-nm-thick epitaxial NbAs(001) film, while excess As leaves as volatile As_2. X-ray diffraction (XRD) φ-scans and electron diffraction patterns reveal a 45° in-plane rotated epitaxial relationship with NbAs(001) || $Al_2O_3(1\bar{1}02)$ and NbAs[110] || $Al_2O_3[11\bar{2}0]$. The XRD ω-rocking curve for the NbAs 004 reflection is 1.24° wide. Reciprocal space mapping of the NbAs 1 1 10 reflection yields NbAs lattice parameters a = b = 3.382 ± 0.003 Å and c = 11.765 ± 0.007 Å. Energy dispersive spectroscopy shows a nearly stoichiometric composition of 52.1 at% Nb and 47.9 at% As. Room-temperature Hall measurements yield a sheet resistance of R_s = 53.5 Ω/□, a resistivity of ρ = 203 μΩcm, a Hall mobility of μ_H = 19.4 cm^2/Vs, and a hole-dominated transport with a carrier concentration $p = 1.50 \times 10^{21}$ cm^{-3}. The resistivity decreases from ρ = 241 μΩcm at room temperature to ρ = 234 μΩcm at 77 K, indicating that transport is dominated by electron-defect scattering. The results establish sputter deposition followed by arsenization as a promising route for the growth of epitaxial NbAs films on sapphire.

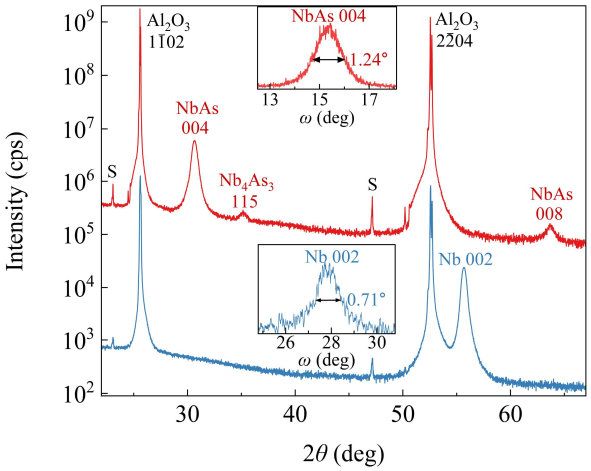

Figure 1 XRD θ-2θ scans from initial epitaxial Nb(001)/$Al_2O_3(1\bar{1}02)$ film (blue) and epitaxial NbAs(001)/$Al_2O_3(1\bar{1}02)$ film (red) after arsenization. Insets show ω-rocking curves.

Reference: [1] D. Gall, J.J. Cha, Z. Chen, H.J. Han, C. Hinkle, J.A. Robinson, R. Sundararaman, and R. Torsi, "Materials for interconnects," MRS Bull. **46**(10), 959–966 (2021).

Graduate Student
Oral Presentation #03

GRATING-COUPLED FLUORESCENCE PLASMONICS (GC-FP) BIOSENSOR: EXPANDING FROM PROTEIN TO NUCLEIC ACID DETECTION

Dwiti Krushna Das [1], Benjamin Taubner [1], Leah Sweeney [1], Michael J. Dolan [2], Jared Baisden [2], Elijah C. Feret [1], Fernando Pesantez Torres [1], Madhanagopal Barathraj [1], Lauren A. Anderson [1], Arturo Pilar [4], William Page [4], Arun Richard Chandrasekaran [1,3], Susan T. Sharfstein [1,3], Scott Tenenbaum [1,2,3], Nathaniel C. Cady [1,3]*

[1] College of Nanotechnology, Science & Engineering, University at Albany, Albany, NY; [2] sxRNA Technologies, Albany, NY; [3] The RNA Institute, University at Albany, Albany, NY; [4] Ciencia Inc., Mansfield Center, CT

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Disease diagnosis and biomarker screening demand sensitive, adaptable biosensing platforms. Grating-coupled fluorescence plasmonics (GC-FP) uses periodic nanoscale gold gratings to amplify fluorescence through surface plasmon-coupled emission (SPCE). When polarized light excites surface plasmons at the metal-dielectric interface, fluorophores couple their emission into these plasmon modes, yielding ~100-fold signal enhancement over flat-surface fluorescence. This boost enables detection of low-abundance targets in complex biological samples, with spatial specificity maintained through multiplexed arrays.

GC-FP chips are fabricated at Albany NanoTech using photolithography, producing 500 nm pitch gratings coated with ~70 nm gold. Biological reagents (antigens, antibodies, aptamers, or oligonucleotides) are deposited via precision microarraying, samples are flowed through automated microfluidics, and fluorescently labeled targets are imaged on a Centinela platform. We have previously demonstrated serological detection of Lyme disease and COVID-19 antibodies with excellent sensitivity and specificity, and have translated the platform into point-of-care dipstick and lateral flow formats.

Current work extends GC-FP to nucleic acid-based detection. Short oligonucleotide probes printed on the grating surface capture complementary DNA or RNA targets through room-temperature hybridization, with preliminary results showing detection down to 100 pM and spatially resolved multiplexing confirming probe specificity.

In parallel, we are developing aptamer-based small molecule detection using a duplex-bubble switch design. A fluorophore-labeled aptamer hybridized to a quencher-bearing displacement strand remains quenched until target binding triggers a conformational change, separating the fluorophore-quencher pair and generating a SPCE-enhanced signal. We are also investigating switchback DNA strand displacement, where invading strands displace switchback structures to form conventional duplexes, tracked through fluorescence changes.

Ongoing efforts focus on optimizing probe design and surface chemistry, and on demonstrating simultaneous nucleic acid and antibody detection on a single chip, positioning GC-FP as a versatile platform for next-generation diagnostics.

Graduate Student
Oral Presentation #04

ADVANCEMENTS IN XPS DEPTH PROFILING USING FEMTOSECOND LASER ABLATION (FS-LA) FOR THIN FILM AND METAL OXIDE SURFACES

James Lallo, *Thermo Fisher Scientific US; Tim Nunney, Thermo Fisher Scientific UK;* Robin Simpson, *Thermo Fisher Scientific UK; Paul Mack, Thermo Fisher Scientific UK;* Mark Baker, *University of Surrey UK; Charlie Chandler, University of Surrey UK*

james.lallo@thermofisher.com

XPS depth profiling is a widely employed analytical technique to determine the chemical composition of thin films, coatings and multi-layered structures, due to its ease of quantification, good sensitivity and chemical state information. Since the introduction of XPS as a surface analytical technique more than 50 years ago, depth profiles have been performed using ion beam sputtering. However, many organic and inorganic materials suffer from ion beam damage, resulting in incorrect chemical compositions to be recorded during the depth profile. This problem has been resolved for most polymers by using argon gas cluster ion beams (GCIBs), but the use of GCIBs does not solve the issue for inorganics. We have introduced a novel XPS system, Hypulse, that employs a femtosecond laser rather than an ion beam for XPS depth profiling purposes. This novel technique has shown the capability of eradicating chemical damage during XPS depth profiling for all initial inorganic, compound semiconductor and organic materials examined. The technique is also capable of profiling to much greater depths (several 10s microns) and is much faster than traditional ion beam sputter depth profiling. fs-LA XPS depth profile results will be shown for selected thin films, coatings, multilayers and oxidized surfaces and the outlook for this new technique discussed.

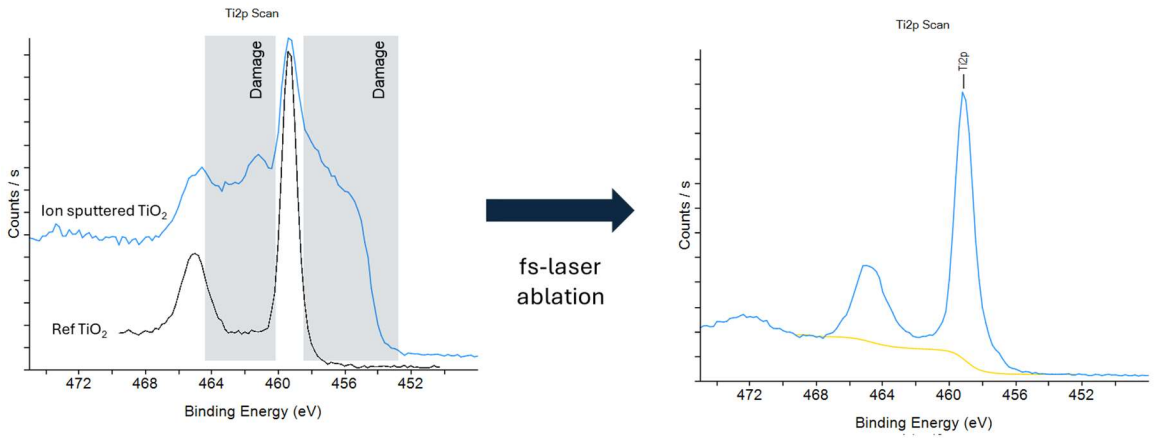

Figure 2 A TiO2 surface was exposed to 500eV monoatomic Ar Ion beam for 200 seconds, creating a damaged region of TiOx<2. Exposure to fs-Laser pulses removes the damaged material and retains the surface TiO2 stoichiometry.

Oral Presentation #05

MOLECULARLY MANIPULATING GROWTH MORPHOLOGY AND THERMAL TRANSPORT IN INORGANIC NANOFILMS AND MULTILAYERS

Ankit Kashyap[1*], Jonas Kendra[2*], Anoop Kushwaha[1], Pawel Keblinski[1], Perk Eklund[3], Theodorian Borca-Tasciuc[2], and Ganpati Ramanath[1,3]

[1]Materials Science & Engineering Department, Rensselaer Polytechnic Institute, Troy, NY, USA
[2]Mechanical Aerospace & Nuclear Engineering Dept., Rensselaer Polytechnic Institute, Troy, NY, USA
[3]Wallenberg Initiative Materials Science for Sustainability, Chemistry Dept., Uppsala Univ., Sweden

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Realizing continuous ultrathin (<~2 nm) metal films on low-k dielectrics, and facile thermal transport across inorganic interfaces are challenges relevant to next-generation nanodevice wiring and packaging technologies. Here, we demonstrate that molecular nanolayers (MNLs) can be used to control the wetting and morphology of Co films on low-k substrates, and enable ultrahigh interface thermal conductance.

In vacuo photoelectron spectroscopy reveals that amine- and thiol-terminated organosilane MNLs suppress Co islanding and facilitate layer-by-layer growth. The thiol-terminated MNL has a greater effect, underscoring the importance of MNL chemistry. These results are corroborated by transmission electron microscopy studies and MNL-induced decrease in surface roughening measured by atomic force microscopy. Molecular dynamics simulations of Co film growth on chemically-modified dielectrics surfaces by machine-learned potentials support these findings.

We further demonstrate a remarkably high interface thermal conductance G_{int} ~ 1 $GWm^{-2}K^{-1}$ across titania/organodiphosphonate-MNL interfaces. Such high G_{int} across interfaces significantly exceeds previously reported values for MNL-modified inorganic interfaces. A careful comparison of our results with prior works indicate that both strong interface bonding and aromatic backbones contribute to high G_{int}. These results suggest that MNLs featuring strongly binding molecular termini and rigid backbones are attractive for mitigating thermal bottlenecks at inorganic interfaces.

[*]**Joint** authors contributed equally to this work.

Graduate Students
Oral Presentation #06

P01. RESISTIVITY SIZE EFFECT IN EPITAXIAL MAX-PHASE $Ti_2AlN(0001)/Al_2O_3(0001)$ FILMS

Mehedi Hasan Prince and Daniel Gall

Department of Materials Science and Engineering,
Rensselaer Polytechnic Institute, Troy, NY 12180.

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MAX-phases are a family of layered materials, with the general formula $M_{n+1}AX_n$ (n = 1, 2, and 3), where 'M' is an early transition metal, 'A' is a group 13 or 14 element, and 'X' is either carbon or nitrogen. Their layered hexagonal crystal structure gives rise to an anisotropic Fermi surface, which enables directional conductivity and reduced resistivity scaling, making them attractive for interconnect applications.[1,2] In this work, epitaxial Ti_2AlN films are grown on $Al_2O_3(0001)$ by reactive magnetron co-sputtering at 850 °C. The processing gas consists of Ar at a constant partial pressure of 3 mTorr while the N_2 partial pressure is cyclic switched between 0 and 0.7 mTorr to mitigate process instability caused by target poisoning. The pulsed N_2 supply causes the Ti and Al targets to switch between metallic and poisoned modes of operation, as evidenced by oscillations in the target voltage. The Ti and Al targets exhibit opposite voltage responses during the N_2-on period, which is attributed to differences in secondary electron emission from the nitrided and metallic target surfaces. Optimized pulse times of 1.9 and 4.1 s with and without N_2, respectively, together with d.c. powers P_{Ti} = 150 W and P_{Al} = 35 W to Ti and Al targets, results in single-phase epitaxial $Ti_2AlN(0001)/Al_2O_3(0001)$ layers, as confirmed by X-ray diffraction θ-2θ scans, rocking curves, and pole figures. The in-plane resistivity is measured using a linear four-point probe, yielding bulk resistivities ρ = 44 and 22 μΩ-cm at 295 and 77 K, respectively, and indicates a relatively low resistivity scaling with ρ = 52.64 μΩ-cm for a 12.9-nm-thick film, confirming the promise of Ti_2AlN for interconnect applications.

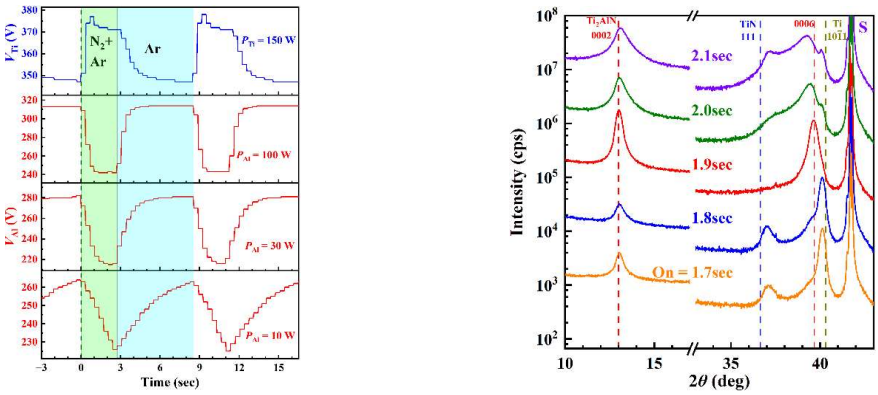

Figure 3: (a) Target voltage during cyclic supply of pulsed N_2, where V_{Ti} and V_{Al} denote the voltage of Ti and Al targets, respectively. (b) θ-2θ scan of films with varying the N_2 pulse-on time, 1.7 to 2.1 s.

1. Wang, B. et al. Cr_2AlC: A High-Temperature Transparent Conducting Ceramic. Adv. Mater. Interfaces e00931 (2026) doi:10.1002/admi.202500931.
2. Zhang, M., Kumar, S., Sundararaman, R. & Gall, D. Resistivity scaling in epitaxial MAX-phase $Ti_4SiC_3(0001)$ layers. J. Appl. Phys. 130, 034302 (2021).

Poster Presentation
Graduate Student

P02. ELLIPSOMETRIC FINGERPRINTS OF PHASE TRANSITIONS IN β-W THIN FILMS

Raid Bader*[1], Argyrios Malapanis[2] and Haralabos Efstathiadis[1]

[1] *Dept. of Nanoscale Science & Engineering, UAlbany, SUNY, Albany, NY 12222*
[2] *Technology Development Engineer, Global Foundries, Malta, NY 12020*

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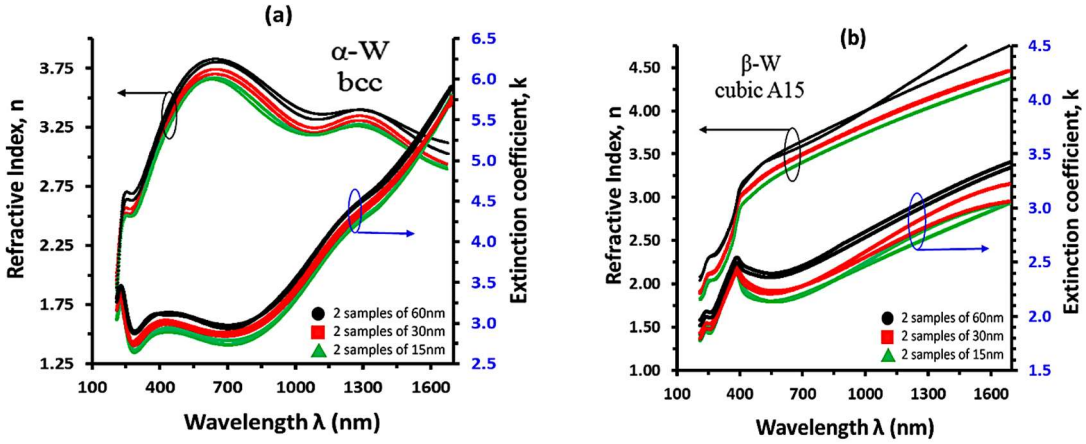
Understanding and monitoring phase transformations in tungsten thin films is crucial for advancing applications in spintronics, including MRAM technology. This study investigates spectroscopic ellipsometry as a non-destructive method for identifying and distinguishing between the tungsten phases beta-tungsten (β-W) and alpha-tungsten (α-W) in thin films. In this study, β-W thin films of, ranging from 15 to 150 nm in thickness, were deposited on silicon substrates using DC magnetron sputtering. Phase transition to α-W was then induced in selected samples. The films were characterized using atomic force microscopy (AFM), scanning electron microscopy (SEM), grazing-incidence X-ray diffraction (GIXRD), X-ray reflectivity (XRR), and four-point probe resistivity. Optical properties were subsequently measured using a spectroscopic ellipsometer, and the data were used to build and fit B-Spline models in CompleteEASE 6 software. The optical parameter data from the tested samples were then fitted successfully for both tungsten phases. The data analysis has shown distinct refractive index patterns for the α-W and β-W phases in films with thicknesses of 15, 30, and 60 nm. This work demonstrates that spectroscopic ellipsometry can effectively be used as an additional in-situ tool, complementing other characterization techniques, to detect and monitor phase transformations in tungsten thin films.



The optical constants dispersion evaluated from SE, n and k for α-W in (a) and β-W in (b), 6 samples each, films represented in two samples for each of three thicknesses (15, 30, and 60nm)

Poster Presentation
Graduate Student

P03. PROBING THERMAL-INDUCED STRAIN AT ATOMIC INTERFACES VIA RAMAN SPECTROSCOPY

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The performance of two-dimensional (2D) material-based nanodevices is heavily influenced by interfacial thermal and mechanical behavior. While temperature-dependent Raman spectroscopy is a common probe for thermal properties, the quantitative decoupling of strain effects from thermal shifts in complex stacks remains relatively unexplored. This work advances beyond basic thermal calibration to quantify thermal-induced strain at atomic interfaces. We utilize Raman spectroscopy to probe various configurations, focusing on SiO_2/graphene/h-BN and MoS_2/graphene/h-BN heterostructure stacks.

To achieve precise thermal control and probe nanoscale effects, we are integrating an 80 nm Joule heater into the device architecture. This allows for localized and controllable thermal excitation, enabling the detection of strain at the nanoscale. Our findings establish a quantitative framework using Density Functional Theory (DFT) and classical mechanical models to correlate Raman G-peak shifts with interfacial biaxial strain. We demonstrate that the nature of the interface significantly dictates strain accumulation, with h-BN encapsulated samples showing superior strain compatibility compared to SiO_2-supported counterparts. Furthermore, we report the temperature-dependent Raman response of MoS_2/graphene/h-BN heterostructures, highlighting how interfacial coupling between the stacked layers. This interaction is clearly reflected in the temperature-induced spectrum shifts observed in our measurements. This study offers new insights into the mechanical-thermal interplay at atomic interfaces and highlights the efficacy of ultra-narrow Joule heaters in thermal-strain engineering for next-generation 2D electronics.

Poster Presentation
Graduate Student

P04. CHARACTERIZATION OF PEPTIDE FRAGMENTATION PROCESSES WITHIN AN ATMOSPHERIC-PRESSURE SOLUTION-CATHODE GLOW DISCHARGE VIA MASS SPECTROMETRY

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Elucidating biomolecular fragmentation in plasmas broadens their analytical utility beyond elemental analysis. Typical techniques for biomlecular analyses include electrospray ionization where fragmentation is achieved within the mass spectrometer via collision-induced dissociation (CID) which predominantly forms only b- and y-type fragment ions. In contrast, a-, x-, c- and z-type ions are formed through radical- or electron-driven processes. Therefore, an ion source capable of obtaining each fragment-ion type remains an area of investigation. The solution-cathode glow discharge (SCGD) is a direct-current plasma sustained between a metal anode and flowing-solution cathode that produces ions from dissolved metals, small molecules, and even biopolymers, such as peptides. The SCGD plasma has been shown to yield each fragment ion type and therefore offers enhanced primary sequence coverage. While the SCGD has been extensively studied for its applications in elemental analysis, tunable fragmentation and ionization of intact molecules within the plasma is less understood.

This study probes the SCGD plasma environment to assess the role of plasma-generated radical species in peptide fragmentation. To assess the role of radical species in peptide dissociation, radical scavengers were added to sample solutions containing model peptide analytes to quench radical species. Each scavenger exhibited unique impacts on the ion signal of the protonated peptide and fragment ions. With radical scavengers present, ion signal for c-, z-, a-, and x-type fragment ions decreased, whereas b- and y-type ion signal was minimally impacted. This work clarifies the role of radical species in the SCGD plasma for peptide fragmentation and may enable further control of fragmentation for enhanced peptide sequence coverage.

Poster Presentation
Graduate Student

P05. IMPACT OF IONS IN PLASMA ENHANCED ATOMIC LAYER DEPOSITION CONFORMALITY

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As progress in nanoelectronics continues, feature size continues to shrink, and more complex higher aspect ratio (AR) structures are being used. To keep up with these developments, new and updated processes are needed to handle the new challenges presented. One of these challenges is the conformal deposition of conductive materials in high AR structures, such as DRAM trench capacitors. Atomic Layer Deposition (ALD) fits this type of deposition well as it has high conformality and can be controlled at the atomic scale. The only downside is that ALD has limited options for the type of conductive material it can deposit. Plasma Enhanced ALD (PEALD) can support a larger variety of materials and could be a good fit for this application, but it has much worse conformality due to its reliance on plasma radicals. In this study, plasma ions were used in conjunction with the radicals to assist during the plasma step in the PEALD process. A bias voltage was applied to the sample, accelerating ions towards it, allowing them to assist radicals with ligand removal. This process can allow for more conformal deposition at higher ARs as it no longer relies solely on radicals diffusing deep to remove ligands.

Poster Presentation
Undergraduate Student

P06. HIGH SENSITIVITY NONDESTRUCTIVE THIN FILM THERMAL CHARACTERIZATION VIA IMMERSION SCANNING THERMAL MICROSCOPY

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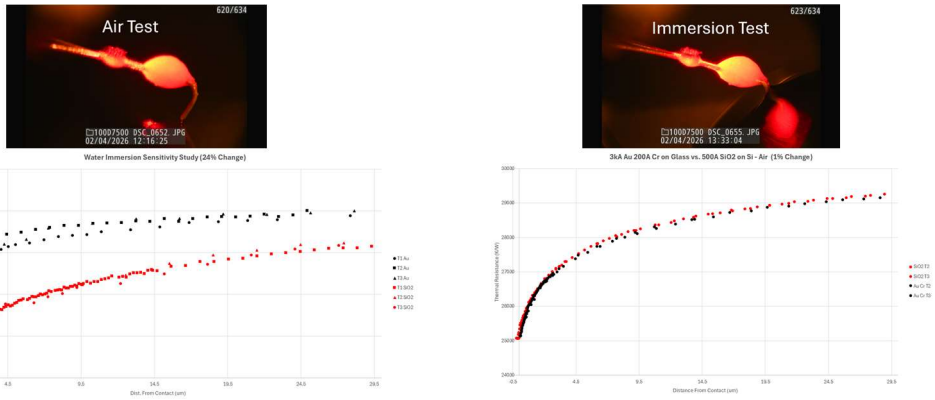
While many techniques exist for thermal characterization of thin films, many are limited from mass adoption as an in-line inspection methodology due to their preparation requirements. As an example, common characterization techniques like time domain thermoreflectance (TDTR) and the 3 omega method typically require deposition of a metal transducer, which is not easily reversible. This introduces complexity, lead time and may cause damage to the sample being analyzed. Scanning thermal microscopy is an alternative method that alleviates these sample preparation limitations.

In the typical contact mode, scanning thermal microscopy is experimentally limited by uncertainty in probe deformation, contact patch, and even capillary effects, making the method often used as a qualitative tool rather than a quantitative one. In a non-contact mode, these sources of uncertainty are eliminated, at the cost of a large thermal contact resistance across the probe-sample gap. While quantitative analysis has been shown to be possible, sensitivity is greatly limited by this large thermal contact resistance.

Fluid immersion is proposed to enhance the quantitative capability of the SThM method by reducing influence of the gap thanks to its high thermal conductivity. In the noncontact mode, a sample's thermal properties can be extracted from a geometry (Eg. Film thickness, probe geometry, and probe-sample distance) and experimental thermal resistance of the probe. At a fixed distance finite element simulations suggest a ~20x enhancement in sensitivity to thin film thermal properties, when compared to a baseline case in air. Similarly, preliminary experiments show a similar degree of sensitivity enhancement, with little change in background noise. Ultimately, this poster will combine high-fidelity finite element modeling, experimentation and design optimization, pushing the limits of quantitative capability in the SThM method.



Poster Presentation
Graduate Student

P07. EFFECT OF TUNGSTEN NUCLEATION LAYER ON MOLYBDENUM FILM PROPERTIES

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Molybdenum (Mo) is a promising metal as possible replacement of Cu and W in back-end of line (BEOL) and middle-of-line (MOL) interconnect applications[1,2]. 5 nm thick Mo films are deposited on SiO_2/Si(001) substrates by DC magnetron sputtering in 20 mTorr Ar at T_s = 400 °C and their microstructure and properties are studied with and without a 3 nm thick nucleation layer. X-ray reflectivity and transmission electron microscopy analyses indicate that the W nucleation layer is relatively smooth, with a root-mean square surface roughness σ = 0.05 nm, and that the grains have a random orientation with an average size D = 5.9 nm. The Mo film directly deposited on SiO_2/Si(001) has a slightly smaller D = 5.1 nm. However, if grown on the W nucleation layer, the Mo grain size is 17% larger, with a measured D = 6.9 nm. Atomic force microscopy indicates that the roughness of the Mo layer is nearly unaffected by the nucleation layer, with σ = 0.22 and 0.26 nm with and without W nucleation layer. In contrast, the lateral correlation length of the Mo surface roughness increases from 7.7 to 14.8 nm, corresponding to a roughly 2-fold increase in the lateral mound width. The measured room temperature resistivity is 168 and 357 μΩ·cm for the film with and without W nucleation layer. The lower resistivity for Mo on a nucleation layer is attributed to reduced electron scattering at grain boundaries due to the larger grain size.

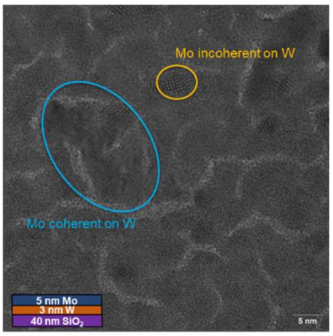

Figure 4. Plane-view TEM image of a 5 nm Mo film grown on SiO_2 grid with a 3 nm W nucleation layer. Blue circle highlights a region where Mo grows coherently on W, while orange circle shows a Mo grain with an orientation different from that of W.

[1] *Anisotropic resistivity size effect in epitaxial Mo(001) and Mo(011) layers*, A. Jog, P. Zheng, T. Zhou, D. Gall, Nanomaterials **13**, 957 (2023)
[2] *Electron scattering at interfaces in epitaxial W(001)-Mo(001) multilayers*, Poyen Shen and Daniel Gall, J. Appl. Phys. **136**, 075305 (2024)

Poster Presentation
Graduate Student

P08. IMPROVEMENT OF TANTALUM OXIDE BASED ReRAM VIA OPTIMIZATION OF THE SWITCHING LAYER

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The conventional von Neumann computing architecture requires memory and logic units to be physically separated. As processor capability and memory size have scaled, this physical separation has created the so-called “von Neumann bottleneck”, where data transfer between logic and memory units significantly limits maximum speed and efficiency. Emerging non-volatile memories have the potential to resolve this bottleneck by enabling logic and other computing functions within or directly adjacent to memory. One of the leading candidates is resistive random-access memory (ReRAM) due to its high read and write speeds, non-volatility, back-end of line (BEOL) fabrication compatibility, storage density, and scalability. This makes ReRAM a strong contender to complement or even replace SRAM, DRAM, and NAND flash memories. Each ReRAM cell consists of a metal-insular-metal device stack in which the insulating material’s conductance can be modified through initial electroforming and subsequent voltage biasing. Transition metal oxides have been heavily investigated as the switching material in ReRAM, due to the ability to generate and manipulate oxygen defects (vacancies) within the material. Oxygen vacancies within such oxides can be manipulated using an applied electric field to vary conductance. One of the primary challenges with ReRAM is relatively high leakage current even when switched to an OFF state. To mitigate this challenge, a novel multi-layer switching stack was proposed and electrical operating conditions were optimized to reduce conductance in the OFF state without affecting other characteristics. To accomplish this, near-stoichiometric TaOy films were deposited on TiN electrodes, followed by the deposition of sub-stoichiometric TaOx through reactive sputtering. The thickness of the sub-stoichiometric film was varied to optimize overall device performance. A tantalum oxygen exchange layer (OEL) was also deposited on top of the switching layer followed by an iridium capping layer. Electrical characterization revealed that bi-layer devices with a 5 nm TaOx layer exhibited the best switching characteristics along with low electroforming voltages ~ 2.5 V. The initial laboratory-scale fabrication process was then transferred to 300 mm wafer scale.

Poster Presentation
Graduate Student

P09. INTERFACE EFFECTS IN TEMPERATURE DEPENDENT EFFECTIVE THERMAL CONDUCTIVITY AND THERMAL RESISTANCE MEASUREMENTS OF THIN FILMS WITH 3W METHOD

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As the chip performance continues to increase, more heat is being generated as a result which can not only harm the chip but also result in performance lag. Better understanding of thermal transport is therefore imminent to ensure proper heat dissipation in the semiconductors. This study focused on 3ω method implementation to measure temperature dependent effective thermal conductivities and Interfacial thermal resistances of multilayer samples consisting of thin films deposited on Si substrates. The experimentally obtained third harmonic response was converted to second harmonic temperature oscillation and analyzed using a multilayer frequency-domain heat conduction model. Thermal conductivities of the film and substrate were extracted using a fitting model over a selected frequency range and then thermal resistances were also measured. The results show a linear incremental order for the thin film thermal resistances as film thickness is increased. This trend can be used to extract interfacial thermal resistances which would be studied for temperature dependence cases and analyzing the interfacial effects. The experiments were run for different heater widths to investigate the repeatability of the results and the effects of the heater widths. They were also run on two different setups where one used 'Automatic Digital Cancellation' and the other one used 'Wheatstone Bridge Circuit' for cancellation process in order to further verify the results. The results will emphasize the significance of interfacial contributions while evaluating temperature dependent thermal conductivity derived from 3ω measurements of thin-film stacks.

Acknowledgements: This work is funded by IBM under the Rensselaer-IBM Artificial Intelligence Research Collaboration (AIRC)

Poster Presentation
Graduate Student

P10. PLATFORM FOR PLASMA SPECTROCHEMICAL ANALYSIS OF LEVITATED PARTICLES THROUGH LASER-BASED SPECTROSCOPIES

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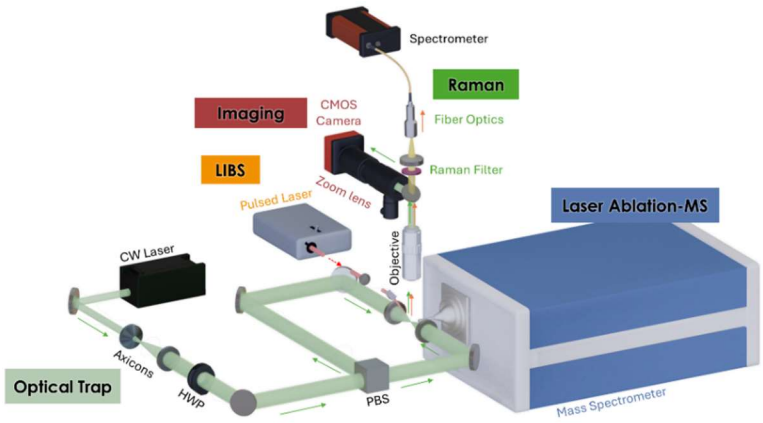
Micron-sized particles are involved in a wide range of physicochemical processes, including material degradation, and their comprehensive spectrochemical characterization has traditionally relied on the sequential use of different techniques. Some cases even require particle digestion and chromatographic separation prior to analysis. However, as the serial workflow approach requires different particles at different stages, it introduces multiple issues, including excessive sample consumption, contamination risk, and mismatched data. To mitigate those problems and to obtain maximum spectrochemical information from the same micron-sized sample, precise single-particle control must be achieved and coupled with an integration of multiple concurrent spectroscopies.



Here, a custom multimodal analysis platform is presented to characterize individual particles levitated in air. The proof-of-concept system employs an optical particle trap formed using hollow Bessel beams to suspend micron-sized particles in air under ambient conditions. The trap is generated using a 532 nm continuous wave laser shaped into an annular profile with a pair of axicons, while particle stability is monitored and tracked using a high-magnification imaging system. Atomic and molecular characterization is performed via laser-induced breakdown spectroscopy (LIBS), Mass Spectrometry (MS), and Raman spectroscopy, respectively. The Raman signal is collected directly from scattering of the trapping beam, whereas LIBS emission is generated by a nanosecond pulsed laser, with the resulting laser-ionization serving as the input to the mass spectrometer. Details of the functioning apparatus, particle tracking capabilities, and representative spectroscopic results will be presented.

Poster Presentation
Graduate Student

P11. AN OVERVIEW OF NORTHEAST REGIONAL DEFENSE TECHNOLOGY HUB (NORDTECH)

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The Northeast Regional Defense Technology Hub (NORDTECH) is a regional coalition of public and private sector leaders advancing innovation in microelectronics as part of the U.S. Microelectronics Commons program. The hub brings together five founding institutions: NY Creates, University at Albany, Cornell University, Rensselaer Polytechnic Institute, and IBM along with a growing network of partners across academia, industry, and government.

NORDTECH supports a broad portfolio of semiconductor technologies through targeted programs, including the Lab-to-Fab Innovation Fast Track (LIFT) program for early-stage projects to accelerate technology innovation, as well as longer-term initiatives aimed at advancing technologies toward scalable manufacturing. A key strength of the NORDTECH hub is its access to a distributed set of advanced tools and facilities, and technical expertise, enabling collaboration between institutions from research to prototyping to manufacturing and deployment.

In addition to its technical focus, NORDTECH maintains a strong commitment to workforce development. Through coordinated education and training efforts, as well as a summer internship program, the NORDTECH hub is designing pathways for students and early-career professionals to enter and contribute to the microelectronics workforce.

By advancing these key initiatives and integrating innovation, infrastructure, and talent development, NORDTECH plays a critical role in strengthening the regional ecosystem and supporting national priorities for semiconductor leadership. This work was primarily supported by the Microelectronics Commons Program, a DoW initiative, under award number N00164-23-9-G061.

Poster Presentation

P12. VISCOELASTIC RESPONSE OF TWO INDEPENDENT POLYMER NETWORKS VIA REACTIVE COARSE-GRAINED MOLECULAR DYNAMICS

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We investigate the viscoelastic response of two independent coarse-grained polymer networks, with different stiffnesses, and their interpenetrating configurations using molecular dynamics (MD) simulations. The networks are synthesized via a reactive modified Lennard-Jones (mLJ) potential that enables the formation of crosslinked amorphous polymer networks. Polymeric glasses are formed through a controlled cooling protocol, yielding entangled network structures.

Dynamic mechanical analysis (DMA) is performed in LAMMPS using an oscillatory strain protocol. Storage modulus (G'), loss modulus (G''), and loss tangent (tan delta) are extracted as a function of temperature. The glass transition temperature (Tg) for each pure network is identified from the tan delta peak. Interpenetrating polymer network (IPN) configurations are then studied by mixing two networks at varying compositions, tuning the cross-species mLJ interaction parameters to control miscibility. Phase-separated and fully mixed IPNs exhibit distinct Tg behavior, demonstrating how interfacial interactions govern the viscoelastic response of multi-component networks.

A geometrically confined configuration is also studied, where the soft network occupies a cylindrical domain embedded within a stiff matrix. DMA on these confined systems reveals how spatial isolation modifies the viscoelastic response relative to the fully mixed IPN.

These results provide molecular-scale insight into the structure-property relationships of IPNs and demonstrate how mLJ-based coarse-grained models can capture key viscoelastic phenomena relevant to multi-component polymer systems.

Acknowledgements

We acknowledge the computational resources and support provided by the Center for Computational Innovations (CCI) at Rensselaer Polytechnic Institute.

Poster Presentation
Graduate Student

P13. IMPACT OF SILICA SURFACE CHEMISTRY ON NUCLEATION OF RUTHENIUM AREA-SELECTIVE ATOMIC LAYER DEPOSITION

Shixian Ha[1*], Hwan Oh[2], Won Il Lee[2], Md Istiaque Chowdhury[2], Xiao Tong[2], Mingzhao Liu[1,2], Chang-Yong Nam[1,2]

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As semiconductor technology advances toward sub-5 nm nodes, ruthenium (Ru) area-selective atomic layer deposition (AS-ALD) is of growing interest as a back-end-of-line (BEOL) interconnect metal due to its favorable scaling behavior over copper (Cu). In BEOL, silica is the dominant dielectric and intended non-growth surface, yet its formation-dependent surface chemistry and its impact on Ru nucleation remain insufficiently explored. Here, we investigate Ru ALD on native oxide SiO_x (N-SiO_x) and thermally grown SiO_2 (T-SiO_2) as model dielectric surfaces using bis(ethylcyclopentadienyl)ruthenium (II) [$Ru(EtCp)_2$] with an O_2 co-reactant at 200–300 ^oC. Cross-sectional scanning electron microscopy (SEM) with surface coverage analysis reveals that both surfaces exhibit intrinsically delayed nucleation, with different extents correlated to their surface hydroxyl (–OH) densities. The lower –OH density of T-SiO_2 results in sparse, island-like nucleation, whereas the higher –OH density of N-SiO_x promotes more uniform nucleation. Introducing a hydrogen-assisted ABC-type ($Ru/O_2/H_2$) sequence markedly shortens the nucleation delay, indicating that the H_2 step promotes nucleation on hydroxyl-deficient T-SiO_2, likely via in situ rehydroxylation. Furthermore, grazing-incidence X-ray diffraction (GI-XRD), atomic force microscopy (AFM), and four-point probe measurements show that these surface-dependent nucleation behaviors lead to distinct early-stage film evolution and associated Ru film properties, including phase, morphology, and resistivity. Overall, this work provides mechanistic insight into surface-chemistry-driven Ru nucleation and establishes design principles for controlling selective growth on dielectric surfaces, advancing ASD strategies for next-generation BEOL integration.

Poster Presentation
Graduate Student

P14. ENHANCEMENT OF EXPERIMENTAL REPEATABILITY AND THERMAL UNIFORMITY IN TCR CHARACTERIZATION VIA BOTTOM-UP HEATING AND AUTOMATED STEADY-STATE DETECTION

S M A Mohaiminur Rahman, Jonas Kendra, Jeffrey Chen, George Moore, Lauren Caraballo, Kazi Masuk Elahi and Theodorian Borca-Tasciuc

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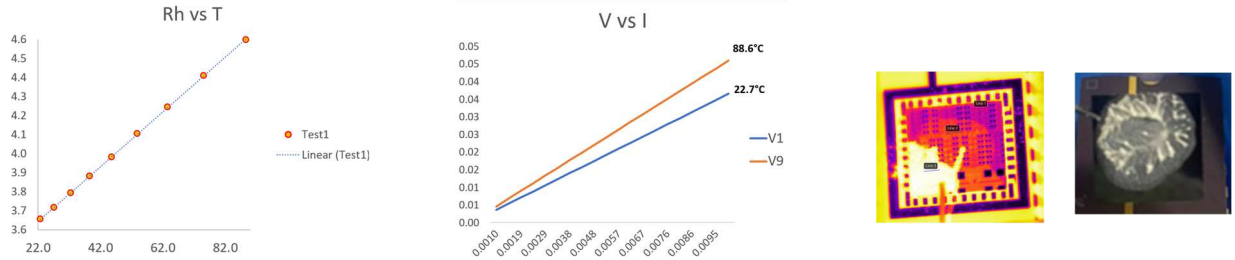
Temperature Coefficient of Resistance (TCR) is one of the essential metrics in electro-thermal characterization methods like the 3-omega technique used in nanoscale heat transfer research. However, measurements of TCR are often inaccurate due to thermal distribution irregularities and non-uniformity in the definition of steady states. This work presents a redesign of an existing TCR measurement setup for chip mounted on chip carrier, focusing on metrological validation.

Firstly, a custom T-shaped Aluminum heat spreader was developed to transition the system from a top-down heating configuration to a bottom-up approach, providing a more stable thermal path to the chip top surface. Secondly, Infrared (IR) thermography was done to observe spatial temperature non-uniformities. Analysis of IR footage showed that inconsistent thermal interface material (TIM) application at the chip-carrier interface led to significant temperature gradients; this was rectified through uniform application of TIM. Thirdly, the control system was modified in LabVIEW to define steady state based on temperature rather than fixed time interval. The system has been improved to automatically acquire data only if there are temperature variations in the range of ±0.2°C within 60 seconds, thus greatly enhancing its efficiency and accuracy to find steady state.

The new system was tested on Aluminum heater lines of different widths. The RSD obtained from the statistical analysis of the nine independent tests was found to be 0.94%, which is indicative of very high precision. No relationship was detected between the heater line width and TCR, which confirms that there is no geometrical dependence on TCR. In addition, the experimentally determined mean TCR value of 0.004037 K^{-1} matches well with the NIST/ASME standards (0.00403 K^{-1} at 20°C).



Figures: Rh vs T and V vs I for 3um heater line and IR validation of previous setup's temperature non uniformity on chip surface due to improper TIM application

Poster Presentation
Graduate Student

P15. BREAKING DOWN FOREVER CHEMICALS: PLASMA DRIVEN MODIFICATION OF PFAS

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Per-/Poly-fluoroalkyl substances (PFAS) are a class of over 10,000 compounds currently challenging environmental and analytical chemists alike. These species were once used in the production of non-stick cookware, fire retardants, food packaging, and other common items. However, PFAS have been linked to decline in both human and environmental health, due to fluorine's highly reactive and stable nature. Due to the high bond energy in carbon-fluorine (C-F) bonds, PFAS are very resistant to decomposition. Unfortunately, this stability leads to large quantities of PFAS persisting in soils and waterways around the world creating a need for analytical techniques that can aid with establishing regulations. Standard analytical techniques like electrospray ionization mass spectrometry (ESI-MS) are limited to the detection of specific polar PFAS, leaving possibly thousands of other PFAS species undetected. Polar PFAS, like perfluorooctanoic acid (PFOA), are easily ionizable due to their susceptibility to deprotonation but nonpolar PFAS, like perfluorooctane (PFO), present an issue.

Here, our group is exploring the use of energetic species produced by atmospheric-pressure plasmas, such as the flowing atmospheric pressure afterglow (FAPA), to readily break C-F bonds and chemically alter non-polar PFAS. The FAPA source was coupled with a high-resolution mass spectrometer to characterize plasma-generated products. We have observed that the FAPA plasma can defluorinate PFO, as determined by the presence of $[M\text{-}F]^-$ and $[M\text{-}F_3]^-$ in the mass spectrum. Not only were fluorine atoms able to be extracted from PFO, but the FAPA also produced oxygenated PFAS (e.g., $[M\text{-}F+O]^-$ and $[M\text{-}F_3+O]^-$). Additionally, the impact of FAPA conditions which alter plasma reagents (e.g., gas flow rate and discharge current), on PFO modification was tested. The study of PFAS with FAPA ionization will enable the development of more efficient identification protocols for known PFAS species and could enable detection of those difficult or impossible to measure using conventional methods.

Poster Presentation
Undergraduate Student

P16. IN-SITU ELECTRON MICROSCOPY OF CONDUCTION FILAMENT DYNAMICS IN ASYMMETRIC METAL-INSULATOR-METAL BASED RESISTIVE SWITCHING DEVICES

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Electrochemical metallization based resistive switching devices are emerging as strong contenders for next-generation non-volatile memory and neuromorphic computing applications, due to their low-power consumption and multi-resistance state switching capabilities. This work investigates the evolution of conduction filaments in asymmetric Metal-Insulator-Metal architectures, specifically Co/SiO_2/Pt devices, with focus on improving device reliability by understanding the factors that lead to stochasticity in switching behavior.

Our devices are laterally fabricated on electron-transparent SiNx TEM grids by electron beam lithography followed by evaporative deposition of the metal electrodes and dielectric oxide deposition. In-situ TEM facilities, integrated with electrical biasing using a Keithley power source and a Gatan heating holder, enable real-time correlation between structural filament evolution and electrical behavior.

We have developed a Finite Element framework using Abaqus to study the temperature profile due to Joule heating, in the devices during our biasing cycles. These simulations are cross-referenced with our experimental observations to study the electro-thermal mechanisms driving the conduction filament dynamics. We are also developing a STEM-EELS-based linear mixing model that will optimize the different electron energy loss function components and map the Co oxidation states across the SiO_2 layer between the electrodes. This will help quantify the spatial distribution and valence states of Co within the dielectric gap, providing chemical insights into nature and evolution of filamentary paths.

The use of in-situ electron microscopy in this context provides a critical advantage over traditional ex-situ characterization. The systematic investigation of device geometry, electrode asymmetry, temperature effects and multi-cycle dynamics in real-time at nanoscale resolution with in-situ microscopy, combined with electro-thermal modeling and oxidation-state mapping - will facilitate a direct structure-function correlation for understanding the stochastic nature of filament kinetics and contribute towards the fundamental understanding of the resistive switching mechanism.

Acknowledgements

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We also acknowledge the facilities and personnel in the RPI Micro and Nano Scale Cleanroom and the RPI Nanoscale Characterization Core operated by the Center for Materials, Devices and Integrated Systems (cMDIS) at RPI

Poster Presentation

Graduate Student

P17. ELECTRON VISION: E-BEAM GLANCING ANGLE SCATTERING FOR HYBRID BONDING SURFACE PLANARITY MEASUREMENT

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The target of next generation 3D/chiplet technology is sub-micron high-density pitch for D2W/W2W (die to wafer/ wafer to wafer) interconnection. Hybrid bonding surface must maintain atomic scale smoothness for the entire wafer to improve yield and reliability. The current tool of choice for metrology is atomic force microscopy (AFM) (Fig. 1) which measures RMS of a small local area with slow scan rate (several minutes for a surface height scan of 10 × 10 μm^2). In this work, we show the application of reflection high-energy electron diffraction (RHEED) technique (Fig. 2) that uses the wave nature of electron incident at less than 1° glancing angle [1] on a chemical mechanical polished hybrid bonding surface with a rapid data acquisition of RMS. The Table is a comparison of AFM and glancing angle incident RHEED scattering. This promising technique [2] offers a **large-area**, **fast**, **high-resolution**, and **non-destructive real time** metrology solution for atomic scale surface roughness measurement. It will improve yield in chiplet production.

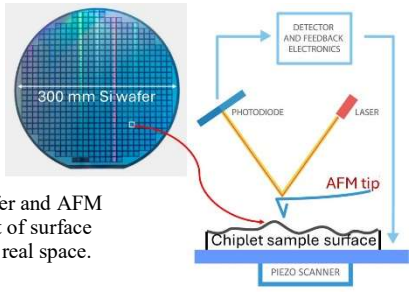

Fig. 1 Si wafer and AFM measurement of surface roughness in real space.

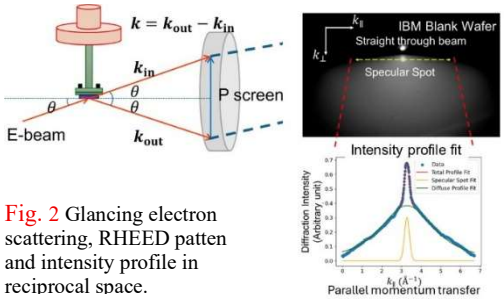

Fig. 2 Glancing electron scattering, RHEED patten and intensity profile in reciprocal space.

Matrix	AFM	Glancing incident RHEED
Area	5 × 5 μm^2	5 × 0.1 **mm^2**
Data acquisition time	10 - 30 minutes	**~ second**
Data analysis time	~ second	Within a fraction of a sec
Throughput	1 AFM image	> **1 million** AFM images
Lateral resolution	Limited by tip size (~10 nm)	**Sub-nm**
Probe to sample distance	< 10 nm	No limit
Vertical RMS roughness from hybrid bonding test chiplets, blank wafer	3.5 ± 0.8 Å	2.7 ± 0.1 Å

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Poster Presentation
Graduate Student

P18. DEPENDENCE OF TEMPERATURE AND PRESSURE ON RESONANT FREQUENCY AND DAMPENING OF MEMS DEVICES

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Microelectromechanical systems (MEMS) are micron scale devices with moving parts. MEMS-based switches have been developed by Menlo Micro for various applications, including RF signal propagation. These switches have higher switching speeds and lower power loss than conventional semiconductor-based switches. The MEMS switches use an electrostatically controlled cantilever that is made from a metal alloy. The electrical contacts of the switch are coated with ruthenium because of its hardness and resistance to oxidation. The MEMS switches are encapsulated in a proprietary gas mixture. This gas mixture helps maintain the stability of the contacts and provides dampening of the cantilevers.

The primary goal of this project is to experimentally determine the effect of temperature and the pressure of the encapsulation gas on the resonant frequency and dampening of the MEMS devices. These MEMS devices are being considered for use in quantum computers, which requires operation at cryogenic temperatures. Since the devices are incapsulated in a hermitically sealed environment, as temperature decreases, the pressure of the encapsulation gas decreases, which results in a change in the dampening of the cantilever. In addition, the stiffness of the cantilever increases as the temperature decreases, which results in a higher resonant frequency.

A custom vacuum chamber has been developed to allow testing of MEMS devices under vacuum and up to an absolute pressure of 1 atm with a variety of different gas mixtures. The system can also measure the performance of the MEMS switches from LN2 temperature up to 100 °C. Our results for measurement of the dynamic performance of the MEMS switches at temperatures ranging from 77 K to 400 K and at pressures ranging from 10^{-7} Torr to atmospheric pressure will be presented. In addition, the design of a chamber modification that will allow measurements at gas pressures up to 2 atm absolute, will be presented.

Poster Presentation
Graduate Student

P19. INTER-CODE VALIDATION OF PHOTON TRANSPORT THROUGH PROGRESSIVELY DEGRADED SHIELDING MATERIALS: OpenMC VERSUS MULASSIS/Geant4

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Radiation shielding materials in nuclear and space systems degrade over time through density loss and void formation, directly increasing transmitted photon dose. Quantifying how much of that predicted increase reflects real physics versus differences between transport codes is an open and practically important question. This study compares OpenMC (v0.15.1, ENDF/B-VIII.0) and MULASSIS/Geant4 (em_opt3) for an idealized 1MeV photon transport through a lead slab across three controlled scenarios: a thickness sweep from 5 to 100 g/cm², a bulk density reduction from 100% to 30%, and progressive void formation at fractions from 0 to 10%. For the void cases, two spatial morphologies were tested: spherical voids arranged on a regular cubic lattice, and voids placed randomly with a non-overlap constraint. Multiple independent realizations of that random case were run to separate spatial arrangement effects from void fraction effects. Both codes agreed within 2% on average across all degradation cases. The largest discrepancy of about 5% appeared only at 100 g/cm², where secondary electron treatment differences between OpenMC's thick-target bremsstrahlung approximation and Geant4's full electromagnetic cascade become detectable at extreme attenuation. At lower areal densities, MULASSIS predicts higher (0.4%) dose than OpenMC, while at higher areal densities the trend reverses and the difference is larger (2%). This crossover supports the conclusion that the two codes handle secondary particle interactions differently, with a dependence on the areal density of the shield. For the void morphology comparison, lattice and random arrangements produced equivalent bulk attenuation with nearly identical flux values but differed in lateral flux distribution at the shield/tissue interface, with a coefficient of variation of 1.5% for the periodic lattice versus 0.9% for random placement. Variability across random realizations was only 0.1%, confirming that void fraction governs total transmitted dose while spatial arrangement affects only local flux distribution. Transmitted fluence spectra show consistent spectral shape agreement between codes confirming that photon transport physics, not secondary electron treatment, governs beam transmission through the shield.

Poster Presentation
Graduate Student

P20. EPITAXIAL TaP(001) FORMATION BY PHOSPHORIZATION OF EPITAXIAL Ta(001)/MgO(001)

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Tantalum phosphide (TaP) is a Weyl semimetal where inversion symmetry is broken, leading to Fermi arcs and topologically protected surface states which are promising for narrow high-conductivity interconnects [1]. TaP thin films are formed by phosphorization of 26 and 40 nm thick epitaxial Ta(001)/MgO(001) and Ta(110)/$Al_2O_3(11\bar{2}0)$ layers using rapid thermal annealing at 850 °C in inert Ar with the Ta layers in direct contact with an InP wafer. Energy dispersive x-ray spectroscopy indicates an increasing degree of phosphorization with increasing annealing time t_a, with a measured Ta-to-P ratio x = 0.46, 0.49, and 0.87 for t_a = 3, 5, and 10 min, respectively. This is confirmed by x-ray diffraction (XRD) measurements which indicate a phase mixture containing BCC α-Ta, metastable β-Ta, and TaP for t_a = 3, 5, and 10 min for an initial Ta thickness d = 40 nm. Phase pure TaP is achieved with t_a = 5 min and d = 26 nm. Phosphorization of Ta(110)/$Al_2O_3(11\bar{2}0)$ results in polycrystalline TaP while Ta(001)/MgO(001) leads to epitaxial TaP(001)/MgO(001) films with an in-plane epitaxial relationship TaP[110]‖MgO[100], as determined by XRD pole figure measurements of the asymmetric MgO 111 and TaP 112 reflections. Transport measurements indicate a relatively high TaP resistivity of 285 – 398 μΩ-cm, with no evident trend as a function of film thickness. The high resistivity is attributed to electron scattering at (i) small-angle grain boundaries as evidenced by a relatively large XRD TaP 004 omega rocking curve full-width-at-half-maximum of 5.1°, and (ii) surface roughness indicated by the absence of fringes in x-ray reflectivity measurements.

[1] D. Gall, J. J. Cha, Z. Chen, H. J. Han, C. Hinkle, J. A. Robinson, R. Sundararaman, and R. Torsi, MRS Bulletin **46**, 959 (2021).

Poster Presentation
Graduate Student

P21. THE SHARED SILICON FRAMEWORK

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This project will create a modular ASIC framework capable of supporting up to four independently developed Verilog modules. At runtime, a control signal will select which module is active, allowing the modules to share I/O ports without interference. The final design must satisfy all standard fabrication and verification requirements, including DRC (Design Rule Check): ensuring compliance with process-specific layout constraints, LVS (Layout vs. Schematic): verifying that the physical layout matches the intended logic, and additional verification steps required by the foundry. By consolidating multiple projects into a single shared tape-out, this approach will reduce fabrication costs while also preparing students with workforce-ready skills in modern semiconductor design and verification. The framework will be well-documented, modular, and designed for scalability to support future teams with minimal interdependencies.

Poster Presentation
Undergraduate Student

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