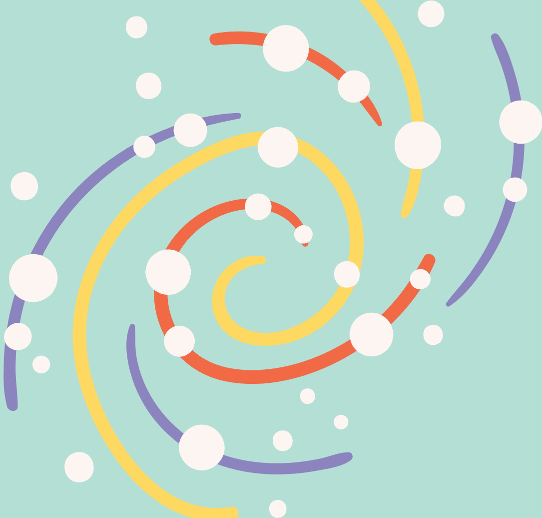
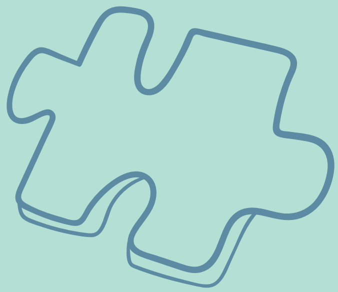
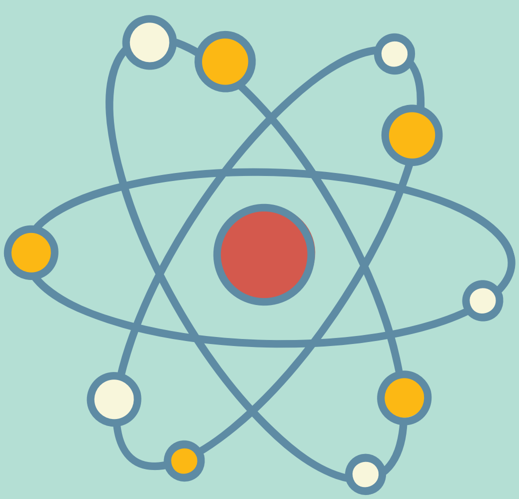




NIST SUMMER UNDERGRADUATE RESEARCH FELLOWSHP

SURF 2025


Greetings,

On behalf of the Director's Office, I proudly present the 2025 SURF Colloquium book. The 2025 SURF Program featured 152 in-person and virtual participants.

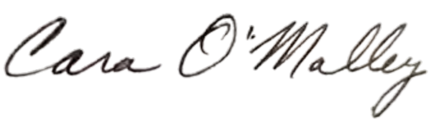
Founded by scientists in the Physics Laboratory (PL) with a passion for STEM outreach, the SURF Program has grown immensely since its establishment in 1993. SURF's first cohort consisted of twenty participants from 8 universities who conducted hands-on research primarily in the physics lab. The 2025 cohort, representing all STEM disciplines, included 138 participants from over 70 universities working on research projects on the NIST campuses in Boulder, CO, and Gaithersburg, MD. Participants from all campuses engaged in activities collectively, including the Colloquium. In the future, the program will likely include virtual and in-person components regularly as we adapt to the nation’s changing workforce is changing.

As you peruse the Colloquium book, you are bound to find topics that pique your interest. You are welcome to email the NIST research advisors about your questions and comments regarding the ongoing research in a specific NIST laboratory. Most staff and scientists are excited to exchange findings and new ideas and love to talk about their roles and research at NIST.

I could not conclude this letter without mentioning the individuals who make the SURF Program possible. Thank you to the Laboratory SURF Directors, the SURF mentors, the administrative staff, OISM, and all the staff who play an integral role in creating valuable experiences for the SURF participants. Also, a huge thank you goes out to the participants, their families and friends, and the ambassadors who spread the word about SURF. Your hard work and support are greatly appreciated.

I hope you enjoy the 2025 Colloquium and learn something new about the nation’s standards laboratory.

Best regards,



Cara O'Malley

NIST SURF Program Director

2025 SURF Directors Team	
IAAO Program Management	
Cara	O'Malley
LaKesha	Perry
Boulder	
Chris	Carson (CTL)
Wendi	Copello (MML)
Mary	Gregg (PML)
Susan	Schima (PML)
CTL Gaithersburg	
Wesley	Garey
David	Griffith
Konstantina	Di Menza
Jian (Jane)	Wang
EL Gaithersburg	
Kathleen	Hoffman
Cartier	Murrill
Lucy	Fox
ITL Gaithersburg	
Yolanda	Bursie
Katya	Delak
Gunay	Dogan
Michaela	Iorga
Derek	Juba
Katherine	Schroeder
Ian	Soboroff
Simon	Su
Avonte	Collins
MML Gaithersburg	
Jacqueline (Jackie)	Mann
Mark	McLean
Jessica (Jess)	Staymates
Daniel	Siderius
NCNR Gaithersburg	
Julie	Borchers
Leland	Harriger
Susana	Teixeira
Julie	Keyser
Rebecca	Ogg
PML Gaithersburg	
Uwe	Arp
Theresa	Ginley-Belcastro
Zachary	Levine
Toni	Litorja
Christina	Hacker
Special Projects	
Michael (Mike)	Berilla
Lisa	Fronczek
John	Bittman

Table of Contents

SURF Colloquium N1ST Plenary Session - July 29, 2025 **Gaithersburg Green Auditorium, Boulder Bldg 81 Rm 1A116**		**Zoom link:** https://nist.zoomgov.com/j/1608639498?pwd=XWArU6w7ZW9vSkOPAkQ56w18aUWKbk.1		
9:45 AM ET	**Welcome Remarks & Gaithersburg Moderator:** *Cara O'Malley*		**Boulder Moderator:** *Ala Bazyleva*	**Zoom Moderator:** *Mary Gregg*
TIME (ET)	***Plenary Speaker*** **and OU**	**Presentation Title**		
9:55 AM	***Joy Roberts*** **- CTL**	Modeling Wireless Communication to Improve Passenger Comfort in Autonomous Vehicles		
10:20 AM	***Abigail Esh*** **- EL**	Expoloration of Large Language Models (LLMs) to Support Early-Stage Circular Product Design of Small Electronics		
10:45 AM	***Isabel Wu*** **- ITL**	Evaluating the Resilience and Generalization of Forensic Generative AI Detection Systems		
11:10 AM	***Ryan C. Giang*** **- MML**	(CHIPS) Lifetime Predictions and Cure Kinetics of Semiconductor Packaging Materials via Thermal Analysis		
11:35 AM	BREAK	N/A		
11:50 AM	***Xuliana O*** **- NCNR**	ROADBot: Autonomous Optimization of Compositionally Diverse Lipid Bilayers on Solid Supports		
12:15 PM	***Harshit Agarwal*** **- PML (Boulder)**	Tracing the Cosmic Microwave Background: Polarization Detection with Superconducting Kinetic Inductance Detectors		
12:40 PM	***Kaleb Jewell*** **- Boulder speaker - MML**	(CHIPS) Democratizing Gallium Nitride Wafer Metrology		
1:05 PM	LUNCH	N/A		

		Parallel Session #1	**Parallel Session #2**	**Parallel Session #3**
Parallel Sessions Tuesday, July 29, 2025	**Location**	**Gaithersburg, Bldg 101, Lecture Room A**	**Gaithersburg, Bldg 101, Lecture Room D**	**Gaithersburg, Bldg 101, Lecture Room B**
	Zoom Link	https://nist.zoomgov.com/j/1613129217?pwd=VltU1fYltWbMIfGRIVP0MzqdYZaARs.1	https://nist.zoomgov.com/j/1608639498?pwd=XWArU6w7ZW9vSkOPAkQ56w18aUWKbk.1	https://nist.zoomgov.com/j/1609805719?pwd=6r3R1CvXbelahJjUu0qNSeM6ZsNhb3.1
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Joe Rice* **Zoom Moderator:** *Susana Deustua*	**Host Laboratory: MML** **Moderator:** *Carrie Campbell* **Zoom Moderator:** *Jackie Mann*	**Host Laboratory: EL** **Moderator:** *Kathleen Hoffman* **Zoom Moderator:** *Judy Bowie*
	1:45 PM	***Meagan Porter*** : The Absolute Flux Calibration of Stars	***Charles Rhys Campbell:*** (CHIPS) CrystalGen: Benchmarking GPT, Diffusion, and Flow Models for Atomic Structure Discovery	***Christopher Jin*** : Degradation Mechanism Study and Failure Analysis of Polymeric Components in Photovoltaic Modules
	2:00 PM	***Lucy Collins*** : Improving Spectral Irradiance Responsivity Calibration with the FLUX Instrument	***Ian Fagan:*** The Challenges of Maintaining Data Infrastructure Systems: A Materials Genome Initiative Case Study	***Nikita Polyakov*** **:** Evaluating 3D LiDAR Performance
	2:15 PM	***Grayson Garner:*** Durability of silicon optic surface treatment for extreme ultraviolet scatterometry	***Owen Lin:*** Atoms to Fields: Bridging Length Scales for Grain Boundary Modeling	***Jeanelle Lin*** **:** Developing a Mobile Automated Refrigerant Charging Machine
	2:30 PM	***Kylil Orr:*** High Speed Arduino Servo		***Alvin Persaud:*** Automating The Data Collection of Alternative Refrigerant Flammibility
	2:45 PM	**BREAK**	**BREAK**	**BREAK**
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Darwin Reyes-Hernandez* **Zoom Moderator:** *Toni Litorja*	**Host Laboratory: MML** **Moderator:** *Carly MuletzWolz* **Zoom Moderator:** *Mark McLean*	**Host Laboratory: EL** **Moderator:** *Ashley Carey* **Zoom Moderator:** *Lisa Fronczek*
	3:00 PM	***Oren Friedlin:*** Robust and Efficient Wavelength Conversion for Hybrid Quantum Networks	***Sarika P. Kapadia*** **:** Unraveling Soil Microbiome Composition and Interactions: A Network Analysis Approach	***Chole Whalen*** **:** HVAC Analysis: Investigating Real Building System Data
	3:15 PM	***Benjamin Pittelkau*** : Simulation-Based Design of a Plasmonic Schottky Detector for Mid-IR Opioid Detection	***Khoa Hoang*** **:** Mammalian Cell Counting Techniques Using the NISTCHO Reference Cell Line	***Meredith Estrella Hernandez*** **:** Program a Raspberry Pi to Emulate an HVAC Controller
	3:30 PM	***Ruben Dasgupta*** : Probing Photonic Crystal Mirror Performance	***Terra Pickett*** **:** Use of varying angles and apertures in ATR and Transmission FTIR to Measure Distance of Specific Functional Groups within AMPs	***Charlie Reed*** **:** Investigation of Thermal Propertues of Encapsulated Phase Change Materials (PCMs)
	3:45 PM	***Lan Le*** : Automating Optofluidic Flow Metrology Calibration through Optimization	***Edgar Robitaille*** **:** CompareLR: A Comparative Analysis Tool for Evaluating Probabilistic Genotyping Software Using Likelihood Ratios	***Rachel Vartanian*** **:** Behavioral Economics of Volcanic Resilience: A Use Case Exploration for Co-DECIDR
	4:00 PM	***Luca Caruso*** : Cell Migration Assays in Microfluidic-based Systems for Studies of Cancer Aggressiveness	***Alitza Soiffer*** **:** Impact of Structural Motifs in Antimicrobial Peptides on Membrane Interaction and Antibacterial Activity	***Victor Mathias*** **:** Automated Measurement of Pressure Loss in Modern Plumbing Fittings
	4:15 PM	**BREAK**	**BREAK**	**BREAK**
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Dan Barker* **Zoom Moderator:** *Steve Eckel*	**Host Laboratory: MML** **Moderator:** *Howie Joress* **Zoom Moderator:** *Mark McLean*	**Host Laboratory: EL** **Moderator:** *Stephanie Watson* **Zoom Moderator:** *Patrick Dixon*
	4:30 PM	***Stephen Chen*** : Developing Fast Readout for High Vacuum Optomechanical Pressure Sensors	***Grace Boyer*** **:** Investigating analytical methods for detection, identification, and quantitation of drug mixtures	***Ting/Xael Shan*** **:** Building a Co-Simulation Platform Integrating Semantic Interoperability for Building Control
	4:45 PM	***Ramon Perez*** : Chemical Enhancement of MgF from a CBGB Source via Laser Excitation	***Zainab Altamimi*** **:** (virtual) QA/QC in Point-of-Care Pharmaceutical Manufacturing and Precision Medicine	***Alexander Ibacache*** **:** Early-Age Mechanical Properties of Triaxial Porcelain Aggregate Concrete
	5:00 PM	***Jeyadave Nuntha Kumar*** : Computational and Experimental Evaluation of Anemometer Blockage in a Benchtop Wind Tunnel	***Johanna Zimmerli*** **:** Optimization of Cryomilling Process for Development of Micro and Nanoplastics Test Materials	***Elizabeth Hackley*** **:** Screening for Pyrrhotite and its Reaction Products in Concrete using Raman and Near IR Spectroscopy
	5:15 PM	***Pragya Natarajan*** : SLowFLowS: Simulating Thermal Effects in Rate-of-Rise Standards Using COMSOL	***Julia Tisaranni:*** Optimizing the Development of Metal-Organic Frameworks Through Autonomous Design	***Melissa Karwoski*** **:** The Oxidation Rates of Pyrrhotite and Other Minerals When Exposed to Bleach
	5:30 PM	**END for the Day**	**END for the Day**	**END for the Day**

		Parallel Session #1	Parallel Session #2	Parallel Session #3
Parallel Sessions Wednesday, July 30, 2025	**Location**	**Gaithersburg, Bldg 101, LR-A**	**Gaithersburg, Bldg 101, LR-B**	**Gaithersburg, Bldg 101, LR-D**
	Zoom Link	https://nist.zoomgov.com/j/1613129217?pwd=VItu1fYltWbMIfGRIVP0MzqdYZaARs.1	https://nist.zoomgov.com/j/1608639498?pwd=XWArU6w7ZW9vSkOPAkQ56w18aUWKbk.1	https://nist.zoomgov.com/j/1609805719?pwd=6r3R1CvXbeIahJjUu0qNSeM6ZsNhb3.1
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Angie Hight-Walker* **Zoom Moderator:** *Theresa Ginley*	**Host Laboratory: MML** **Moderator:** *Yvonne Gerbig* **Zoom Moderator:** *Jess Staymates*	**Host Laboratory: CTL** **Moderator:** *Wesley Garey* **Zoom Moderator:** *Jian Wang*
	9:00 AM	***Grant Chapman*** **:** Laser Locking to Distinct Spectral Peaks	***Shawn Chen*** **:** (CHIPS) A Dual Approach to Digital Image Correlation (DIC): Open-Source Benchmarking and Deep Learning	***Benjamin Winig*** **:** Deep Reinforcement Learning for Configuring Multi-Hop Sidelink Relay Networks
	9:15 AM	***Thea Bielejec*** : Off-axis Holographic Imaging of Marangoni Surface Waves on a Shallow Ferrofluid Layer	***Siena Iavarone-Garza*** **:** (CHIPS) Characterizing Residual Stress in Semiconductor Packaging Films Induced by Hygrothermal Cycling	***Milosz Fecko*** **:** A Path to Zero-Trust-Enabled Deployment of O-RAN Components in Cloud-Native Environments
	9:30 AM	***Gopinath Ramakrishnan*** : Advancing Magneto-Optical Spectroscopy through Automation of Spatial, Temperature and Field Mapping	***Dante Ribeiro*** **:** (CHIPS) Development of a Low Dielectric Epoxy Test Material for Semiconductor Packaging	***Tyler Wong*** **:** IoT Smart Sensor Network for Real-Time Environment Monitoring
	9:45 AM	***Arden Dombalagian*** : Sub Microgram Mass Measurement and Analysis	***Leonardo Borchert*** **:** (CHIPS) Measuring Interfacial Bonding Strength of Photonic Devices by Indentation-Induced Blistering	
	10:00 AM	***Kira Yuen*** : Improving Commercial Viability of a Kibble Principle Torque Standard	***Annabel Shim:*** Microstructural Evolution in Direct Reduction Ironmaking	
	10:15 AM	**BREAK**	**BREAK**	**BREAK**
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Uwe Arp* **Zoom Moderator:** *Christian Pederson*	**Host Laboratory: MML** **Moderator:** *Alex Landauer* **Zoom Moderator:** *Mark McClean* **/** *Jess Staymates*	**Host Laboratory: TPO** **Moderator:** **Zoom Moderator:**
	10:30 AM	***Juandiego Astudillo*** : Numerical Simulation of Heat Transfer in Cryogenic Silicon to Inform Design of a Novel Quantum Sensor	***Avery Ye*** **:** Advancements in OCEAN: Curvilinear Real-Space Grids for Core-Level Spectroscopy	
	10:45 AM	***Tarun Jacob*** : Monte Carlo Modeling of Ionization Chambers for Brachytherapy Dosimetry	***Ritika Rajamani*** **:** WebFF Molecular Dynamics (MD) Force-Field Repository: Schema Expansion, Programming and Data Testing	
	11:00 AM	***Ravi Jain*** : Simulation of Subkelvin Transition Edge Sensors for the True Becquerel Project	***Bridget Bidwell*** **:** (CHIPS) Accelerated Discovery of Amorphous Dielectric Materials Using Machine Learning and First-Principles Simulations	***Jackson Brunner*** **:** Resolving discrepancies in federal agency data
	11:15 AM	***Christopher Kniss*** : Reducing Thermal Load: Wireless Interconnects Inside the Cryogenic Chamber	***Nishwanth Gudibandla*** : Tuning the Magnetic Properties of Two-dimensional (2D) VxTi1-xSe2 Through Alloying	***Angela Guan*** **:** Fight or Flight: Unique trends in federal research commercialization
	11:30 AM	***Jameson Lau*** : Developing Reflow Solder Packaging for Cryogenic Devices to Improve Fidelity		
	11:45 AM	**LUNCH**	**LUNCH**	**LUNCH**
Time (ET)	**Host Info**	**Host Laboratory: PML** **Moderator:** *Christina Hacker* **Zoom Moderator:** *Eric Switzer*	**Host Laboratory: MML** **Moderator:** *Erin Adkins* **Zoom Moderator:** *Jackie Mann*	**Host Laboratory: EL** **Moderator:** *Jason Averil* **Zoom Moderator:** *Anthony Downs*
	12:45 PM	***Jack Stawasz*** : Measuring the Kerr Effect in Silicon via Ultrafast Spectroscopy	***John Kline*** : Anchoring O_2 A-band Spectra Using an Optical Frequency Comb	***Ben Johnsson*** **:** Time-resolved Viscoelastic Properties of Hydrating Cement Pastes
	1:00 PM	***Ariam Yohannes*** : Predicting Atomic-Scale Device Properties using IBM Heron v2 Digital Quantum Simulators	***Christopher Gutowski*** : (CHIPS) Probing Molecular Diffusion Into BARC Layers in Advanced Photoresists	***Gabriel Johnson*** **:** Corrosion Mechanisms at the Steel-Concrete Interface: Insights from Pore Solution Chemistry Electrochemical Characterization
	1:15 PM	***Nathan Gehl:*** Improving Nanoscale Electrical Devices for Use in Quantum Sensing Regimes	***Tyra E. Espedal*** **:** Measuring Fluorescence Phenomena in Time-Gated Raman Spectroscopy	***Hagan Yeoh:*** **(CHIPS)** Enhancement in PDR by Adding Usage Metrics Summary and Exploring
	1:30 PM	***Marios Kalpakis*** : Associative Memories in Temporal Networks	***Samuel Bentz*** **:** In-Situ Monitoring of Ceramic Vat Photopolymerizaton 3D Printing	***Raeid Raunak*** **:** Changes in PFAS Levels over Time in Unused Firefighter Gear
	1:45 PM		***Dylan Roberts:*** (CHIPS) An Analysis of the Thermal Stability of Magnetic Nanostructures	***Ambika Anand*** **:** Characterizing PFAS Exposure in the Firefighter Workplace
	2:00 PM	**BREAK**	**BREAK**	**BREAK**
Time (ET)	**Host Info**	**Host Laboratory: ITL** **Moderator:** *Simon Su* **Zoom Moderator:** *Yolanda Bursie*	**Host Laboratory: MML** **Moderator:** *Trey Diulus* **Zoom Moderator:** *Dan Siderius*	**Host Laboratory: EL** **Moderator:** *Joannie Chin* **Zoom Moderator:** *Anthony Downs*
	2:15 PM	***Brittney Meza*** **:** Digital Identity Guidelines and OSCAL: Advancing Machine Readable Techniques for Assessing Compliance with NIST SP 800-63	***Lina Stensland*** **:** (CHIPS) Exploring chemistry & thickness of tin photoresists for extreme ultra-violet photolithography	***Huda Kemal*** : Per- and Polyfluoroalky Substances (PFAS) Concentrations in Upholstery Textiles at Elevated Temperatures
	2:30 PM	***Fenrir Badorf*** **:** Exploring Combinatorial Methods for Dimensionality Reduction in ML	***Aditya Chezhiyan*** **:** Modeling Ion Distributions in Block Copolymers Using Resonant Soft X-ray Scattering	***Sebastian Seda*** : The Hazards of E-Scooter Fires & Their Implications for Public Safety
	2:45 PM	***Abigail Hanson*** **:** Synthetic Overlays on Real-World Road Data for Testing the Robustness of AI Perception	***Katia Graciela Gonzalez-Adame*** **:** Understanding Density Functional Theory for Copper Electrodeposition Analysis	***Christopher Sixbey*** : The Optimization and Construction of the Controlled Atmosphere Pyrolysis Apparatus (CAPA II)
	3:00 PM	***Rajeev Raghuram*** **:** Building a Computer Vision-Based Video Browser for the Text Retrieval Conference (TREC)	***Aryn Loew*** **:** (CHIPS) Step by Step: Investigating the Electrodeposition of Copper	***Philip Huang*** : Development of Material Flammability Database: Integrating Legacy Cone Calorimeter Data Into Backend-External Data Flow
	3:15 PM	***Rowan Wiles*** **:** Exploration Into Immersive 3D Data Visualization	***Harkeerith Vij*** **: (CHIPS)** Developing Standard Reference Materials for Use in CHIPs Through X-Ray Florescence	***McCarthy Devine*** : Design, Implementation, and Validation of Test Methods for Emergency Response Robots and UAVs
	3:30 PM	**BREAK**	**BREAK**	**BREAK**

Time (ET)	Host Info	Host Laboratory: ITL	Host Laboratory: MML	Host Laboratory: EL
		Moderator: *Derek Juba*	**Moderator:** *Julie Rieland*	**Moderator:** *Andre Thompson*
		Zoom Moderator: *Yolanda Bursie*	**Zoom Moderator:** *Dan Siderius*	**Zoom Moderator:** *Amy Mensch*
	3:45 PM	***Millie Vyas* :** Readme_AI Tool: Building Context for LLMs	***Eliana Crew* :** Development of SAFT-based Coarse-grained Models of Noble Gases and Other Small Molecules for Vapor-liquid Equilibria Simulations	***Jia Xi Lin :*** Accuracy Evaluation of Human Motion Tracking Systems
	4:00 PM	***Daksh Gautam* :** Extraction of Technical Insights from Scientific Papers using Large Language Models	***Naman Parikh:*** Evaluating the Performance of VQE for Quantum-DFT Embedding on Chemical Databases	***Charles Bradshaw*** : Mobile Manipulator Performance under Dynamic End Effector Payloads
	4:15 PM	***Arjun Parikh* :** Quantifying Uncertainty of Texture Directionality Prediction by Neural Networks	***Preston Yeung* :** Computational Fluid Dynamics (CFD) Analysis of L-PBF Additive Manufacturing	***Michael Donnelly*** : Training Data Generation for Robots Reinforcement Learning
	4:30 PM	***Rugved Zarkar* :** Line Width Measurements of Integrated Circuits Using Time-efficient Acquisition of Scanning Electron Microscopy Images and Artificial Intelligence	***Trisha Lad* :** Sample Form Effects in Near-IR Analysis of Post-Consumer Polyolefins for Machine Learning	***Arnav Juneja*** : Twin Robot Demonstration on Vive Headset
	4:45 PM	***Diana Petrenko* :** Linking Broken Trajectories for Gene Therapy Particle Tracking		***Joseph Sanchez*** : Development of a Verification, Validation, and Uncertainty Quantification Method for Digital Twins of CNC Machines
	5:00 PM	**END for the Day**	**END for the Day**	**END for the Day**

Parallel Sessions Thursday, July 31, 2025		Parallel Session #1	Parallel Session #2	Parallel Session #3	Parallel Session #4
	Location	**Gaithersburg, Bldg 101, LR-A**	**Gaithersburg, Bldg 101, LR-B**	**Gaithersburg, Bldg 101, LR-D**	**Boulder: Bldg 81, Rm 1A116**
	Zoom Link	https://nist.zoomgov.com/j/1613129217?pwd=VItu1fYltWbMIfGRIVP0MzqdYZaARs.1	https://nist.zoomgov.com/j/1608639498?pwd=XWArU6w7ZW9vSkOPAkQ56w18aUWKbk.1	https://nist.zoomgov.com/j/1609805719?pwd=6r3R1CvXbeIahJjUu0qNSeM6ZsNhb3.1	https://nist.zoomgov.com/j/1617027153?pwd=zOdVa9QQu2LI0MWGvtxieN4IfagLBg.1
Time (ET)	Host Info	**Host Laboratory: ITL** **Moderator:** **Zoom Moderator:** *Yolanda Bursie*	**Host Laboratory: NCNR** **Moderator:** *Dr. Charles Ying and Dr. Debasis Majumbar, NSF* **Zoom Moderator:**	**Host Laboratory: EL** **Moderator:** *Kathleen Hoffman* **Zoom Moderator:** *Savannah Wessies*	
	9:00 AM	***Marianne Nguyen* :** Calibration and Validation of X-Ray CT Simulation for Advanced Packaging	***Clara Do* :** Effects of Mixing, Aging and pH on Lipid Nanoparticle RGTM	***Madyann Saidi:*** Evaluating Tactile Sensors for Human-Robot Safety Compliance Using Biomechanical Simulation	
	9:15 AM	***Yuna Chun:*** Towards High Fidelity Localization for Latched Readouts in Quantum Dot hybrid Qubit Systems	***Abigail Lapadula* :** Rheology and Nanostructure of Hydroxypropyl Methylcellulose at High-Shear Rates	***Alex Tamagno* :** Application of IEEE Standard for Robot Task Representation in ARIAC	
	9:30 AM	***Olivia Cong* :** Quantum Process and State Tomography Modeling in Cesium Vapor Cell Quantum Memory	***Eric Welp:*** Piezostrain behavior and Magnetoelectric Coupling in Co/PMN-PT structures	**END of Parallel Session #3** **Join Parallel Session #4 at 10:40 amET**	
	9:45 AM	***Angela Shen* :** Polarization Reference Frame Alignment Using the Inverse-matrix Method	***Henry Pires-Tolson* :** Magnetic Properties of Chemically-tuned Nickel Compounds		
	10:00 AM	***Jack Deye:*** Higher-Order Numerical Methods for Integro-differential Equations in Biological Field Effect Transistors	***Taian Chen* :** Remote Camera for Reactor Latch Inspection, and Other Reactor Engineering Projects		
	10:15 AM	**END of Parallel Session #1** **Join Parallel Session #4 at 10:40 am ET**	**END of Parallel Session #2** **Join Parallel Session #4 at 10:40 am ET**	**BREAK**	**BREAK**
Time (ET)				Host Info	**Host Laboratory: SURF Boulder** **Moderator:** ***Genevieve Holliday*** **Zoom Moderator:** ***Henry Axon***
	10:40 AM		Time (MT)	8:40 AM	**Boulder Colloquium Wecome Remarks:** *Susan Schima*
	10:45 AM			8:45 AM	***Suvan Ravi* (CTL)**: Squeezed Microwave States from a Kinetic Inductance Traveling Wave Parametric Amplifier (TWPA)
	11:00 AM			9:00 AM	***Dennis Chunikhin* (PML)**: Measuring Microwave Qubits with Millimeter Wave Photons
	11:15 AM			9:15 AM	***Ariana Taylor* (PML)**: Improving Accuracy of Capacitance Participation Simulations for Superconducting Quantum Devices
	11:30 AM			9:30 AM	***Kyla Letko* (PML)**: Laser Intensity Stabilization for Interrogation of a Trapped 88Sr+ Ion
	11:45 AM			9:45 AM	***Gavin Lopez* (PML)**: Low-Noise PCB Development of a Coherent Microwave Synthesizer for the NIST Cesium Fountains
					BREAK
Time (ET)				Host Info	**Host Laboratory: SURF Boulder** **Moderator:** ***Adaku Ihekwoaba*** **Zoom Moderator:** ***Deborah Hodson***
	12:15 PM		Time (MT)	10:15 AM	***Matthew Younce* (ITL)**: Exploring Likelihood Ratio Systems for Forensic Automatic Speaker Recognition
	12:30 PM			10:30 AM	***Christopher Hartman* (MML)**: Analysis of the Efficacy of Machine Learning for Chemical Property Prediction
	12:45 PM			10:45 AM	***Ben Mesko* (PML)**: Clock Statistics and Algorithms for Time Scale Ensembles
	1:00 PM			11:00 AM	***Henry Axon* (PML)**: RF Birdcage Coil Development for NMR/MRI Quantitative Measurements
	1:15 PM			11:15 AM	***Ash Hegde* (PML)**: Arduino Platform Increases Sensitivity of Smart Hydrogel pH Measurements
	1:30 PM			11:30 AM	**LUNCH BREAK**
Time (ET)				Host Info	**Host Laboratory: SURF Boulder** **Moderator:** ***Harshit Agarwal*** **Zoom Moderator:** ***Kyla Letko***
	2:30 PM		Time (MT)	12:30 PM	***Ian Soukup* (ITL)**: (CHIPS) Witnessing Discrepancy in Imaging
	2:45 PM			12:45 PM	***Genevieve Holliday* (PML)**: (CHIPS) Development of Quantitative Analysis Standards for FIB-SIMS
	3:00 PM			1:00 PM	***Deborah Hodson* (CTL)**: (CHIPS) Measuring Sound Speed Dispersion Relations in Piezoelectric Materials
	3:15 PM			1:15 PM	***Andrew Fox* (CTL)**: (CHIPS) An Improved Correlation Instrument for Measurements of Noise in Amplifiers and Transistors
	3:30 PM			1:30 PM	***Adaku Ihekwoaba* (CTL)**: Methods for Disseminating Public Safety Communications Research Updates to Key Stakeholders
	3:45 PM			1:45 PM	**Boulder Colloquium Closing Remarks:** *Susan Schima*

END of 2025 SURF Colloquium

THANK YOU! CONGRATULATIONS!

Boulder, CO
2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

NIST Boulder Labs

Communications Technology Laboratory (CTL)

Information Technology Laboratory (ITL)

Material Measurement Laboratory (MML)

Physical Measurement Laboratory (PML)

Student Names and Talk Titles (in order of presentation)

Harshit Agarwal - PML *(plenary speaker):* Tracing the Cosmic Microwave Background: Polarization Detection with Superconducting Kinetic Inductance Detectors

Kaleb Jewell - MML *(plenary speaker):* (CHIPS) Democratizing Gallium Nitride Wafer Metrology

Suvan Ravi (CTL): Squeezed Microwave States from a Kinetic Inductance Traveling Wave Parametric Amplifier (TWPA)

Dennis Chunikhin (PML): Measuring Microwave Qubits with Millimeter Wave Photons

Ariana Taylor (PML): Improving Accuracy of Capacitance Participation Simulations for Superconducting Quantum Devices

Kyla Letko (PML): Laser Intensity Stabilization for Interrogation of a Trapped 88Sr+ Ion

Gavin Lopez (PML): Low-Noise PCB Development of a Coherent Microwave Synthesizer for the NIST Cesium Fountains

Matthew Younce (ITL): Exploring Likelihood Ratio Systems for Forensic Automatic Speaker Recognition

Christopher Hartman (MML): Analysis of the Efficacy of Machine Learning for Chemical Property Prediction

Ben Mesko (PML): Clock Statistics and Algorithms for Time Scale Ensembles

Henry Axon (PML): RF Birdcage Coil Development for NMR/MRI Quantitative Measurements

Ash Hegde (PML): Arduino Platform Increases Sensitivity of Smart Hydrogel pH Measurements

Ian Soukup (ITL): (CHIPS) Witnessing Discrepancy in Imaging Modalities

Genevieve Holliday (PML): (CHIPS) Development of Quantitative Analysis Standards for FIB-SIMS

Deborah Hodson (CTL): (CHIPS) Measuring Sound Speed Dispersion Relations in Piezoelectric Materials

Andrew Fox (CTL): (CHIPS) An Improved Correlation Instrument for Measurements of Noise in Amplifiers and Transistors

Adaku Ihekwoaba (CTL): Methods for Disseminating Public Safety Communications Research Updates to Key Stakeholders

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Harshit Agarwal

Academic Institution: Missouri University of Science and Technology **Major:** Physics

Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	R&D/Entrepreneurship in Quantum Science and Tech.
NIST Laboratory, Division, and Group:	PML, Quantum Sensors Division, Long Wavelength Sensors and Applications Group
NIST Research Advisor:	Anna Vaskuri, Jason Austermann
Title of Talk:	Tracing the Cosmic Microwave Background: Polarization Detection with Superconducting Kinetic Inductance Detectors

Abstract:

Superconducting microwave kinetic inductance detectors (MKIDs) are a powerful superconducting sensor technology for astronomical imaging and spectroscopy, as well as in applications for cosmology and calorimetry. MKIDs are operated in high vacuum and near absolute zero temperature and can be made polarization sensitive. Careful understanding and characterization of the polarization qualities of the sensor is critical to many of the end-use science goals. In this project a new cryogenic measurement system was developed to replace an existing system where light was coupled from room-temperature in the cryostat for measuring detector polarization response. Fully cryogenic measurements permit lower optical loading to MKIDs which together with the reduced number of optical components will lead to greater sensitivity, lower noise, and higher overall measurement accuracy.

Custom-made mechanical parts of the polarization measurement system were designed using a 3D CAD software. These parts include the cryogenic motor mount on the 4 K stage, connecting the polarized radiation source to the motor shaft via a long rod, and the connector flanges for the motor wiring through the various temperature stages of the cryostat. The cryogenic source consists of a thin-film blackbody which is filtered by a polarizer. After the polarizer a set of low-pass filters and feedhorn waveguide limit the spectral range of radiation incident on the MKID. A 3D thermal model was developed to predict the electrical power needed to heat up the thin-film source. The polarization response of the MKID detector will be measured by rotating the polarized source by a cryogenic stepper motor. Specifically, the detector signal is measured at different polarization angles so that we obtain the cross-polarization component, which is found at the angle where the detector signal reaches its minimum. An automated control software using python was developed for the described measurement sequence. The performance of this polarization response measurement system and an example polarization response of an MKID will be presented. All the measurements are compared against the simulated predictions.

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name:	Kaleb Jewell		
Academic Institution:	Texas Tech University	**Major:**	Chemical Engineering
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Attend Grad School to obtain a Ph.D. in Chemical Engineering or Material Science and Engineering		
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Applied Chemicals and Materials, Nanoscale Reliability Group		
NIST Research Advisor:	Dr. Thomas Kolibaba		
Title of Talk:	Democratizing Gallium Nitride Wafer Metrology		

Abstract:

Gallium Nitride (GaN) is an emerging wide-bandgap semiconductor (Eg ≈ 3.2 eV vs. Si's ≈ 1.2 eV) whose superior thermal stability, high breakdown strength, and power-handling capabilities offer significant advantages over conventional silicon devices. However, realizing GaN's full potential requires rigorous surface characterization and efficient metrology workflows to ensure consistent device performance. In this work, we employ Atomic Force Microscopy (AFM) to generate high-resolution topography maps of GaN wafers and extract three complementary roughness descriptors: average roughness (Ra), root-mean-square roughness (Rq), and spatial-frequency content via power spectral density (PSD). We demonstrate how each metric captures distinct aspects of surface morphology: Ra quantifies the overall "mean bumpiness," Rq emphasizes extreme peaks and valleys that can exacerbate local electric-field enhancements and leakage currents, and PSD analysis decomposes roughness across spatial scales to distinguish long-wavelength wafer bow from short-wavelength scattering centers. In addition we compare a five-point bow test method for quantifying wafer bow that streamlines results compared to traditional tests from Optical Profilometers. Future work will focus on correlating these quantitative surface descriptors with key device-performance parameters such as carrier scattering rates, dielectric breakdown voltages, and interface-trap densities to establish predictive models for GaN device reliability. Together, these elements form a scalable GaN surface-quantification framework that could be used for standardizing GaN wafer characterization and accelerating its adoption in next-generation semiconductor manufacturing.

SURF Student Colloquium

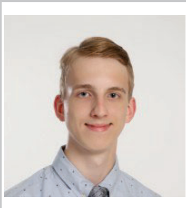
NIST – Boulder, CO

July 29 - 31, 2025

Name:	Suvan Ravi		
Academic Institution:	University of California Berkeley	**Major:**	Electrical Engineering & Computer Sci.
Academic Standing (Sept. 2025):	4th Year Undergraduate		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	CTL, RF Technology Division, High Speed Waveform Metrology Group		
NIST Research Advisor:	Jacob Davidson		
Title of Talk:	Squeezed Microwave States from a Kinetic Inductance Traveling Wave Parametric Amplifier (TWPA)		

Abstract:

Transduction between microwave and optical frequency domains is required to realize networking between distant superconducting quantum processors. To achieve this, our transducer device couples microwave and optical domains via a mechanical mode which requires microwave and optical pump tones. For the microwave pump, a TWPA can produce one-mode squeezed photons reducing noise in one quadrature to lower transducer added noise. A TWPA also provides two-mode squeezing by reducing variation through correlations between two modes providing a microwave entanglement source for future quantum networking experiments. To create a two-mode squeezed state, we send pump and seed tones to produce signal and idler modes through the TWPA's non-linear three-wave mixing process. We measure the squeezing between these modes using a balanced heterodyne detection system. In this presentation, we start by verifying the classical phase insensitive amplification properties of the TWPA. We then show characterization of the two-mode squeezed state through various measurements and automated sweeps of pump frequency, power, and phase. We then discuss future experiments and considerations for using TWPAs in enabling quantum networking.



SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Dennis Chunikhin

Academic Institution: University of Maryland, College Park | **Major:** Physics, Mathematics

Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate school/Ph.D. in Physics
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Applied Physics Division, Advanced Microwave Photonics Group
NIST Research Advisor:	Akash V. Dixit, John D. Teufel
Title of Talk:	Measuring microwave qubits with millimeter wave photons

Abstract:

Superconducting qubits present a promising platform for quantum information. Practical use of superconducting qubits including the implementation of quantum error correction codes and dynamic circuits requires accurate state measurement without perturbing the qubit As qubit measurements are performed by encoding the qubit state on a microwave carrier, a stronger readout tone improves the accuracy of the measurement. However, this simultaneously increases unwanted, measurement-induced transitions of the qubit. Recent work has shown that the dominant mechanisms causing measurement-induced transitions of superconducting qubits can be reduced by increasing the separation of the qubit and readout tone frequencies. In order to probe measurement-induced transitions in the highly detuned regime, we operate a microwave qubit in a cryostat cooled to 11mK and measure the qubit using a millimeter wave rather than a conventional microwave carrier. We set up infrastructure for full vector control and measurement at millimeter wave frequencies. The qubit measurements are performed by a readout tone calibrated to distinguish the qubit's ground and first 3 excited states with post-selection for 95% confidence in state assignment. We characterize the rate of measurement-induced transitions by measuring qubit state transitions in response to a strong millimeter wave readout drive.

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name:	Ariana Taylor		
Academic Institution:	University of Texas at San Antonio	**Major:**	Physics
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Quantum Sensors Division, Quantum Electronics Group		
NIST Research Advisor:	Dr. Corey Rae McRae		
Title of Talk:	Improving Accuracy of Capacitance Participation Simulations for Superconducting Quantum Devices		

Abstract:

Dielectric loss is a significant source of decoherence in superconducting qubits, which limits the performance and scalability of quantum computing systems. To study this loss, we focus on coplanar waveguide (CPW) resonators, as they serve as an effective proxy for superconducting qubits. We explore the mechanisms of dielectric participation and loss that impact qubit performance. Accurate simulations of these devices are a necessity for guiding improvements in both qubit design and in selecting materials.

This project focuses on improving both the reliability and accuracy of capacitance participation simulations in CPW resonators. We utilize a 2D boundary element method (BEM) capacitance solver to simulate electric field distributions and extract participation ratios in multi-dielectric layered CPW structures. Special attention is given to modeling variations in geometry, such as trench depths, gap widths, and dielectric regions, to better reflect realistic and complex fabrication features. By generating parameter sweeps and other visualizations, we can easily analyze how these design changes influence electric field localization and dielectric participation. To validate our simulations, we also compared the BEM results with those obtained from high-frequency finite element simulations.

This work supports the broader goal of developing standardized and highly accurate modeling tools that enable the predictive design of superconducting qubits and resonators. Ultimately, this contributes to the advancement of scalable qubit designs and quantum devices by understanding where loss is happening and improving qubit coherence.

SURF Student Colloquium

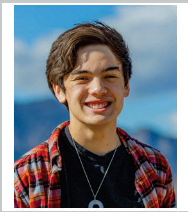
NIST – Boulder, CO
July 29 - 31, 2025

Name:	Kyla Letko
Academic Institution:	University of California, Los Angeles
Major:	Physics
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	PhD in physics
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Time and Frequency Division, Time Realization and Distribution Group
NIST Research Advisor:	Jeff Sherman
Title of Talk:	Laser Intensity Stabilization for Interrogation of a Trapped 88Sr+ Ion

Abstract:

The UTC(NIST) timescale relies on an ensemble of over twenty atomic clocks, most of which are cesium beam clocks and hydrogen masers. However, frequency drifts and random walk noise present in both types of clocks must be corrected for both algorithmically and manually. Optical atomic clocks can be highly precise, and the implementation of an optical frequency reference for the UTC(NIST) timescale will help to correct drifts, improving the reliability and stability of the timescale.

A single trapped strontium ion is a leading candidate for this frequency reference due to its accuracy and relative simplicity. After cooling the ion, two laser beams with a wavelength of 674 nanometers are used: a higher intensity beam for state preparation, and a lower intensity beam for interrogation of the clock transition. The interrogating beam must be quickly turned on and intensity stabilized, and must be able to scan across the ultranarrow linewidth of the transition. Both intensity and frequency can be controlled using an acoustic optical modulator (AOM). Following implementation of a double pass AOM system in the laser beam path, we report the intensity stabilization of the probe laser pulses and observe the interrogation of the trapped strontium ion at the clock transition.



SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Gavin Lopez

Academic Institution: University of Colorado Boulder | **Major:** Mechanical Engineering, Chemistry

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Grad School for Mechanical Engineering at CU

NIST Laboratory, Division, and Group: Physical Measurement Laboratory | Time and Frequency Division | Time Realization and Distribution

NIST Research Advisor: Jeffrey Sherman

Title of Talk: Low-Noise PCB Development of a Coherent Microwave Synthesizer for the NIST Cesium Fountains

Abstract:

During interrogation of Cesium atoms in an atomic fountain clock, the atoms are exposed to microwaves at exactly 9.19263177 GHz twice—once on the way up and once on the way down. These microwaves are on resonance with a specific transition of the atoms, the frequency of which is used to define the second. In between these two interactions, however, the atoms have to travel and evolve unperturbed. The microwaves also must be phase and frequency coherent, meaning that, to the atoms, the waves must appear to have run continuously during their time of flight. This means that we must shield the atoms from any external influences that might interfere with their state, while also keeping the microwaves "running" without stopping.

The aim of this project was to develop a microwave synthesizer that could be detuned while remaining phase coherent. This would allow us to probe the atoms on the way up at the correct frequency, then shift the microwaves to a non-resonant frequency, protecting the atoms from any interference during their flight. Then, as the atoms returned to the microwaves, the frequency could be tuned back to the correct resonant frequency while maintaining the correct phase, making it appear to the atoms as if they had been running continuously without interruption.

To optimize the design of the synthesizer, we turned to printed circuit board (PCB) design to try and eliminate as much noise as possible. Using a commercially-available microcontroller and direct digital synthesis (DDS) chip, we designed a PCB to generate, isolate, and protect the microwave signal from any unwanted electrical and thermal effects.

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Matthew Younce

Academic Institution: University of Colorado Boulder | **Major:** Applied Mathematics

Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Return to get my masters degree at CU in applied mathematics.
NIST Laboratory, Division, and Group:	Information Technology Laboratory, Statistical Engineering Division, Applied and Computational Statistics Group
NIST Research Advisor:	Jack Prothero
Title of Talk:	Exploring Likelihood Ratio Systems for Forensic Automatic Speaker Recognition

Abstract:

The forensic science community has recently pushed to incorporate more statistical methods to analyze and interpret evidence. One such area of forensic science attempting to adopt statistical approaches is speaker recognition. Statistical methods for automatic speaker recognition rely on likelihood-based inference to draw conclusions about evidence strength. This category of inference includes several approaches, and the choice of approach greatly impacts the performance and interpretability of the speaker recognition system.

The objective of this project was to explore the variability in performance and interpretability of a speaker recognition system across different valid modeling approaches. The different choices explored in this work involved a range of possible models grounded in two distinct statistical philosophies: frequentist and Bayesian. Evaluation was carried out by training and testing the models on a benchmark speaker recognition dataset.

The exploration of these different methods indicates that a speaker recognition system based off the benchmark dataset is fairly robust to model choice in the regions where the data is consistent, and more variability is introduced where the data is sparser. The results of these experiments have the potential to inform professional standards development for forensic speaker recognition.

SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

Name:	Christopher Hartman		
Academic Institution:	Juniata College	**Major:**	Biochemistry
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Applied Chemicals and Materials Division, Thermodynamics Research Center.		
NIST Research Advisor:	Vladimir Diky, Ala Bazyleva		
Title of Talk:	Analysis of the efficacy of machine learning for chemical property prediction.		

Abstract:

Machine learning is a topic that is in no need of an introduction. This study focuses on the specific application of graph neural networks on the regression of properties of simple organic compounds. Two existing programs were examined in this study. The first of which calculated the viscosity of a binary mixture, for a given temperature and composition. The second was a more versatile model, that could be used to predict any number of properties for a single organic compound. The viscosity model was found to have reasonably accurate predictions when using the pretrained models, however when attempts were made to train new models on more extensive data, the program yielded significantly worse results. The structure of the model was studied, and updates were made to the source code, fixing issues with out-of-date dependencies. The second program overall yielded better results when trained with novel data, however even it fell short, due to limitations with the dataset used for training. During the improvement of program used for the prediction of viscosity of binary mixtures, it was determined that a superior approach to the stated problem existed. In the original program there existed an issue where varying the order of molecular inputs varied the model's output. In addition, disconnected graphs such as salts could not be used as inputs. Through the usage of the library Pytorch Geometric, it was hypothesized that the batching function could be utilized to solve both issues. Additionally, it was believed, that usage of this library could expand the capabilities of this model, beyond the prediction of binary mixtures, potentially to ternary and quaternary mixtures, though the addition of this feature presents difficult questions as to how this data will be structured. It was determined that implementation of these changes, the program would need to be rebuilt from the ground up. Due to limitations on time, many of the frontend features would need to be cut back in favor of simplicity. As of writing, development is ongoing. Resultingly, the success of this alteration is yet to be determined.

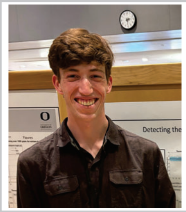
SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

Name:	Ben Mesko
Academic Institution:	Whitman College — **Major:** Physics, Mathematics
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate School
NIST Laboratory, Division, and Group:	PML/Time and Frequency/Time scale Group
NIST Research Advisor:	Biju Patla and Judah Levine
Title of Talk:	Clock Statistics and Algorithms for time scale ensembles

Abstract:

Accurate noise analysis and combining the data from multiple clocks into an ensemble are essential to the work of NIST's Time and Frequency Division, which is responsible for maintaining and disseminating precise time. During my internship, I developed and tested methods for modeling and combining clock data to analyze the reliability of time estimates. I began by implementing a least-squares model to estimate phase offset, frequency offset, and frequency drift of measurements of the difference between two clocks. While effective for some datasets, this approach revealed several challenges; the residuals often deviated from a white Gaussian noise distribution; clocks occasionally failed or malfunctioned, introducing outliers; and individual clocks lacked the reliability needed for robust timekeeping. To address these issues, I used the Allan deviation to characterizethe types of noise present and to better interpret fitting results. I implemented techniques to remove data jumps and outliers exceeding four standard deviations from the expected value, and conditionally above three. I then began to build a Kalman filter to estimate the fitting parameters as a function of time. The filter algorithm is designed to estimate the optimum weight for each clock based on its statistical stability and to construct an ensemble basedon these estimates. The statistical properties of the average time and frequency computed by the ensemble software would be evaluated by comparing the results with the same parameters computed by the AT1 algorithm, which is currently used to compute UTC(NIST). The Kalman algorithm should have better stability than AT1 because it is not run in real time and therefore is better able to identify and remove outliers and other problems with the data.



SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name:	Henry Axon
Academic Institution:	University of Oregon — **Major:** Physics
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Applied Physics Division, Magnetic Imaging Group
NIST Research Advisor:	Karl Stupic
Title of Talk:	RF Birdcage Coil Development for NMR/MRI Quantitative Measurements

Abstract:

The National Institute of Standards and Technology (NIST) provides calibrated measurements to support quantitative MRI imaging protocols. To meet the needs of these protocols, there is an increasing demand for NMR probes capable of operating across a wide range of magnetic field strengths, from 0.064 T to 7 T. Currently, the Magnetic Imaging Group lacks a sufficient number of NMR probes compatible with this full range, particularly as the current sample preparation procedure is being altered, and a new cryogen free magnet is being set up.

This project aims to address that gap by designing and testing new RF birdcage coils for NMR/MRI applications. Using COMSOL simulations, we evaluated various 3 T birdcage coil designs to optimize RF homogeneity and sensitivity. We then fabricated a prototype and benchmarked its performance against a commercial Litzcage coil. Upon successful validation at 3 T, we plan to scale the design approach to cover additional field strengths, enabling in-house development of cost-effective, high-performance probes for measurement services

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Ash Hegde

Academic Institution: Carnegie Mellon University

Major: Chemical and Biomedical Engineering

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Ph.D. in Chemical or Biomedical Engineering

NIST Laboratory, Division, and Group: PML, Applied Physics Division, Magnetic Imaging Group

NIST Research Advisor: Mark Ferris and Gary Zabow

Title of Talk: Arduino Platform Increases Sensitivity of Smart Hydrogel pH Measurements

Abstract:

Currently, many high-sensitivity measurement tools found in laboratories are expensive and inaccessible for daily personal use. A growing demand for at home analysis, such as blood glucose tests for diabetics or water safety tests for campers, has led to rapid developments in portable devices that maintain the high sensitivity of laboratory equipment. Recently, smartphones have become an attractive sensing platform, as they are ubiquitous, and the variety of built-in sensors allow for a multitude of measurements. Magnetics-based smartphone sensing uses the built-in compass/magnetometer and provides quantitative measurements in the form of magnetic field readings, as opposed to relatively qualitative data from optical-based sensing. A prototype of a magnetic smartphone sensor has been built by using magnetic hydrogel composites. These hydrogels, engineered to respond to various analytes, curl upward in response to the presence of a particular analyte. Magnetic particles attached to the hydrogel are displaced, resulting in a change in the magnetic field strength, reported by the magnetometer. However, as magnetic field has an inverse squared dependence on distance, much of the magnetic sensitivity is lost due to the magnetometer being buried approximately 5mm below the phone surface.

To remedy this issue, the smartphone is replaced with an Arduino chip magnetometer, allowing for the magnetic hydrogel to be placed much closer to the magnetometer, resulting in increased sensitivity. Measurements taken on both setups indicate that the Arduino produces a response almost 40x greater compared to the smartphone for the same chemical stimulus. While the smartphone achieved detection down to single-digit micromolar glucose concentration, the increased sensitivity of the Arduino is expected to be able to detect up to nanomolar sensitivities, suggesting that the Arduino can be an affordable and accessible alternative to laboratory testing.

SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

Name: Ian Soukup	
Academic Institution: University of Colorado Boulder	**Major:** Applied Mathematics and Computer Science
Academic Standing (Sept. 2025): Undergraduate Degree Senior	
Future Plans (School/Career): Pursue graduate studies in applied mathematics.	
NIST Laboratory, Division, and Group: Information Technology Laboratory, Applied and Computational Mathematics Division, Mathematical Modeling Group	
NIST Research Advisor: Zachary Grey	
Title of Talk: Witnessing Discrepancy in Imaging Modalities	

Abstract:

Inspection of integrated circuits (advanced packaging) to identify defects and adversarial objects relies on a subjective examination of complicated images generated by X-ray computed tomography (xCT). This method is both time-intensive and human-dependent. We explore a method of visualizing and automatically quantifying discrepancies in random distributions of shapes informed by boundary segmentations of microchip xCT imaging. Through the use of Maximum Mean Discrepancy (MMD), a kernel-based metric for comparing features of random variable distributions, we can analyze segmented images in a Separable Shape Tensor (SST) framework to test if a "trusted" image and a "discovered" image contain shapes from the same or different distributions of generalized scale and undulation. Then, so-called "witness functions" can be used to visualize subsets of shapes that correspond to significant discrepancies.

In this presentation, I give an overview of theoretical and numerical methods that facilitate objective interpretations and explanations to automate decision-making for advanced packaging manufacturers. In addition, we explore the advantages, disadvantages, and potential technological innovations enabled by our workflow. We summarize preliminary results and theoretical interpretations to emphasize the discovery of discrepancies with witness functions and future directions for refining segmentation techniques to improve detection of defective or adversarial objects in images.

SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

Name:	Genevieve Holliday
Academic Institution:	University of North Carolina at Chapel Hill — **Major:** Chemistry
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Materials science (most likely a PhD)
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Applied Physics Division, Quantitative Nanostructure Characterization Group
NIST Research Advisor:	Dr. Allison Mis and Dr. Alexana Roshko
Title of Talk:	Development of Quantitative Analysis Standards for FIB-SIMS

Abstract:

The FIB-SIMS (Focused Ion Beam - Secondary Ion Mass Spectrometer) addition to a scanning electron microscope is a promising technique for high spatial-resolution 3-D characterization of isotopes in semiconductor chips. However, the dependence of sputter rate and ionization probability on sample composition means that SIMS isotopic counts do not correspond directly to isotopic concentration in the sample; standards from standalone SIMS cannot be crossapplied because of differences between the sputtering and vacuum regimes of the two techniques. Useful quantitative information, such as dopant concentration, is therefore currently unachievable using a FIB-SIMS setup.

This project aims to utilize FIB-SIMS for the characterization of aluminum gallium nitride (AlGaN), a broad band gap semiconductor. Before material characterization, however, appropriate operation parameters must first be determined for the FIB-SIMS, such as the upper limit of ion dose before the SIMS detector reaches saturation. Then a variety of doses (FIB ions per sample area) and chamber pressures are analyzed for different ratios of Al:Ga in the AlGaN alloy. The detected isotopic counts for different parameters are used to determine the effect of chamber pressure and effective dose on the Al:Ga mass ratio compared to its true value.

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name:	Deborah Hodson
Academic Institution:	Ohio State University
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	First Year PhD Student
Future Plans (School/Career):	PhD in Mechanical Engineering at University of Colorado, Boulder
NIST Laboratory, Division, and Group:	CTL 672-3
NIST Research Advisor:	Robert Lirette
Title of Talk:	Measuring Sound Speed Dispersion Relations in Piezoelectric Materials

Abstract:

Ultrasonic pulse techniques can measure the mechanical properties of fluid or solid materials. Of particular interest to industry are the mechanical compliances of a material which are determined from a measurement of the frequency-dependent speed of sound. This frequency dependence is called dispersion. The primary focus of my project was writing a computer program to analyze ultrasonic pulse data to determine the dispersion in the phase speed of sound in various fluids. In a separate set of experiments, I also measured the speed of sound in solids using a pulse-echo method. For this method, I placed an ultrasonic transducer in contact with the sample and recorded the pulse as it travelled multiple times from the transducer to the back side of the sample and then back to the transducer. Using this method, I measured the speed of sound in both piezoelectric and non-piezoelectric materials. Lastly, in another project I worked on, we began the design of a laser interferometer to measure the small displacements of piezoelectric devices. By knowing these displacements and the electric fields we applied to the devices, we can obtain the piezoelectric constant for the material. More generally, measurements of acoustic and piezoelectric properties of materials can improve models for devices that incorporate these materials.

SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

Name: Andrew Fox

Academic Institution:	University of Colorado - Boulder	**Major:**	Electrical & Computer Engineering
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	CTL, Spectrum Technology and Research Division, Shared Spectrum Metrology Group		
NIST Research Advisor:	Dazhen Gu		

Title of Talk: An Improved Correlation Instrument for Measurements of Noise in Amplifiers and Transistors

Abstract:

Minimization of noise in electronic devices has long been sought after for improving sensitivity of wireless systems and increasing the link budget of communication channels. Aside from growing demands from the telecommunication sector, emerging applications have driven the efforts in the development of ultra-low-noise transistors. Electronic devices can now be made that have a lower noise than the current measurement techniques can quantify, so newer more precise methods are required. The current industry practice for noise measurement relies on the source-pull technique, which has, at best, fractions of a decibel of precision. Newer transistors and amplifiers can reach noise factors of .5 dB or less, thanks to advances in semiconductor design and fabrication. The existing instruments involve cumbersome source-pull components that limit measurement precision and repeatability.

The CHIPS Noise project explores an alternative technique that samples noise waves emanating from the input and output ports of a device under test (DUT), either a semiconductor amplifier or transistor. Next, the noise waves are digitally processed by correlation methods to achieve high precision noise measurements. For this SURF project, we have worked on redesigning and refining a prototype for this new measurement technique. This new version integrates many improvements over the original prototype, which includes reconfigurable detection chains, broadened dynamic range, and a significantly reduced footprint, among others. We designed the mechanical assembly of the improved system in computer-aided design (CAD) software. The CAD models enabled precise manufacturing of the assembly parts by computer numerically controlled machining. We qualified and calibrated the assembled system and conducted noise-wave measurements on a couple of commercially packaged amplifiers.

SURF Student Colloquium

NIST – Boulder, CO
July 29 - 31, 2025

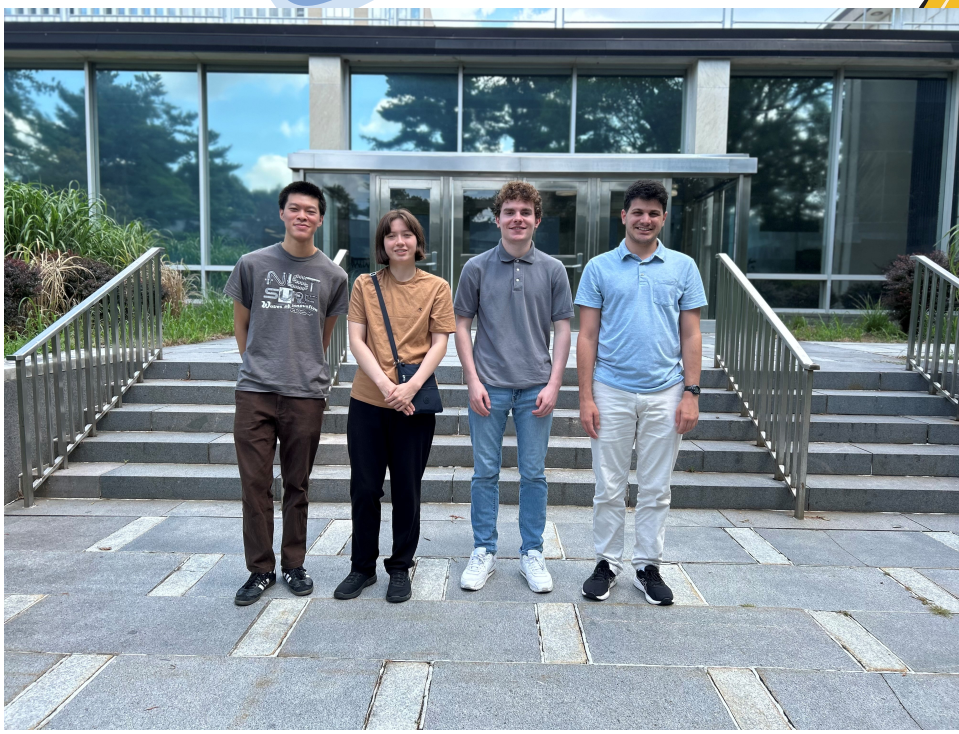
Name:	Adaku Ihekwoaba
Academic Institution:	Baylor University — **Major:** Neuroscience
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Medical School
NIST Laboratory, Division, and Group:	Public Safety Communications Research (Div 671)
NIST Research Advisor:	Kerianne Gibney
Title of Talk:	Methods for Disseminating Public Safety Communications Research Updates to Key Stakeholders

Abstract:

In this talk, I'll provide a behind-the-scenes look at the communications and outreach projects I've been working on for the Public Safety Communications Research (PSCR) Division at NIST. As a Division whose mission depends heavily on stakeholder engagement, effective external communications and outreach are essential to PSCR's role as a convener of stakeholders across the federal government, public safety, academia, and industry. These efforts enable PSCR to share research updates, gather requirements from first responder end-users, and help shape the direction of project plans. The communications and outreach initiatives highlighted in this presentation are designed to support these goals.

Attending this year's 5x5 Public Safety Innovation Summit provided me the unique opportunity to immerse myself in PSCR's stakeholder community and gain insights directly from our researchers, academic collaborators, and industry partners. Through public safety keynote presentations, speed networking sessions, technical breakouts, and hands-on, cutting-edge technology demonstrations, I gathered valuable knowledge across key research areas. By investigating both internal and external research projects, including conducting an interview with a PSCR prize challenge winner, I've been able to translate complex, technical work into compelling narratives for a diverse audience that showcase the research, people, and partnerships advancing public safety communications technology, further aligning with the Division's goal to disseminate research outcomes and collect stakeholder feedback .

Presentation highlights include coverage of the 5x5 Summit; published blogs and accompanying social media, including a spotlight on Ascent Integrated Tech; refreshed content across the PSCR website to make research outputs more accessible and actionable; and the development of a Summer 2025 newsletter, a culmination of all these efforts.



NIST COMMUNICATIONS TECHNOLOGY LABORATORY

2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Communications Technology Laboratory (CTL)

Student Names and Talk Titles (in order of presentation)

Joy Roberts *(plenary speaker):* Modeling Wireless Communication to Improve Passenger Comfort in Autonomous Vehicles

Benjamin Winig: A Path to Zero-Trust-Enabled Deployment of O-RAN Components in Cloud-Native Environments

Milosz Fecko: A Path to Zero-Trust-Enabled Deployment of O-RAN Components in Cloud-Native Environments

Tyler Wong: IoT Smart Sensor Network for Real-Time Environment Monitoring

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Joy Roberts
Academic Institution:	University of Maryland, College Park
Major:	Computer Science
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Software Development/Graduate School
NIST Laboratory, Division, and Group:	Communications Technology Laboratory, Smart Connected Systems Division, IoT Devices and Infrastructure Group
NIST Research Advisor:	Dr. Wendy Guo, Hadhoum Hajjaj
Title of Talk:	Modeling Wireless Communication to Improve Passenger Comfort in Autonomous Vehicles

Abstract:

While existing research on automated vehicle (AV) behavior has primarily concentrated on enhancing vehicle safety and operational consistency, passenger comfort represents another significant factor that AV manufacturers consider. Motion physics determines the connection between AV actions and subjective comfort - gentle vehicle movement corresponds with reduced jerk (the rate of change of acceleration with respect to time). Some AV systems exhibit harsh, uncomfortable motion when braking or accelerating due to lack of situational awareness and delayed human reaction. Vehicle-to-Infrastructure communication (V2I) is an emerging technology by which road devices, such as traffic lights, can wirelessly send information on future traffic changes or recommended actions to AVs. This pre-emptive warning system allows AVs to brake earlier and more gently than with sensors alone so that passengers can feel more comfortable riding the AV.

I utilize a combination of real-world data and simulated models to evaluate how V2I communication can enhance passenger comfort. After collecting motion information from braking trials with a test vehicle, I analyzed data patterns in velocity, acceleration, and jerk. Because there are more potential AV scenarios than can be tested in the field, digital models are vital for our research. Based on the braking profiles, I developed a Simulink model representing a potential AV decision-making algorithm. Once validated against the field-testing data, the model can generate additional synthetic data to complement the group's field-testing work. Furthermore, we can integrate the model with advanced AV simulation software, such as CARLA, to improve the realism and versatility of our research tools. Our goal is to advance vehicle comfort evaluation standards and provide public access to our datasets.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Benjamin Winig
Academic Institution:	University of Maryland
Major:	Computer Science
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Considering a Master's Degree in Cybersecurity or Data Science
NIST Laboratory, Division, and Group:	Communications Technology Laboratory, Wireless Networks Division, Wireless Systems Innovation and Performance Group
NIST Research Advisor:	Dr. Chunmei Liu and Dr. Thomas Henderson
Title of Talk:	Deep Reinforcement Learning for Configuring Multi-Hop Sidelink Relay Networks

Abstract:

First responders and other specialized users of cellular networks face several challenges specific to their use cases. Public safety incidents may damage network infrastructure or require teams to work in remote locations or cellular dead zones, resulting in an inability to communicate with base stations. NIST's Wireless Networks Division is researching new approaches to enable device-to-device communications, enhancing the robustness and resilience of networks in critical situations and environments. Among these is 5G Sidelink (SL) multi-hop relay, which will extend the reach of degraded networks and facilitate peer-to-peer data transfer without the need for any centralized network.

As the implementation of these and other new technologies causes wireless networks to become more complex, reinforcement learning (RL) has become popular for managing the configuration of multiple network parameters with competing performance objectives. Implementations of RL for this purpose include network optimization algorithms and neural networks. This presentation will discuss early-stage efforts to develop RL approaches for configuring cellular networks using 5G Sidelink multi-hop relays. An overview of basic ML concepts, including (deep) neural networks and hyperparameters, will also be provided.

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Milosz Fecko

Academic Institution: Purdue University | **Major:** Computer Science

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Graduate School

NIST Laboratory, Division, and Group: CTL, Wireless Networks Division, Internet Technologies Research Group

NIST Research Advisor: Scott Rose and Oliver Borchert

Title of Talk: A Path to Zero-Trust-Enabled Deployment of O-RAN Components in Cloud-Native Environments

Abstract:

In 5G cellular networks, the Radio Access Network (RAN) manages connected cellular devices by leveraging the Near and Non RT-RICs (Real-Time RAN Intelligent Controls). The Near-RT-RIC is closer to cell towers and makes quick decisions to serve many, potentially-moving cellular connections, while the Non-RT-RIC occupies an administrative role over the Near-RT-RICs farther away from cell towers. Open-RAN (O-RAN) is an open source implementation of RAN that defines how the Near and Non RT-RICs should be structured. According to O-RAN, the Non-RT-RIC should be deployed to a virtualization platform as a collection of distinct microservices that are managed, scaled, and deployed by a container-based orchestration technology such as Kubernetes.

Deploying the Non-RT-RIC as a cluster of separate services is functionally powerful but introduces several security complexities that constitute this project's focus. The principle of authentication holds that services' identities must be verified before establishing secure communication. Individual services must also be authorized to perform specific actions. In zero trust architecture, every request between two parties must be both authenticated and authorized. This project aims to enforce zero trust within the Non-RT-RIC by using multiple technologies.

One avenue of research is tying a service's identity to its privileges. Identity can be provided by the SPIFFE Runtime Environment (SPIRE), an open-source implementation of Secure Production Identity for Everyone (SPIFFE). Authorization can be handled by an OAuth2.0 server that issues JSON Web Tokens (JWTs) to microservices. These tokens contain a scope that lists the access privileges granted to the service identity in possession of the token; how this scope is created and formatted is another topic of interest. Moreover, service mesh technology like Istio provides fine-grained traffic control between microservices in a Kubernetes cluster. Istio enforces secure communication between services via mutual Transport Layer Security (mTLS) and supports granular authorization policies.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Tyler Wong		
Academic Institution:	University of Maryland, College Park	**Major:**	Computer Engineering
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Electronic Device Development		
NIST Laboratory, Division, and Group:	Communications Technology Laboratory (CTL), Smart Connected Systems Division, IoT Devices and Infrastructures Group		
NIST Research Advisor:	Dr. Eugene Song		
Title of Talk:	IoT Smart Sensor Network for Real-Time Environment Monitoring		

Abstract:

Smart sensors are becoming increasing valuable to Internet of Things (IoT) applications to enable real-time monitoring and control for improved reliability and resilience. However, the interoperability of smart sensor data is a major challenge for various IoT applications. Adoption of standards for IoT sensor networks can improve sensor data interoperability, such as the IEEE 1451.0-2024 standard which defines common functions of IoT sensor network components, network services, sensor services, and Transducer Electronic Datasheet (TEDS) formats. IEEE P1451.1.6 defines a method for transporting IEEE 1451.0 services messages over a user network using Message Queue Telemetry Transport (MQTT) to achieve sensor interoperability for IoT applications.

My work this summer involved designing and developing a 1451-based IoT smart sensor network testbed in order to demonstrate smart sensor and actuator interoperability with an IoT application via a MQTT broker. This involved using a smart temperature sensor to conduct real-time environment monitoring of smart buildings, a smart actuator to control temperature fluctuations in the environment, and an MQTT broker which acts as a middle-ware for communications among IoT applications via IEEE 1451.0 and P1451.1.6 standardized commands and replies. IoT platforms like Node-RED were integrated with this sensor network in order to further demonstrate IoT system interoperability.

Engineering Laboratory 2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Engineering Laboratory (EL)

<u>**Student Names and Talk Titles** (in order of presentation)</u>

Abigail Esh *(plenary speaker):* Expoloration of Large Language Models (LLMs) to Support Early-Stage Circular Product Design of Small Electronics

Christopher Jin: Degradation Mechanism Study and Failure Analysis of Polymeric Components in Photovoltaic Modules

Nikita Polyakov: Evaluating 3D LiDAR Performance

Jeanelle Lin: Developing a Mobile Automated Refrigerant Charging Machine

Alvin Persaud: Automating The Data Collection of Alternative Refrigerant Flammibility

Chole Whalen: HVAC Analysis: Investigating Real Building System Data

Meredith Estrella Hernandez: Program a Raspberry Pi to Emulate an HVAC Controller

Charlie Reed: Investigation of Thermal Propertues of Encapsulated Phase Change Materials (PCMs)

Rachel Vartanian: Behavioral Economics of Volcanic Resilience: A Use Case Exploration for Co-DECIDR

Victor Mathias: Automated Measurement of Pressure Loss in Modern Plumbing Fittings

Ting/Xael Shan: Building a Co-Simulation Platform Integrating Semantic Interoperability for Building Control

Alexander Ibacache: Early-Age Mechanical Properties of Triaxial Porcelain Aggregate Concrete

Elizabeth Hackley: Screening for Pyrrhotite and its Reaction Products in Concrete using Raman and Near IR Spectroscopy

Melissa Karwoski: The Oxidation Rates of Pyrrhotite and Other Minerals When Exposed to Bleach

Ben Johnsson: Time-resolved Viscoelastic Properties of Hydrating Cement Pastes

Gabriel Johnson: Corrosion Mechanisms at the Steel-Concrete Interface: Insights from Pore Solution Chemistry Electrochemical Characterization

Hagan Yeoh: (CHIPS) Enhancement in PDR by Adding Usuage Metrics Summary and Exploring GenAI

Raeid Raunak: Changes in PFAS Levels over Time in Unused Firefighter Gear

Ambika Anand: Characterizing PFAS Exposure in the Firefighter Workplace

Huda Kemal: Per- and Polyfluoroalky Substances (PFAS) Concentrations in Upholstery Textiles at Elevated Temperatures

Sebastian Seda: The Hazards of E-Scooter Fires & Their Implications for Public Safety

Christopher Sixbey: The Optimization and Construction of the Controlled Atmosphere Pyrolysis Apparatus (CAPA II)

Philip Huang: Development of Material Flammability Database: Integrating Legacy Cone Calorimeter Data Into Backend-External Data Flow

McCarthy Devine: Design, Implementation, and Validation of Test Methods for Emergency Response Robots and UAVs

Jia Xi Lin: Accuracy Evaluation of Human Motion Tracking Systems

Charles Bradshaw: Mobile Manipulator Performance under Dynamic End Effector Payloads

Michael Donnelly: Training Data Generation for Robots Reinforcement Learning

Arnav Juneja: Twin Robot Demonstration on Vive Headset

Joseph Sanchez: Development of a Verification, Validation, and Uncertainty Quantification Method for Digital Twins of CNC Machines

Madyann Saidi: Evaluating Tactile Sensors for Human-Robot Safety Compliance Using Biomechanical Simulation

Alex Tamagno: Application of IEEE Standard for Robot Task Representation in ARIAC

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Abigail Esh

Academic Institution: Clemson University | **Major:** Industrial Engineering

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): I hope to get my masters degree in data science and pursue a career in manufacturing afterwards.

NIST Laboratory, Division, and Group: Engineering Lab, Division 734, Life Cycle Engineering Group

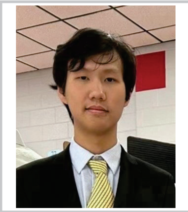
NIST Research Advisor: Ashley Hartwell and Anaya Nandy

Title of Talk: Exploration of Large Language Models (LLMs) to Support Early-Stage Circular Product Design of S

Abstract:

Sustainable design is of the utmost importance to ensure efficient resource allocation and responsible product manufacturing. Many companies still design considering a linear product life cycle, where items are manufactured, put into use, and discarded when the user no longer wants or needs them. A circular product design strategy seeks to change that by turning the product's lifecycle into a continuous loop; items are manufactured, used, and then recycled, repaired, or reused once the owner is finished or the product becomes unusable in its current form. In this manner, old resources are no longer seen as waste and can be utilized in a new product. For manufacturers pursuing circular design in such a manner, there are a variety of circular product design (CPD) principles to choose from to manufacture goods. Due to this large number, it is difficult to determine which principles are most applicable to the product or task, and how companies should focus their resources when designing sustainably.

This work addresses this gap by exploring the use of large language models (LLMs) to help prioritize CPD principles given a set of common consumer products, i.e., small electronics. CPD principles that accompany the ASTM standard on circular product design are input into pre-trained LLMs with a variety of inputs comprising a product description, such as the product names, components, and bill of materials. The models then return a semantic similarity score between the product description and principles, which is used to develop a relevance ranking of all of the principles for each product. Results were compared to determine if principles correlated with specific lifecycle stages were over- or underrepresented, as well as how modifying the product description impacted the semantic similarity results. Additionally, the models themselves were reviewed to see if they contained any inherent biases. Early results demonstrate that for pretrained models, query formatting (i.e., tuning of the information contained in the product description and how it is structured) yields greater improvement in performance of the task of highlighting relevant CPD principles for the set of electronic products than changing the models themselves. This information



SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Christopher Jin		
Academic Institution:	Carnegie Mellon University	**Major:**	Electrical and Computer Engineering
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Research or higher education		
NIST Laboratory, Division, and Group:	Engineering Laboratory, Materials and Structural Systems Division, Infrastructure Materials Group		
NIST Research Advisor:	Dr. Xiaohong Gu		
Title of Talk:	Degradation Mechanism Study and Failure Analysis of Polymeric Components in Photovoltaic Modules		

Abstract:

Solar panels are often deployed in adverse conditions, where environmental factors like UV light, temperature, and humidity can cause degradation within polymeric components, such as the backsheet. Prolonged degradation can cause lower efficiency and lead to the failure of the solar cell. Temporary solutions such as backsheet repair are vulnerable to the same problems. Understanding the durability and degradation modes of these components is critical to the development and improved longevity of photovoltaic (PV) modules.

Surface and cross-sectional samples of backsheets and coupons from retrieved modules were characterized to analyze degradation across the thickness. Raman spectroscopy and laser scanning confocal microscopy were used to analyze chemical and morphological degradation. The results will be used to understand the root causes of backsheet failure and provide the scientific basis for material selection and product development, as well as help create standards for PV backsheet repair.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Nik Polyakov		
Academic Institution:	Boston University	**Major:**	Mechanical Engineering
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Mechanical Design Engineering		
NIST Laboratory, Division, and Group:	Engineering Laboratory, Intelligent Systems Division, Sensing and Perception Systems Group		
NIST Research Advisor:	Prem Rachakonda		
Title of Talk:	Evaluating 3D LiDAR Performance		

Abstract:

Light Detection and Ranging (LiDAR) sensors operate by emitting laser pulses and measuring the time it takes for the reflected light to return from a target—known as time-of-flight. By performing this process across numerous locations in the scene, LiDAR systems generate point clouds that offer a detailed 3D representation of the surrounding environment. LiDAR systems have numerous applications, from automated navigation in uncrewed vehicles to building information modeling that provide a digital representation of the objects around the lidar.

However, the LiDAR measurements are influenced by several factors. At greater distances, the emitted light beam diverges, introducing noise and reducing spatial resolution. Additionally, distinguishing reflected signals from ambient light becomes increasingly challenging. To characterize these performance trends and identify key influencing variables, a series of controlled experiments will be conducted using two LiDAR sensors with distinct principles of operation. These tests will evaluate how measurement noise varies with target distance and angle, with results visualized through comprehensive plots correlating distance, angle, and sensor response. This information will enable us to design artifacts for evaluating other parameters of the lidar such as radial separation and distance error.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

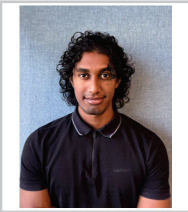
Name:	Jeanelle Lin
Academic Institution:	Georgia Institute of Technology
Major:	Computer Engineering
Academic Standing (Sept. 2025):	Undergraduate Freshman
Future Plans (School/Career):	Engineer, grad school
NIST Laboratory, Division, and Group:	Engineering Laboratory
NIST Research Advisor:	Dr. Vance Payne

Title of Talk:	Developing A Mobile Automated Refrigerant Charging Machine

Abstract:

For refrigerant vapor compression systems in a laboratory, precise control of refrigerant is required for accurate testing. These tests are often implemented to study residential air conditioners, heat pumps, commercial rooftop units, and other systems where refrigerant charge is necessary. The process of adding and removing refrigerant is dependent on a trained technician. However, this often repetitive and person-dependent task can be automated using a Mobile Automated Refrigerant Charging Machine (MARCM). Automating the charging process improves consistency between tests and enables more precise control of refrigerant flow rates. This results in improved safety and reduces human error in experimental setups.

The MARCM system utilizes a Raspberry Pi to manage solenoid valves and interface with pressure transducers, load cells, and temperature sensors via MODBUS RTU. Load cells are used to monitor the mass of refrigerant cylinders, while pressure and temperature data calculate the subcooling and superheat. This data is continuously collected to control the solenoid valves to control the flow of refrigerant based on target commands. A TCP/IP server allows commands to be issued through a LabVIEW interface and includes built-in alerts for abnormal conditions such as pressure spikes, low refrigerant mass, or communication loss.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Alvin Persaud

Academic Institution:	University of Maryland, College Park	**Major:**	Computer Science

Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Join the workforce, and possibly get a Masters degree during my career
NIST Laboratory, Division, and Group:	Engineering Lab - Division 732.01 - HVAC&R Equipment Performance
NIST Research Advisor:	Dr. Gregory Linteris
Title of Talk:	Automating The Data Collection Of Alternative Refrigerant Flammability

Abstract:

Heat Pumps are required for decarbonization of heating/cooling applications, but their working fluids are usually strong global-warming fluids that are being phased out. Replacements are available but they are flammable, and this property must be quantified for their safe use. A compact, efficient experiment has been developed to do so but it requires manual operation. The laminar burning velocity of the refrigerant is the desired parameter, the experiment measures the dynamic pressure rise and then a thermodynamic model is used calculate the burning velocity. This experiment can be automated through LabVIEW, which greatly reduces the time to perform the experiment, limits the possibility of human error, and improves safety for people conducting the experiment.

Fuel and air is mixed into a chamber where the mixture will be ignited. An absolute pressure transducer connects to the chamber to measure pressure. The flame propagates, the pressure rises, and the burning velocity is measured. The LabVIEW program utilizes solenoid valves to automate valve control while simultaneously collecting data from pressure transducers. Signals are sent to the solenoid valves via Modbus RTU through a serial connection from the computer to the Modbus. One of the pressure transducers connects directly to the labview program via serial connection. A second pressure transducer is read via Optical Character Recognition (OCR) where a camera captures pressure reading and sends the data to a Python script where the image is parsed into a numeric value to be sent to the LabVIEW program. The usage of multiple pressure transducers allows for the calibration of the multiple transducers. The LabVIEW program also has safety checks written in the program to ensure there are no leaks or pressure spikes within the chamber. This program allows for the experiment to be conducted swiftly and improves the precision of the data being collected.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Chloe Whalen

Academic Institution: Vanderbilt University **Major:** Climate Studies

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Environmental Researcher

NIST Laboratory, Division, and Group: Engineering Laboratory, Energy and Environment Division, Mechanical Systems and Controls Group

NIST Research Advisor: Michael Galler

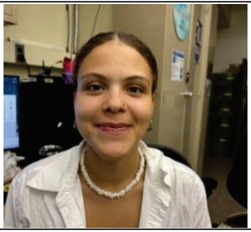
Title of Talk: HVAC Analysis: Investigating Real Building System Data

Abstract:

Issues in HVAC (heating, ventilation, and air conditioning) units often cause comfort, financial, and efficiency issues for a building's guests and operators. This project aims to improve the performance of HVAC systems through analysis and identification of faults within the AHUs (air handling units) in a building's system. By using sensor data rather than a more invasive physical analysis, identifying issues can happen with less delay and be made more efficient.

The data was collected by sensors on the AHUs at the Robert E. Parilla Performing Arts Center, part of the Montgomery College Rockville campus. The data was processed using HVAC-Cx, a specialized analysis software, that evaluated the data using a set of rules and formulas to identify faults in the AHUs. Further data visualization and analysis was conducted using Microsoft Excel and Python.

Using statistical analysis methods with the cleaned data, each AHU was evaluated for which mode of operation led to the most faulty behavior. With this information, building operators are able to see where the units struggle to perform optimally and what may be the causes of these issues in the units' hardware and control systems. By introducing a more efficient way of discovering HVAC issues, building operators can save energy, time, and money while maintaining a comfortable indoor environment for patrons.



SURF Student Colloquium

NIST – Gaithersburg, MD
July 29-31, 2025

Name: Meredith Estrella Hernandez		**Grant Number**	
Academic Institution: Bowdoin College		**Major:** Computer Science and Math (Physics Minor)	
Academic Standing (Sept. '25):	Get a job or keep applying to graduate school		
Future Plans (School/Career):	Graduate School in Mechanical Engineering		
NIST Laboratory, Division, and Group:	Engineering Laboratory, Energy and Environment Division, Mechanical Systems and Controls Group		
NIST Research Advisor:	Dr. Amanda Pertzborn, Glen Glaeser		
Title of Talk:	Program a Raspberry Pi to emulate an HVAC controller		

Abstract:
Commercial buildings account for an increasing portion of U.S energy use, creating the need to improve the efficiency of the building systems, especially heating, ventilating, and air conditioning (HVAC), that make up most of their energy usage. Intelligent agents are combinations of hardware and software that have the potential to reduce energy consumption, maximize comfort, and cut the cost of operation of building systems using existing equipment by learning the performance of the systems they monitor, and communicating and collaborating with other agents.

This project supports the Intelligent Building Agents Laboratory (IBAL) in exploring advanced HVAC control algorithms by prototyping a Raspberry Pi-based HVAC controller. The initial phase involved configuring the Raspberry Pi for remote and direct access, then developing a proportional-integral-derivative (PID) controller to regulate temperature in a test setup. The PID Controller contains the algorithms to make control decisions based on the information from the equipment. A thermocouple sensor and heating pad were used to calibrate the PID parameters to emulate a thermostat. Future work includes implementing a graphical user interface (GUI) via LabVIEW or a custom alternative as well as enabling communication between the Pi and one piece of lab equipment. Later, it will be trained to do that for the rest of the equipment in IBAL.

The broader goal is to establish the infrastructure for intelligent agent research, enabling the Pi to execute control algorithms for individual HVAC components while integrating with the larger system data. This summer's work laid the groundwork by addressing hardware-software interfacing, basic control tasks, and preliminary system integration.

SURF Student Colloquium

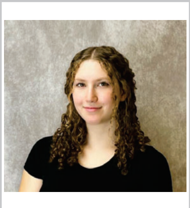
NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Charlie Reed
Academic Institution:	University of North Carolina at Charlotte
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	Graduate Student
Future Plans (School/Career):	Complete M.S. in Mechanical Engineering and pursue R&D roles in Industry
NIST Laboratory, Division, and Group:	Division 732.03 - Heat Transfer and Alternative Energy Systems
NIST Research Advisor:	Dr. Jae Hyun Kim
Title of Talk:	Investigation of Thermal Properties of Encapsulated Phase Change Materials (PCMs)

Abstract:

Phase Change Materials (PCMs) offer effective thermal energy storage by absorbing or releasing latent heat during phase transitions within a material-dependent temperature range. Commercial PCMs are commonly encapsulated to contain the material in both its solid and liquid phases and to isolate it from the surrounding environment; this is especially important for thermal storage and building applications. However, the encapsulation introduces complex heat transfer behavior that affects the overall thermal performance of the system. To optimize the thermal storage and release efficiency of the system, an in-depth understanding of the thermal properties of both the PCM and its encapsulating structure is essential. This study investigates the effects of encapsulation material properties by comparing a low-conductivity material (PMMA) and a high-conductivity material (aluminum). Thermal conductivity (k) and specific heat capacity (Cp) of the raw PCM were evaluated using the Transient Plane Source (TPS) method, and the Heat Flow Meter (HFM) technique was used to assess the complete PCM encapsulated structure. Additionally, Finite Element Analysis (FEA) was conducted using Multiphysics simulations to model the thermal response of the system and was validated by the experimental findings. The results offer insight into how encapsulation impacts heat transfer and demonstrate the importance of accurate thermal characterization in the design of PCM-based thermal storage and building applications. The preliminary findings suggest a dependency on the encapsulation material for the thermal properties of the system; this is particularly pronounced within the phase transition region. Specifically, the measured specific heat of PMMA-encapsulated PCM exhibited an elevated peak during phase change, most likely attributed to thermal lag effects: The low thermal conductivity of PMMA delays heat propagation into the bulk PCM, which increases heat input over a fixed temperature interval and thus yields a higher effective specific heat capacity. Further, more in-depth results will be discussed during the SURF project presentation.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Rachel Vartanian

Academic Institution: Lafayette College

Major: Economics, Psychology

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Undecided

NIST Laboratory, Division, and Group: Engineering Laboratory, Applied Economics Office

NIST Research Advisor: Jennifer Helgeson

Title of Talk: Behavioral Economics of Volcanic Resilience: A Use Case Exploration for Co-DECIDR

Abstract:

Communities in Southcentral Alaska, USA confront an extraordinary confluence of challenges when preparing for natural hazards, particularly the looming threat of volcanic eruptions. Beyond the immediate physical dangers, effective mitigation strategies are shaped by resource scarcity, pervasive uncertainty, and the inherent heuristics that guide human decision-making. Consequently, truly resilient planning necessitates a deep understanding of how individuals, communities, and industries assess and choose alternatives when faced with uncertainty.

This project outlines a conceptual use case investigating the critical role that behavioral economic insights could play in bolstering disaster resilience planning within a representative small Alaskan community near an active volcano. This is a test case for the Co-DECIDR (Community-informed decisions for equitable, cost-effective, and inclusive disaster resilience) planning approach, a framework designed to enhance decision-making in complex environments. The cost-effectiveness and broader co-benefits associated with mitigation strategies from built infrastructure will be analyzed, as well as how decision heuristics influence community choices and risk perceptions.

A mixed-methods approach is used, involving the Economic Decision Guide Software (EDGe$) and Fuzzy Cognitive Mapping. The EDGe$ platform is instrumental in facilitating the comparative analysis of resilience strategies from an economic standpoint, while behavioral economic frameworks are employed to examine the often-overlooked non-monetary influences that significantly impact decision-making in high-stakes environments. This conceptual work should inform broader applications in other remote and high-uncertainty settings where economic efficiency is necessary but individual and collective decision-making can affect safety and financial security.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Victor Mathias
Academic Institution:	University of Maryland
Major:	Aerospace Engineering
Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	Earn a master's in aerospace engineering at UMD
NIST Laboratory, Division, and Group:	Engineering Laboratory, Division 732, Group 2
NIST Research Advisor:	Glen Glaeser and Natascha Milesi Ferretti
Title of Talk:	Automated Measurement of Pressure Loss in Modern Plumbing Fittings

Abstract:

Plumbing design in residential and commercial buildings continues to rely on sizing methods developed in the early 20th century, despite significant advances in pipe materials and fitting designs. As modern plumbing systems incorporate materials like CPVC, copper, and PEX, there is a pressing need for updated pressure loss data to allow for approaches that enhance both water efficiency and quality. In this study, we investigated the pressure loss across three commonly used ¾-inch elbow fittings (one each made of CPVC, copper, and PEX). A custom test rig was used to measure static pressure upstream and downstream of each fitting across a range of flow velocities (1.0 ft/s to 10.0 ft/s). From this data, we calculated pressure losses, friction factors, and surface roughness of the elbows for each material. These results contribute to a more accurate understanding of how different materials affect performance in plumbing systems. By improving pressure loss modeling at the fitting level, this research supports more efficient system designs, potentially reducing construction costs, improving fixture performance, and conserving water in newly built homes.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Ting/Xael Shan		
Academic Institution:	University of Maryland, College Park	**Major:**	Computer Science
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	B.S./M.S. in Computer Science and B.S. in Immersive Media Design		
NIST Laboratory, Division, and Group:	NIST Engineering Laboratory, Div. 732		
NIST Research Advisor:	Parastoo Delgoshaei, Amanda Pertzborn		
Title of Talk:	Building a Co-Simulation Platform integrating Semantic Interoperability for Building Control		

Abstract:

This project aims to build an open source Co-Simulation Platform that serves as the foundation for a building's digital twin. A digital twin is a simulated digital representation of a physical system, often used for analysis and/or optimization. This platform allows Building Researchers to update lab experiments in real-time with simulated calculations. Building Researchers utilize multi-program interactions to simulate different areas of interest: building thermal loads, occupant behavior, equipment operation, control logic, indoor air quality, etc. These programs are not cross compatible with each other, leading to the utilization of co-simulation platforms such as Simulink and BCVTB. These other programs also lack access to the NIST physical lab, preventing live updates and integration with live data. NIST Co-Sim aims to be an open-source co-simulation platform with FMU verification and connection with NIST's on-site lab through TCP/IP Communication with LabVIEW.

This open source cross-platform Co-Simulation program allows connection to LabVIEW for real time simulation between the digital twin (simulation models) and on site NIST Laboratories. This platform was developed as an alternative to licensed co-simulation platforms, utilizing Python package PyFMI to connect Functional Mock-Up Units (FMUs): compiled dynamic models compliant with the Functional Mock-Up Interface (FMI). An application programming interface (API) is being developed alongside NIST Co-Sim to integrate the standalone program to interact with LabVIEW.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Alexander Ibacache
Academic Institution:	Virginia Tech
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Pursue a master's degree
NIST Laboratory, Division, and Group:	EL 731 IMG
NIST Research Advisor:	Patrick Dixon
Title of Talk:	Early-Age Mechanical Properties of Triaxial Porcelain Aggregate Concrete

Abstract:

Concrete foundations of buildings in Connecticut and Massachusetts have experienced extensive deterioration, which has been attributed to aggregate containing pyrrhotite, a reactive iron sulfide mineral. In Connecticut, roughly 1600 houses have been affected by this deterioration, and hundreds to thousands more could experience it in the future. Systematic laboratory studies are required to better determine pyrrhotite's reactions and effects on concrete in controlled conditions. Effective laboratory studies would also benefit by varying the pyrrhotite content systematically and isolating variations in the geology of the rock surrounding the pyrrhotite. This is a particular challenge, given that relatively small amounts of pyrrhotite can cause damage, and the complex and highly variable geology associated with pyrrhotite in New England.

To address this challenge, NIST is using triaxial porcelain, namely a three-part simple ceramic consisting of clay, quartz, and feldspar minerals, as a synthetic rock. While this fixes the geology and allows for control of pyrrhotite content, it must be understood if triaxial porcelain is broadly suitable for use in concrete. This project specifically aims to investigate early-age mechanical properties of concrete with triaxial porcelain aggregate.

A triaxial porcelain concrete and a control concrete, with geologically sourced aggregates, was mixed with the same proportions of materials for each. Three cylinders were cast from each mix. Dynamic elastic moduli were measured on the cylinders with the impact-driven resonant frequency testing (ASTM C215) throughout a 28-day cure in a moist atmosphere. Analysis showed at the 3-day point the dynamic Young's modulus in longitudinal mode was 36.43 GPa ± 0.35 GPa for triaxial porcelain and 40.61 GPa ± 1.20 GPa for the control. Both values are within normal expectations for such concrete. Compressive strengths were measured at 28 days of cure. XRD analysis was performed on aggregate materials. These results can be used as a reference for projects including concrete featuring pyrrhotite-bearing triaxial porcelain aggregates while furthering our understanding between the differences of triaxial porcelain concrete and standard concrete.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Elizabeth Hackley		
Academic Institution:	Gettysburg College	**Major:**	Biochemistry & Molecular Biology
Academic Standing (Sept. 2025):	Graduated in May 2025		
Future Plans (School/Career):	Research career in biochemistry/organic chemistry, eventually an advanced degree.		
NIST Laboratory, Division, and Group:	EL, Div. 731, Infrastructure Materials Group		
NIST Research Advisor:	Dr. Stephanie Watson		
Title of Talk:	Screening for pyrrhotite and its reaction products in concrete using Raman and Near IR spectroscopy		

Abstract:

Pyrrhotite is an iron sulfide that is especially prone to react with air and moisture. Due to its reactivity, the presence of pyrrhotite in concrete can be destructive. Concrete aggregate that is sourced from certain geographic regions can contain higher amounts of pyrrhotite. In particular, aggregate sourced from Connecticut, rich in pyrrhotite, has been linked to cracking and crumbling of house foundations. As pyrrhotite reacts, it damages concrete by causing volume expansion. There are two main steps to this process: pyrrhotite oxidation and sulfate attack. The initial oxidation of pyrrhotite, forming products like ferric oxyhydroxides, causes some volume increase and cracking within the aggregate. In this initial step, sulfate is formed, which allows for the second step of volume expansion. Sulfate reacts with components of the surrounding cement, in which the original volume can increase by as much as 150%, and this stress leads to cracking of the cement matrix. Part of this project is to screen concrete samples for pyrrhotite reaction products.

In addition to pyrrhotite reaction product screening, this project is also examining the use of concrete sealants, which might prevent water and moisture from accessing pyrrhotite within the concrete and minimize secondary products. The idea with sealants is to prevent further damage to existing concrete structures. These reactions must be further understood, so that mitigation methods can be tested for efficacy.

In this project, Raman and near IR (NIR) spectroscopy are being investigated as means of monitoring progress of pyrrhotite oxidation and sulfate attack in concrete samples that have undergone different amounts of aging and weather exposure. Trends such as changes in band intensity and shifts in wavenumber could indicate changing chemical structure within the concrete samples. Pyrrhotite itself has limited Raman and NIR activity. However, pyrrhotite oxidation products, like ferric oxyhydroxides ($FeO(OH)$), and the sulfate attack products can be detected by Raman. The sulfate attack products, gypsum ($CaSO_4 \cdot 2H_2O$) and ettringite ($Ca_6Al_2(SO_4)_3(OH)_{12} \cdot 26H_2O$), are also detectable by NIR. Furthermore, using Raman microscopy, the spatial extent of pyrrhotite reactions and concrete permeation by sealants will also be examined.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Melissa Karwoski
Academic Institution:	University of Maryland, College Park
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Pursue a Ph.D in Mechanical Engineering
NIST Laboratory, Division, and Group:	EL, Division 731, Infrastructure Materials Group
NIST Research Advisor:	Dr. Michael Mengason
Title of Talk:	The oxidation rates of pyrrhotite and other minerals when exposed to bleach

Abstract:

Home foundations in areas of Connecticut and Massachusetts are experiencing premature cracking and crumbling due to pyrrhotite, an iron sulfide mineral present in the concrete of the home foundations. When pyrrhotite interacts with water and air, it oxidizes and produces sulfate, which causes secondary-mineral formation. This leads to a volume expansion in the foundations due to internal sulfate attack, leading to the deterioration of these home foundations in the form of map cracking, white deposits, and wide cracked openings in the concrete. These damages significantly reduce the value of the home, and the cost of replacement is approximately $200,000. The process of deterioration can take anywhere from 3-30 years, so there is a proposed method to accelerate the oxidation process by using bleach as the oxidant to investigate aggregate and concrete. In this project, the oxidation rate of pyrrhotite exposed to a solution of equal parts bleach and deionized water is evaluated in a time series. X-ray fluorescence (XRF), along with a BaCl2 wet-chemical precipitate method, are be used to determine sulfur content in the bleach solution resulting from pyrrhotite oxidation. This concentration is evaluated over time to estimate the oxidation rate and compared to the results of experiments with pyrite, chalcopyrite, and a mix of all three minerals. These measurements can provide insight into how bleach-accelerated testing may show the speeds of deterioration of home foundations containing pyrrhotite and other potentially harmful minerals when exposed to oxygen.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Ben Johnsson

Academic Institution: Grove City College | **Major:** Mechanical Engineering

Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Graduate with my bachelor’s degree and attend grad school
NIST Laboratory, Division, and Group:	Engineering Laboratory, Materials and Structures Systems Division, Infrastructure Materials Group
NIST Research Advisor:	Gavin Donley
Title of Talk:	Time-resolved Viscoelastic Properties of Hydrating Cement Pastes

Abstract:

Cementitious materials are widely used in building and infrastructure construction. When cement powder is mixed with water, it forms a paste which deforms and flows under mechanical loading. As time progresses, the cement undergoes a hydration reaction with the water where Calcium Silicate Hydrate Gel forms and strengthens the paste’s microstructure. Cement pastes exhibit elastic (solid-like) and viscous (fluid-like) properties which evolve as the cement cures. Understanding how these properties change with time will enable improved design of manufacturing and construction processes involving cement and other materials with time-evolving physical properties.

In this study, we characterize the time-dependent viscoelastic properties of simple hydrating Ordinary Portland Cement (OPC) pastes using time-resolved, strain-controlled rheometry. The rheological properties of the pastes are measured using linear regime oscillatory measurements over the course of several hours, from which the dynamic moduli of the pastes are extracted. The evolution of these moduli and their derivatives enable time-resolved characterization of the pastes as they cure. These are compared with the timeline of the cement hydration process, produced by isothermal calorimetry testing and common setting time tests, to provide a clearer picture of the progression of mechanical changes in cement pastes during the early stages of cement hydration.

SURF Student Colloquium

NIST – Gaithersburg, MD July 29 - 31, 2025

Name: Gabriel Johnson	
Academic Institution: University of Maryland College Park	**Major:** Aerospace Engineering
Academic Standing (Sept. 2025): Junior	
Future Plans (School/Career):	Grad school for aerodynamics research
NIST Laboratory, Division, and Group:	Engineering Laboratory, Materials and Structural Systems Division, Infrastructure Materials Group
NIST Research Advisor: Dr. Scott Jones	
Title of Talk:	Corrosion Mechanisms at the Steel–Concrete Interface: Insights from Pore Solution Chemistry and Electrochemical Characterization

Abstract:

Rebar enhances concrete's effectiveness in infrastructure by increasing its tensile strength. While steel rebar is typically protected by a passive iron oxide layer formed in the high alkaline environment of concrete, chloride from external sources can break down the protection and allow corrosion of the rebar to occur. Chloride induced corrosion poses a growing threat in the United States who's direct and indirect effects endanger both American lives and infrastructure. Whether from Seawater spray or deicing salt, corrosion weakens infrastructure and industries with damage, repairs, and prevention costing 500 billion dollars annually. These effects span an area including 284 million Americans and includes bridges, sewer systems, cars, and aircraft among others.

The Forward-Looking Building Standards program project aims to develop reliable test methods to better asses structural performance. To assist the project, this research took a 2-pronged approach to its goal, focusing both on chemical composition of novel concrete and rebar corrosion rates to aid in developing new methods and standards. Cement research aimed to identify the chemical composition and structure of different forms of cements including Ordinary Portland cement (OPC), Portland Limestone Cement (PLC), and multiple types of Calcium Carbonate (CAC41, CAC71). Cement samples were measured and mixed at a water content (W/C) ratio of 0.5 in a centrifugal mixer. Each cement type was mixed on a unique centrifuge run plan before being poured into molds to set. Once hardened each sample was crushed with a mortar and pestle, sieved, then dried using acetone in a vacuum chamber. The dried powder was then used for analysis with X-ray diffraction (XRD) and thermogravimetric analysis (TGA) lab equipment. XRD used X-ray to identify what unique crystal structures of different materials were contained within each sample. Conversely, TGA used weight change due to decomposition at specific temperature regimes to identify how much of each material were contained.

On the other prong, rebar research aimed to investigate surface chemistry and morphology of rebars sourced from different mills in the U.S. and the corrosion properties of each sample. Rebars were first cut into small sections, with some embedded in epoxy for scanning electron microscope- energy dispersive spectroscopy (SEM-EDS) analysis of the cross-sections to investigate mill scale non-uniformities of the surface. Other sections were examined under a stereoscopic microscope and SEM-EDS to observe surface morphology. Finally, corrosion potential measurements and potentiodynamic polarization and tests were performed on iron samples in solutions containing H_2SO_4, NaCl and NaOH to understand the corrosion behavior of iron in environments with varying pH and chloride content. Further steps of the study include electrochemical testing of rebar samples with different surface characteristics in solutions replicating unique pore solution chemistries to better understand their corrosion behavior in concrete made with innovative cement formulations.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Yeoh, Hagan		
Academic Institution:	University of Maryland, College Park	**Major:**	Information Science, Computer Science
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	RDCO - Research Data and Computing Office		
NIST Research Advisor:	Deoyani Nandrekar Heinis		

Title of Talk:	Enhancement in PDR by adding usage metrics summary and exploring genAI

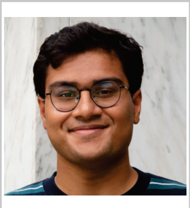
Abstract:

This project enhances the Public Data Repository (PDR) UI by developing a comprehensive summary page based on data usage metrics. Trustworthy and open release of usage statistics is extremely crucial for evaluating the impact and efficacy of digital data repositories. This project imposes a firm reporting interface with prominent presentation of major performance indicators, such as month-to-month metrics on data downloads and unique statistics like latest downloaded datasets, and most popular datasets. Another important addition involves the integration of citation metrics within the metrics pages, providing a quantitative measure of the repository's research influence. This required a thorough run through of the DataCite API to effectively display citations metrics and figuring out how DataCite queries its database for relevant citation information.

The development process leverages modern web technologies such as Python for backend, Angular for the frontend, and RESTful APIs for data transfer. Familiarity with the existing PDR system architecture and usage patterns of the data were a necessary requirement for understanding the design and helped with implementation.

In addition to this main project, I experimented with the usage of Generative AI in data management. Initial research involved learning about Retrieval-Augmented Generation (RAG), an approach that enhances large language models by introducing information retrieval for improved factual accuracy. Practical efforts involved the installation and setup of local generative AI models, specifically Ollama via Open-WebUI, to determine if they can be applied to automate data analysis and system efficiency in the PDR. While issues with model integration and connection stability were encountered, this foundation sets the stage for future development and integration of faster and smarter AI to enhance PDR.

This work aims to further increase the transparency and value of PDR usage data, delivering valuable



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Raeid Raunak
Academic Institution:	University of Maryland at College Park
Major:	Chemical Engineering
Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	Graduate School/ PhD in Chemical Engineering
NIST Laboratory, Division, and Group:	Engineering Laboratory, Fire Research Division, Flammability Reduction Group
NIST Research Advisor:	Andre Thompson
Title of Talk:	Changes in PFAS Levels over Time in Unused Firefighter Gear

Abstract:

Per- and polyfluoroalkyl substances (PFAS) are a class of man-made chemicals with water, oil, and heat-resistant properties with applications in a wide variety of industries. These compounds can take years to break down, earning them the name “forever chemicals.” PFAS are a public health concern, as exposure has been linked to various health issues such as thyroid disease and cancer. Recent studies have detected elevated PFAS concentrations in the blood serum of firefighters compared to levels detected in the general population. Previous research has demonstrated that firefighter gear often contains high levels of PFAS. This project investigates how PFAS concentrations in unused firefighter gear change over time.

In this study, 11 fabric samples were analyzed for 31 types of PFAS. Of the fabric samples, 8 of them were fabrics previously analyzed more than 3 years ago. The remaining 3 were newly purchased versions of a previously studied fabric from a different manufacturer. The PFAS were extracted using a solid-phase extraction method and analyzed using a Liquid Chromatography Tandem Mass-Spectrometer (LCMS/MS). The results were statistically compared with the original measurements taken 3 years prior.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Ambika Anand
Academic Institution:	University of Maryland
Major:	Chemical Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Masters, Energy and Urban Planning
NIST Laboratory, Division, and Group:	Engineering Laboratory, Fire Research Division, Flammability Reduction Group
NIST Research Advisor:	Andre Thompson, PhD
Title of Talk:	Characterizing PFAS Exposure in the Firefighter Workplace

Abstract:

Per- and polyfluoroalkyl substances (PFAS), are a class of chemicals widely used in industry applications and consumer products due to their resistance to heat, water and stains. These substances are commonly used in plastic utensils, non-stick cookware, and textiles. However, PFAS chemical stability makes them difficult to degrade, resulting in a bioaccumulation of these products in the air, soil, water, and ultimately into living organisms. Once within the body, PFAS may disrupt hormones and damage DNA. The EPA links PFAS with reproductive harm, certain cancers, lowered immunity, and developmental delays in children. Understanding the types and concentrations of PFAS individuals are exposed to is crucial to aid in assessing potential health risks.

This project analyzed concentrations of PFAS found on commonly touched surfaces and objects within the NIST fire station. Since PFAS have commonly been used in firefighter gear and foam, firefighters may be at an increased risk of exposure. A total of 30 alcohol wipes were collected from areas such as the floor, firetruck, and the gear storage room. PFAS compounds were extracted using solid-phase extraction and analyzed through liquid chromatography-mass spectrometry (LC-MS) to identify specific PFAS compounds and concentrations. By evaluating PFAS concentrations and determining exposure limits, this study will support efforts in reducing potential PFAS health risks firefighters may be exposed to.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Huda Kemal

Academic Institution: University of Maryland, College Park

Major: Materials Science and Engineering

Academic Standing (Sept. 2025): Graduated

Future Plans (School/Career): Masters in Biomaterials

NIST Laboratory, Division, and Group: Engineering Laboratory (EL), Fire Division, 733

NIST Research Advisor: Brittany Stinger

Title of Talk: Per- and Polyfluoroalkyl Substances (PFAS) Concentrations in Upholstery Textiles at Elevated Temperatures

Abstract:

Per- and polyfluoroalkyl Substances (PFAS) are variations of manufactured chemicals that have been in use since the mid-1900s. They have properties that introduce oil, water and stain repellency, in addition to thermal stability. Given their chemical and thermal stability, the chemicals persist in the human body and environment. These allow them to be incorporated into a variety of industries, including semiconductor, aviation, biotechnology, and consumer products such as non-stick pans and carpets. Although these chemicals are used in a wide variety of applications, PFAS has been linked to potential health issues.

During house fires, specifically living room fires, PFAS embedded into the carpet could be emitted into the air or adhere to soot. When firefighters arrive to extinguish the fire, they could be exposed to these PFAS via their emissions or soot deposition on their gear.

In this project, a living room fire is modeled on a small scale by exposing upholstery fabrics to elevated temperatures in a tube furnace. The emissions of burning upholstery fabrics are examined through the soot. The PFAS in the heated fabrics were extracted via solid-phase extraction and measured by Liquid Chromatography Mass Spectrometry (LCMS) analysis. This provides insight into the PFAS types and varying levels of concentration that firefighters could encounter.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Sebastian Seda

Academic Institution: University of Maryland Baltimore County

Major: Mechanical Engineering

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Ph.D. in aerospace engineering

NIST Laboratory, Division, and Group: Fire research division, engineering fire safety group, 733.03

NIST Research Advisor: Amy Mensch

Title of Talk: The hazards of E-scooter fires & their implications for public safety

Abstract:

This study aims to measure the conditions experienced in a building during fires caused in lithium ion battery-powered devices. With rising energy demands of electronic products, lithium-ion batteries have become increasingly prevalent in our everyday lives. Lithium-ion batteries are utilized in everyday appliances to meet the energy demands of the modern world. However, overcharging, overheating, short circuiting or misuse of lithium-ion batteries can cause the dangerous condition of thermal runaway, which can result in battery off-gasing and fire.

This study examines the thermal and smoke hazards of lithium-ion battery fires using a pack of 30 18650 cells in a standing e-scooter, commonly used for personal mobility. Thermal runaway was generated through overheating by utilizing a 300 W cartridge heater. We implemented 8 thermocouples on different cells in the pack that monitored the variation of temperatures across the battery pack during overheating. We conducted experiments with different configurations of the battery placement and its environment. In one scenario, the e-scooter is burning underneath a calorimetry hood without any surrounding objects. In the second scenario, the e-scooter is burning within a 3.6m x 3.6m x 2.4m room. In some of the room experiments the scooter is placed alongside an upholstered chair to demonstrate its ability to act as an ignition source for other residential items. The key measurement originates from 3 photoelectric smoke alarms installed in the room that helps us assess activation times of how quickly occupants will be notified in the event of an e-scooter fire. Through the measurements of HRR, smoke alarm response times, heat flux gauge (HFG) and mass loss, we aim to better characterize the hazards that e-scooter fires pose to occupants in residential buildings.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 30-31, 2024

Name: Christopher Sixbey

Academic Institution: University of Maryland, College Park | **Major:** Mechanical Engineering

Academic Standing (Sept. 2025): Senior / 4th Year

Future Plans (School/Career): Pursue a career in the aerospace engineering sector after graduation

NIST Laboratory, Division, and Group: Engineering Lab, Fire Research Division, 733 Fire Research Group (FRG)

NIST Research Advisor: Isaac Leventon

Title of Talk: **The Optimization and Construction of the Controlled Atmosphere Pyrolysis Apparatus (CAPA II)**

Abstract:

An important aspect within the realm of fire protection and materials research is pyrolysis. Pyrolysis is the thermal decomposition of materials, which can lead to the production of harmful gasses, liquids, and solids such as char. Given that pyrolysis often produces flammable vapors that can ignite, the study of pyrolysis can give researchers powerful predictive insight into flame dynamics and fire growth. Such insight is valuable in developing new fire-resistant materials, creating measures to combat flame spread, and formulating modern safety systems that can save lives. My project complements research in this area primarily through the development of an improved bench scale flammability testing device: the Controlled Atmosphere Pyrolysis Apparatus, or CAPA II. The data that will eventually be collected using this apparatus will feed into the larger goal of creating a unified Material Flammability Database.

In its design, CAPA II is related to the existing NIST Radiative Gasification Apparatus, albeit smaller and able to provide a more convenient method of measuring the charring and pyrolysis of intumescent polymers. Some of the sample properties that will be measured with this device include mass loss rate, temperature distribution, shape changes, and exhaust content under radiative heating. CAPA II’s open chamber design, spark igniter system, and nitrogen-air mixer will provide improved testing diagnostics as well as fulfilling the long-term goal of studying pyrolysis during reduced atmosphere burning.

To achieve these functionalities, CAPA II requires well-controlled 1D heating, safe sample chamber cooling, the ability to facilitate burning under varied equivalence ratios, and the ability to analyze data in real time. Accordingly, the specifics of my project responsibilities include installing water cooling and electrical systems, implementing the nitrogen delivery lines, designing the spark igniter and safety panels, as well as integrating pertinent sensors and analyzers like heat flux gauges. Another important part of this project involves the integration and calibration of data acquisition units as well as test monitoring software.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Philip Huang

Academic Institution: University of Maryland, College Park | **Major:** Computer Engineering

Academic Standing (Sept. 2025): Senior/4th Year

Future Plans (School/Career): Pursue Masters

NIST Laboratory, Division, and Group: Engineering Lab, Fire Research Division, 733

NIST Research Advisor: Isaac Leventon

Title of Talk: Development of Material Flammability Database: Integrating Legacy Cone Calorimeter Data Into Backend-External Data Flow

Abstract:

In response to the growing demand for a reliable fire-testing tool, NIST invented the Cone Calorimeter, a bench-scale apparatus measuring key indicators such as heat release rate, heat of combustion, and ignitability to help characterize material flammability behavior in response to known heating conditions. Since its launch, the Cone has been consistently used to accurately test the flammability of materials ranging from composite materials to various plastics, as well as establish dozens of fire testing standards. NIST has thoroughly preserved paper records dating back to the Cone Calorimeter's initial introduction while storing recent experiments digitally, all detailing thousands of Cone Calorimeter tests accompanied by their experiment parameters and tabled flammability properties measured through time. Despite the accessibility of historical Cone tests, efficiently filtering through records, extracting applicable results, and analyzing overarching correlations is rendered impossibly time-consuming due to the incredible quantity of tests and spread of their contained locations. In turn, my project serves to construct a backend flow and user-customizable interface to facilitate the viewing and analysis of NIST's collection of Cone tests.

The starting component for my project is a backend pipeline, funneling legacy data files through parsing, correcting, manually reviewing, and processing stages to automatically generate simplified data tables strictly displaying crucial measured values and corresponding categorized metadata files for each individual test. The generated test files are read and reformatted onto designated Material Flammability Database pages, featuring aggregated metadata, test peaks and averages, critical flammability values, and general-purpose material information into sortable minimizable tables. Additionally, I constructed an interface with plotting and visualization functionalities in comparing multiple materials or multiple heat fluxes for one material. From the completion of this project, fire researchers and project workers will be able to simply and efficiently view and extract NIST Cone Calorimeter data and trends to inform accurate predictive material flammability capabilities.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	McCarthy Devine		
Academic Institution:	University of Colorado Boulder	**Major:**	Aerospace Engineering
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Attend Graduate School; Pursue Career in Aeronautic Vehicle Enginering		
NIST Laboratory, Division, and Group:	Engineering Laborotory, Intelligent Systems Division, Emergency Response Robots and Drones		
NIST Research Advisor:	Adam Jacoff		
Title of Talk:	Design, Implementation, and Validation of Test Methods for Emergency Response Robots and UAVs		

Abstract:

The Emergency Response Robotics project develops standard test methods to evaluate robotic systems used by first responders and their operators. This summer, I have worked directly with members of ATF, TSA, Capitol Police, and Montgomery County Fire and Rescue on innovations that will support far more than just these organizations.

The most significant accomplishment of my work this summer was the development and standardization of a ground robotics shipping container layout that comprehensively evaluates traverse, search, and dexterity capabilities. These shipping containers will be utilized by various organizations, including the Capitol Police and NATO, to train and credential their operators before field deployment. I used CAD software to design and assess potential layouts and participated in the fabrication of the first implementation. I applied the same concepts to a cargo trailer layout that will be replicated across all bomb squad regions in the US, traveling periodically to support local bomb squads.

I also revisited the standard test methods for UAVs that I helped develop as a SURF student in 2024. I designed and outfitted a fire-suppressant sprayer on an agricultural-focused UAV to validate our Wildfire apparatuses. This coincided with the preparation of these apparatuses for a burn test in collaboration with the NFRL in August. I also made the CAD and finalized the assembly of the "Labyrinth" terrain. When I return to Boulder in August, I will assemble the Labyrinth for the FirstNet Authority Lab at the NIST Boulder campus.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Jia Xi Lin		
Academic Institution:	Virginia Tech	**Major:**	Industrial and Systems Engineering
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Attend graduate school and participate in projects that help increase sustainability		
NIST Laboratory, Division, and Group:	Engineering Lab, Intelligent Systems Division, Sensing and Perception Systems Group		
NIST Research Advisor:	Benjamin Beiter, Ph.D		
Title of Talk:	Accuracy Evaluation of Human Motion Tracking Systems		

Abstract:

Exoskeleton devices can be used to decrease physical loads on the user's body and workplace injuries. Being able to measure an exoskeleton device's performance will help in creating standards and further developing this technology. A tool used to measure exoskeleton performance is motion capture systems. Motion capture systems can observe the interactions between the user and exoskeleton by tracking the body's movements; however, the accuracy of different motion capture systems needs to be evaluated.

The goal is to create a systematic approach for evaluating the accuracy of different motion capture systems. The motion capture systems used to start include Captury's markerless motion capture system and Optitrack's marker-based motion capture system, which is acting as the project's ground truth. There is focus on three areas in this systematic approach: understanding the systems' representation of the human body model, creating a set of repeatable motions, and comparing values from a variety of metrics from prior research.

To evaluate the systems, data is collected from five subjects by both the Captury and Optitrack systems simultaneously. Each subject performed a set of motions, which included motions that account for different ranges of motion and different body part movements. Accuracy of the motion capture systems is evaluated by using several metrics and comparing the different values to Optitrack's ground truth value. This pilot study is the first step towards ensuring accurate performance of tools when used in later exoskeleton studies and research.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Charles Bradshaw

Academic Institution: Salisbury University

Major: Computer Science & Data Science

Academic Standing (Sept. 2025): Good Academic Standing (4.0), (Sophmore)

Future Plans (School/Career): I intend to continue my education and pursue a master's degree in computer science. I am hoping to work in the software engineering or robotics fields.

NIST Laboratory, Division, and Group: Engineering Laboratory, Intelligent Systems Division, Sensing and Perception Systems Group

NIST Research Advisor: Omar Aboul-Enein

Title of Talk: Mobile Manipulator Performance under Dynamic End Effector Payloads

Abstract:

Mobile manipulators, platforms combining an automated or autonomous mobile base with a robotic arm, are poised to enhance automation of repetitive tasks in fields such as agriculture, construction, and manufacturing. To receive the benefits of automating these tasks, the mobile manipulator must achieve high position and orientation accuracy and repeatability. However, mobile manipulators typically operate in unstructured environments with dynamic impairments such as vibration from connected tools or nearby machinery. To measure the effects of such disturbances, the National Institute of Standards and Technology has developed methods of testing a disturbance's impact on mobile manipulator functionality, such as the Mobile Manipulator Workpiece Agitator (MMWA). The MMWA applies repeatable disturbances to a workpiece, which allows for testing of the mobile manipulator's capability to reposition and correct for the applied disturbance. A natural extension of this work is to instead apply a disturbance to the manipulator itself. Therefore, the contribution of this project was the creation and validation of an apparatus, constructed largely from commercial off-the-shelf components, to induce a repeatable and measurable disturbance on a mobile manipulator end effector. Such disturbances could be representative of factors like the vibrations of dynamic payloads such as power tools and robotic grippers. The repeatability of the induced disturbance was validated using an accelerometer to measure the g-force of the end effector. The accelerometer readings were then compared with an optical tracking system, an established ground truth reference, to validate its measurements.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Michael Donnelly
Academic Institution:	University of Maryland, College Park
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	I plan to pursue a career in robotics.
NIST Laboratory, Division, and Group:	Engineering Lab, Intelligent Systems Division, Manipulation and Mobility Systems Group
NIST Research Advisor:	Dr. Helen Qiao
Title of Talk:	Training Data Generation for Robots Reinforcement Learning

Abstract:

In industrial settings—particularly within smart manufacturing—robotic arms play a vital role in executing complex tasks with high flexibility, powered by advanced AI and deep learning (DL) algorithms. Unlike traditional methods that depend on fixed programming and require frequent manual adjustments, AI-driven training approaches significantly enhance efficiency and streamline the learning process by leveraging sophisticated algorithms and large training datasets. This research focuses on generating training data for reinforcement learning (RL) in robotic drilling applications. A custom test artifact with a randomized drilling hole pattern was developed. A Universal Robot (UR5), equipped with two Intel RealSense cameras, was used to provide vision-based feedback for the RL system. Robotic drilling is a persistent challenge in industry, and improving training accuracy in this domain is essential for reducing costs related to quality assurance.

Two methods were used for data collection. The first method employed teleoperation using a 3D SpaceMouse to guide the robot during a probing operation on the drilling test piece, allowing for simultaneous collection of robot joint states and camera data. The second method involved synthetic data generation using RoboDK to construct a simulated environment integrated with RealSense cameras. RoboDK offers capabilities such as direct robot control via Python scripting, collision detection, CAD file import, simulated camera integration, and position/orientation data collection—bridging the gap between virtual simulations and real-world execution. Compared to teleoperation, synthetic data generation enables the creation of diverse and realistic task scenarios within a controlled lab environment. The aim of this study is to compare both methods by training RL models using their respective datasets and evaluating their performance, with the ultimate goal of identifying areas for improvement in synthetic data generation to enhance the effectiveness of training for real-world applications.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Arnav Juneja

Academic Institution: Purdue University	**Major: Computer Engineering**

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Master's in Computer Engineering

NIST Laboratory, Division, and Group: Engineering Laboratory, Intelligent Systems Division, Manipulation & Mobility Systems Group

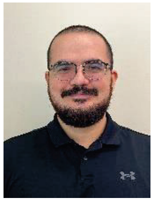
NIST Research Advisor: Shelly Bagchi

Title of Talk: Digital Twin Robot Teleoperation Interface in Virtual Reality

Abstract:

The Human-Robot Interaction (HRI) Lab at NIST is setting up a study where participants will use a robot to assemble a taskboard, which is an iteration of the NIST assembly taskboards. It is designed to simulate the processes of a robotic hand in a manufacturing setting. These tests will help engineers understand an efficient, and intuitive way for workers to use robots to automate manufacturing processes. Automating some of these tasks in a manufacturing environment can make the setting safer with more precise movements and cut down on costs to companies.

This project involves creating a digital twin environment of the study being conducted, with a virtual UR3e robotic arm, the NIST HRI taskboard, with testbed setup precisely to mimic the real-world environment. I am creating this environment through Unity, a real-time 3D development platform. I have also configured the virtual twin robotic arm to mimic the real arm, and such that the movement of the robot and the angles of the robot's joints are replicated in the digital twin using inverse kinematics of the arm. This project is useful for giving a visual representation of the robot's movement in real-time while the study is being conducted.



SURF Student Colloquium

NIST – Gaithersburg, MD July
29 - 31, 2025

Name: Joseph Sanchez

Academic Institution: Salisbury University	**Major:** Data Science

Academic Standing (Sept. 2025): Graduated May 2025

Future Plans (School/Career): Get a master's degree in robotics engineering and transition into a research-oriented career.

NIST Laboratory, Division, and Group: EL, Systems Integration Division (734), LCE Group

NIST Research Advisor: Shao, Guodong

Title of Talk: Development of a Verification, Validation, and Uncertainty Quantification Method for Digital Twins of CNC Machines

Abstract:

Digital twins are becoming increasingly popular tools in the manufacturing industry. Manufacturing digital twins are digital representations of observable manufacturing elements (OMEs). They analyze data from the OME for either directly controlling the OME to achieve optimal performance or providing actionable recommendations to human decision makers who will then take appropriate actions. Specifically, manufacturing digital twins can perform system analyses for applications such as predictive maintenance, virtual commissioning, and process optimization. This requires that digital twins be trustworthy. Verification, Validation, and Uncertainty Quantification (VVUQ) are essential techniques for ensuring credibility of digital twins. However, currently there is a lack of formal VVUQ procedures, methods, and frameworks for digital twins. This project proposes a method of VVUQ for CNC machine digital twins. This VVUQ method concerns three aspects of the digital twin: (a) data collection, (b) data analysis, and (c) controls. To demonstrate the VVUQ method, a CNC machine digital twin was created in the Digital Twin Laboratory (DTL) as a case study. This CNC digital twin is a descriptive digital twin that generates insights into the health of the machine and the quality of the part using real-time operational data and 3D visualization. Applying the VVUQ method to the CNC digital twin provides formal steps for verifying, validating, and quantifying a few uncertainties to provide confidence in the digital twin outputs. In the project, multiple standards such as ISO 23247, MTConnect, STEP, and MQTT, have been investigated and applied.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Madyann Saidi
Academic Institution:	University of Maryland — **Major:** Mechanical Engineering
Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	Robotics Engineering
NIST Laboratory, Division, and Group:	Engineering Laboratory, Intelligent Systems Division, Manipulation and Mobility Systems Group
NIST Research Advisor:	Yong Sik Kim
Title of Talk:	Evaluating Tactile Sensors for Human-Robot Safety Compliance Using Biomechanical Simulation.

Abstract:

Today, industries such as manufacturing, automotive, and electronics are increasingly using autonomous robotic systems to improve efficiency. Whether these systems adopt collaborative robots or fully hands-off automation, human-robot contact is inevitable. Since robots are generally heavy and potentially dangerous, safety standards have been developed. One such guideline is ISO/TS 15066, which provides safety requirements specifically for collaborative industrial robot systems. This document includes thresholds for maximum permissible biomechanical pressure and force, both quasi-static and transient, for various body parts to prevent minor injuries. To ensure systems comply with these guidelines, tactile sensors are commonly used. While many solutions exist for measuring pressure and force in human-robot interactions, the question remains: how accurate are they?

In my work, I evaluated and characterized two commercial tactile sensing solutions in the context of these safety standards, and I also provided supporting data for potential FEA-based simulation approaches. During testing, I applied force to the sensors using stainless steel cylinders of varying diameters and radii. To simulate the biomechanical response of the human abdomen, a spring-damper shaft, a layer of silicone, and a layer of artificial cow skin were placed beneath the sensors (each selected to mimic abdominal compliance). The experiment used an ADMET Universal Testing Machine to apply 100 N of force over five seconds and hold it for an additional five seconds, creating a controlled and repeatable test cycle.

MATLAB software was developed to streamline analysis of the resulting datasets. This tool processes scanned images of pressure-sensitive film, converts pixels into pressure via polynomial fitting and extrapolation, allows comparison of maximum force values under different noise-reduction techniques/degrees (box averaging and Gaussian filtering), and generates interactive 3D heat maps visualizing pressure distribution. The experiments revealed strengths and limitations of each sensor and

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Alex Tamagno		
Academic Institution:	University of Maryland, College Park	**Major:**	Computer Science
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Attend graduate school		
NIST Laboratory, Division, and Group:	Engineering Labratory, Intelligent Systems Division, Cognition and Collaboration Systems Group		
NIST Research Advisor:	Anthony Downs		
Title of Talk:	Application of IEEE Standard for Robot Task Representation in ARIAC		

Abstract:

ARIAC (Agile Robotics for Industrial Automation Competition) is a yearly robotics competition that has been taking place for nearly the past decade. In this competition, competitors are asked to code a simulation that controls robots, having them perform a series of tasks. These tasks resemble real world scenarios in a factory, such as creating packages, picking items, and placing items. This competition can be completed in numerous fashions, allowing for different approaches to work and have various efficacies. For my project, I worked on completing ARIAC following the IEEE Standard for Robot Task Representation. (IEEE Std. 1872.1-2024)

The IEEE Standard for Robot Task Representation, in part, discusses that robotic tasks can be represented by a series of simple steps, called atomic tasks. A series of these atomic tasks, known as a composite task, can be used to represent a complex task. Therefore, my goal was to break down the competition into multiple composite tasks, which would be made up of multiple simple atomic tasks. For example, in ARIAC, you must grab a cell off of a conveyor belt. In my application of the standard on ARIAC, this was seen as a composite task. This composite task was made up of multiple smaller atomic task, such as opening a gripper, closing a gripper, and moving the robot.

Applying the standard in ARIAC allowed for the versatility of the standard to be applied in more rigorous programs, as well as testing difficulties of the standard's application. Testing the standard also allowed for insight on using the standard as a layout in order to complete a difficult task.

Information Technology Laboratory 2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Information Technology Laboratory (ITL)

Student Names and Talk Titles (in order of presentation)

Isabel Wu *(plenary speaker):* Evaluating the Resilience and Generalization of Forensic Generative AI Detection Systems

Brittney Meza: Digital Identity Guidelines and OSCAL: Advancing Machine Readable Techniques for Assessing Compliance with NIST SP 800-63

Fenrir Badorf: Exploring Combinatorial Methods for Dimensionality Reduction in ML

Abigail Hanson: Synthetic Overlays on Real-World Road Data for Testing the Robustness of AI Perception

Rajeev Raghuram: Building a Computer Vision-Based Video Browser for the Text Retrieval Conference (TREC)

Rowan Wiles: Exploration Into Immersive 3D Data Visualization

Millie Vyas: Readme_AI Tool: Building Context for LLMs

Daksh Gautam: Extraction of Technical Insights from Scientific Papers using Large Language Models

Arjun Parikh: Quantifying Uncertainty of Texture Directionality Prediction by Neural Networks

Rugved Zarkar: Line Width Measurements of Integrated Circuits Using Time-efficient Acquisition of Scanning Electron Microscopy Images and Artificial Intelligence

Diana Petrenko: Linking Broken Trajectories for Gene Therapy Particle Tracking

Marianne Nguyen: Calibration and Validation of X-Ray CT Simulation for Advanced Packaging

Yuna Chun: Towards High Fidelity Localization for Latched Readouts in Quantum Dot hybrid Qubit Systems

Olivia Cong: Quantum Process and State Tomography Modeling in Cesium Vapor Cell Quantum Memory

Angela Shen: Polarization Reference Frame Alignment Using the Inverse-matrix Method

Jack Deye: Higher-Order Numerical Methods for Integro-differential Equations in Biological Field Effect Transistors

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Isabel Wu		
Academic Institution:	Carnegie Mellon University	**Major:**	Computer Science
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Pursue a career in Software Engineering or AI		
NIST Laboratory, Division, and Group:	Information Technology Lab, Information Access Division, Multimodal Information Group		
NIST Research Advisor:	Haiying Guan		
Title of Talk:	Evaluating the Resilience and Generalization of Forensic Generative AI Detection Systems		

Abstract:

With the continuously rapid advancement of deepfake and generative AI technologies, forensic examiners face increasing difficulty in distinguishing authentic content from AI-generated media. The widespread access to new commercial and public domain tools increases the challenge in dealing with fabricated and manipulated digital evidence, cybercriminals using AI technology, and complications in legal admissibility. In response, researchers have been actively developing AI-driven forensic tools to detect such AI generated media.

Compared to detection systems in other domains, a significant challenge in generative AI detection is the dynamic changing of detection targets due to the constant evolution of new generators and novel generative AI techniques. This makes the robustness/resilience and generalization capabilities of these systems crucial for real-world application. Based on 10 years of research and collaboration with forensic communities, it was found that detection tools trained on a known type of image generator may not generalize well to other unknown generators with different neural network architectures. Accordingly, our experiment demonstrates that the performance of detectors can be greatly reduced when faced with images from unknown generator techniques. With models performing at 98% AUC on seen generators, but performance dropping to 61% AUC when faced with a new generator type, our study finds that the failure to generalize means many detectors are unusable in practice to the forensic community.

In this study, we highlight the major barriers that prevent the use of generative AI detectors in the forensic community for real-world applications. We investigate a variety of synthetic image detectors on varied real & synthetic datasets and post-processing techniques, analyze the performance of these models, and relate these patterns to the training techniques of the system. Finally, we propose a direction for the

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Brittney Meza		
Academic Institution:	University of North Georgia	**Major:**	Computer Science
Academic Standing (Sept. 2025):	4th year, in good standing		
Future Plans (School/Career):	Graduate, work for my University's IT Division, and pursue my masters in Computer Science.		
NIST Laboratory, Division, and Group:	Information Technology Laboratory (ITL), Applied Cybersecurity Division (ACD), Cybersecurity and Privacy Applications Group		
NIST Research Advisor:	Ryan Galluzzo		
Title of Talk:	Digital Identity Guidelines and OSCAL: Advancing Machine Readable Techniques for Assessing Compliance with NIST SP 800-63		

Abstract:

OSCAL stands for Open Security Controls Assessment Language. It utilizes XML, JSON, and YAML, to translate human-readable control documents into a format that is readable for machines, enabling automated and ongoing assessments of compliance. NIST Special Publications, such as NIST SP 800-63-4: Digital Identity Guidelines, contain extensive requirements that are often manually evaluated by an assessor, a process that is both time consuming and expensive. This is where OSCAL comes into play. It utilizes machine-readable formats to enable automated and ongoing assessments, saving time and money while also improving security posture. It is important to note, OSCAL does not do the automating, but rather it provides all the information necessary for a software product to utilize the files to check whether those controls are met, and therefore compliant.

My task was to implement the new SP 800-63A-4, Section 3.1 Identity Service Documentation and Records using OSCAL's structure to provide the identity program with insights into the time, effort, and process of converting the Digital Identity Guidelines into this machine-readable format. It will also offer a stepping-stone to accelerate program activities by enabling a framework for and demonstration of what is needed for future related endeavors. My presentation will focus on the work done to date including the phases of the project, the outputs generated, and the lessons learned.

SURF Student Colloquium

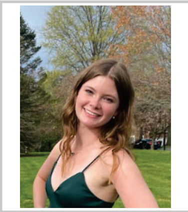
NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Fenrir Badorf	
Academic Institution: Loyola University Maryland	**Major:** Data Science
Academic Standing (Sept. 2025):	Adult/non-traditional student, Senior (5th year)
Future Plans (School/Career):	Master's program of Data Science, working in research after receiving my degree.
NIST Laboratory, Division, and Group:	ITL, Computer Security Division, Security Components and Mechanisms Groups, 773.02
NIST Research Advisor:	Dr. M S Raunak
Title of Talk:	Exploring Combinatorial Methods for Dimensionality Reduction in ML

Abstract:

Datasets with high dimensionality pose several challenges for machine learning (ML) such as making it more difficult for the model to learn meaningful patterns. This happens due to extra noise and redundancy in the data, which can also lead towards overfitting, excessive computational cost, and often makes it difficult to visualize or understand. For building more robust and interpretable models, researchers and practitioners try to reduce the data dimensions using different approaches like feature selection, feature extraction, and autoencoding. Commonly used feature extraction approaches such as Principal Components Analysis (PCA) or Linear Discriminant Analysis (LDA), while useful, are sensitive to outliers and often lead to loss of valuable information and interpretability of the data. In this research, we explore the applicability and usefulness of combinatorial approaches towards dimensionality reduction. In particular, we look at a novel technique named combination frequency differencing (CFD) towards identification of redundant or less impactful features in a data set and use that information for reducing the dimensionality. We aim to examine whether the frequency of value combinations appearing in one class compared to the other in a machine learning classification problem can indicate feature importance and thus allowing us to identify features that can be reduced without impacting the model’s learning ability significantly. We compare our approach to other traditional dimensionality reduction techniques such as PCA for effectiveness.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Abigail Hanson

Academic Institution: University of Wisconsin-Madison **Major:** Computer Science and Data Science

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Enter industry or pursue graduate degree

NIST Laboratory, Division, and Group: Information Technology Laboratory, Computer Security Division, Security Components & Mechanisms Group

NIST Research Advisor: Apostol Vassilev

Title of Talk: Synthetic Overlays on Real-World Road Data for Testing the Robustness of AI Perception

Abstract:

Autonomous driving is an emerging technology, aiming to transport those that are unable to drive and eliminate accidents caused by human error. The difference between humans and autonomous vehicles is that humans are able to observe their surroundings and make decisions based on what they see when driving, whereas in an autonomous car, decisions that are made using artificial intelligence (AI) are based on the circumstances under which the AI models have been trained on, so the cars cannot generalize and act instinctively in scenarios that they have not seen before. To solve this problem, we aim to develop scenarios in which object detection models fail to detect or classify objects correctly and use them to develop a public benchmark dataset for the industry to use and improve their AI models.

In this project, we have created a hybrid testing approach to evaluate the performance and accuracy of object detection in AI models in various inclement weather scenarios. We are using a hybrid approach due to enormous cost and severe availability restrictions of obtaining real-world data in various weather conditions. To increase the utility of already acquired road data and save additional costs, we are creating virtual weather effects that can be applied to any video with any set of weather parameters, creating a testbed for object detection in AI models used in autonomous vehicles.

With this technology, we aim to identify inclement weather conditions in which various object detection models fail to identify an object within the safe car braking distance. Using an ensemble of AI models for object detection and classification, weather effects will be applied to videos, then processed by the AI models. Based on this, we estimate the uncertainty and mean prediction probability, allowing us to evaluate the performance disparity between each model, and the performance of object detection models as a whole on certain inclement weather conditions. This data will help to improve the accuracy of object detection in AI models under challenging weather conditions and foster innovation in the industry to increase the robustness of AI models by exposing the models to new scenarios.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Rajeev Raghuram

Academic Institution: University of California, Davis | **Major:** Data Science & Physics

Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Pursue PhD in astrophysics, become professional astronomer
NIST Laboratory, Division, and Group:	Information Technology Laboratory (ITL), Information Access Division (IAD), Retrieval Group
NIST Research Advisor:	Dr. George Awad
Title of Talk:	Building a Computer Vision-Based Video Browser for the Text Retrieval Conference (TREC)

Abstract:

The Text Retrieval Conference (TREC) intends to encourage research in information retrieval from large test collections. TREC teams are tasked with comparing different algorithms for text and multimedia retrieval, which they use to create test collections that are judged to determine the current state of the art search algorithms, based on accuracy and runtime.

The goal of my project is to create a video retrieval system similar to systems used by TREC teams. I will build a frontend web browser that will find the videos that are most relevant to the user's search query. The system uses three variations of OpenAI's Contrastive Language-Image Pretraining model (CLIP) to extract features from videos in NIST's dataset and from the user's textual query. The videos are segmented into shots, which are further subdivided into keyframes, all of whose feature vectors (extracted by CLIP) are stored in a FAISS vector database. By using the FAISS similarity metric between the feature vectors of the text and every video in our database, the frontend application will display the 15 videos with the highest similarity scores with the user's text input. With all the important components of the retrieval system (videos, feature extraction models, database, and frontend browser), it allows for future experimentation with the system by plugging in new models and testing their output. This will allow the NIST team to investigate and evaluate various different models' performance on the system.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Rowan Wiles
Academic Institution:	University of Maryland, Baltimore County — **Major:** Computer Science
Academic Standing (Sept. 2025):	Post-baccalaureate
Future Plans (School/Career):	Graduate School
NIST Laboratory, Division, and Group:	ITL, Applied and Computational Mathematics Division, High Performance Computing and Visualization Group
NIST Research Advisor:	Simon Su
Title of Talk:	Exploration Into Immersive 3D Data Visualization

Abstract:

As our tools to collect data advance, the need to understand this data grows. Traditional visualization tools are limited to 2d screens: which are unable to properly display complex 3d objects. In order to solve this growing issue, we are developing new technologies to allow for true 3d visualization. The hardware to support 3d visualization includes headmounted devices (HMDs) and CAVEs.

The biggest hurdles to 3d visualization have always been cost of equipment and setup difficulty. In recent times, the cost hurdle has fallen dramatically. Many consumer HMDs are easily affordable and even basic CAVE systems have fallen into reach for many. While these systems often come with easy to use applications for gaming and entertainment, the software infrastructure for data visualization still requires intensive setup and expertise.

Applications like Paraview offer a quick and easy route to get data into XR. Paraview allows users to import many different kinds of data and has a multitude of online tutorials and documentation to manipulate the data into a visually digestible form. Once the visualization has been made, putting it into XR is incredibly easy. The XRInterface plugin for Paraview can make XR as little as five clicks away. Paraview also offers CAVE support through its CAVEInterface plugin.

Unreal Engine and Unity also offer XR support. Through plugins like nDisplay and LiveLink, complex and interactive visualizations can be accessed.

By developing new tools and documentation, these tools can be made more and more accesible to researchers who wish to properly visualize, understand, explore, and communicate their data.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Millie Vyas

Academic Institution: Purdue University

Major: Computer Science

Academic Standing (Sept. 2025): Sophomore

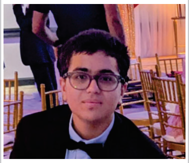
Future Plans (School/Career): Master's Degree

NIST Laboratory, Division, and Group: Information and Technology Lab, Systems and Software Division (775), Information and Systems Group

NIST Research Advisor: Timothy Blattner

Title of Talk: Readme_AI Tool: Building Context for LLMs

Abstract: When querying a Large Language Model (LLM), it often lacks specific knowledge relevant to the user's question. While the LLM uses its pre-existing training data for a response, this information can frequently be inaccurate or unreliable in the context of the user's specific query. Providing the LLM with query-specific context will significantly improve the usefulness of its responses. To allow the LLM to build context from outside sources, I have developed a tool using the Model Context Protocol (MCP) and the FastMCP library. This acts as a bridge for LLMs to interact with general data sources. While others have attempted to address this problem, like Context7 and llms.txt, their approaches are limited: Context7 is confined to only extracting library documentation, and llms.txt is limited to pure text to build context. This presentation introduces a new tool called Readme_AI that builds context from its json file specification, offering a decentralized approach to how LLMs build their context. The Readme_AI tool automatically downloads from a data source using git, and checks for the Readme_AI.json file. This file is then read and used to build context. The Readme_AI.json file specification allows the data source owner to provide useful content for the LLM to use when querying about its data sources. Currently, the specification provides the following capabilities: (1) custom tags with descriptions, (2) website crawling, and (3) downloading and parsing PDFs. In this presentation, we demonstrate the Readme_AI tool's capabilities by querying about the NIST-developed Hedgehog library, which is unknown by the LLM. Without the tool, the LLM hallucinates information about Hedgehog. Using Hedgehog's Readme_AI.json file, the tool presents the API, documentation, examples, high-level descriptions, and publications to the LLM. This provides enough context, enabling the LLM to generate parallel execution code for a specified algorithm using the Hedgehog library when prompted.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Daksh Gautam		
Academic Institution:	University of Maryland, College Park	**Major:**	Computer Science
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Master's in Computer Science/Artificial Intelligence/Quantum Technology		
NIST Laboratory, Division, and Group:	Information Technology Laboratory, Software and Systems Division, Information Systems Group		
NIST Research Advisor:	Alden Dima		
Title of Talk:	Extraction of Technical Insights from Scientific Papers using Large Language Models		

Abstract:

The rapid growth of scientific literature has created a pressing need for efficient methods to extract technical insights from large volumes of text. Systematic literature reviews, a crucial component of research synthesis, involve the comprehensive analysis of existing research on a particular topic. However, the manual extraction of relevant information from scientific papers can be a time-consuming and labor-intensive process. This project explores the application of Large Language Models (LLMs) to extract relevant information, such as methodologies, results, and conclusions, from scientific papers on arXiv. A key aspect of my research is the experimentation with different LLMs to identify the most effective models for extracting relevant information, such as methodologies, results, and conclusions. Through a comprehensive comparison of various open-weight LLMs, I analyzed the trade-offs between model complexity and performance, and identified the point at which further increases in model complexity or size no longer yield significant improvements in extraction accuracy. My experiments demonstrate that different LLMs have varying strengths and limitations, and that some models are more effective than others for extracting technical insights from scientific literature. By automating the process of extracting methodologies, LLMs can help reduce the manual effort required for data extraction, improve the accuracy and consistency of extracted information, and enable researchers to focus on higher-level tasks such as analysis and interpretation. The results of my study provide valuable insights into the optimal LLM architectures and sizes for extracting technical insights from scientific text, and highlight the potential of LLMs to facilitate the conduct of systematic literature reviews. My work contributes to the development of efficient methods for extracting technical insights from large volumes of scientific text, with implications for knowledge discovery, research synthesis, and the advancement of scientific research.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Arjun Parikh

Academic Institution: Cornell University | **Major:** Biological Engineering

Academic Standing (Sept. 2025): May 2026

Future Plans (School/Career): Graduate School

NIST Laboratory, Division, and Group: Information Technology Laboratory (ITL)

NIST Research Advisor: Derek Juba

Title of Talk: Quantifying Uncertainty of Texture Directionality Prediction by Neural Networks

Abstract:

This project explores how neural networks predict directional data in images and how confident those predictions truly are. The goal for my project is to better understand model uncertainty by analyzing both final predictions and the underlying logits, which offer insight into how strongly the model favored one outcome over others. The idea is to determine if multiple models agreeing on a predicted direction, or a model's logits showing a clear single prediction, indicates a highly reliable prediction.

We are using a data set that has over 400,000 images with four different identifying factors: width, period, and distortion (Gaussian Blur or Noise), and true direction. Each image was then run through 12 different activation functions of the GNO4tr3 model, each with 3 trials for each activation function. Logits and predicted directions were then extracted from inferencing based on a Python script. To investigate this data, I wrote many Python scripts to calculate a number of different error values, and metrics like RMSE and standard deviation to evaluate model performance. Some pertinent examples are determining which images work best in certain models, or which models perform the best on average between many images. A major focus has been on interpreting the logits behind each prediction, since they offer a deeper look into the model's confidence. I am currently analyzing how consistent those logits are across different models for each image with their given distribution.

We expect that when multiple models agree on the predicted direction or the shape of the logits shows a clear prediction, the prediction will be correct with high likelihood. The goal is to formalize this pattern into a usable confidence score, helping us flag reliable predictions and improving how we evaluate model outputs in uncertain data settings.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Rugved Zarkar

Academic Institution: University of Maryland - College Park

Major: Computer Science & Finance

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Masters in Artificial Intelligence

NIST Laboratory, Division, and Group: ITL, Software and Systems Division, Information Systems Group

NIST Research Advisor: Dr. Peter Bajcsy

Title of Talk: Line width measurements of integrated circuits using time-efficient acquisition of scanning electron microscopy images and artificial intelligence

Abstract:

Fast dimensional measurements of various integrated circuit (IC) structures at the nanometer scale (10^{-9} m) are critical for lithographic fidelity and fabrication yield. However, scanning electron microscope (SEM) measurements with the required atomic scale (10^{-10} m) resolution and accuracy are time-consuming and expensive, creating a need for efficient data acquisition strategies that maintain measurement quality.

This project tackles three fundamental challenges in SEM-based metrology: (1) determining the minimum set of measurement points that are needed for reliable line width estimation (sampling), (2) inpainting the missing points from the measured set (modeling), and (3) quantifying line width uncertainty across different sets of SEM measurement points and inpainting strategies (measurement time versus line width uncertainty tradeoff analysis). We address the sampling challenge by using random sampling, Latin hypercube sampling, and other published randomized strategies over a regular image grid to form an acquisition mask. Such a mask enables sparse line scan acquisition across reference IC structures. Next, missing image data is reconstructed using classical interpolation and supervised inpainting models trained on large SEM datasets that become the input into a line width estimation algorithm. Finally, for measurement tradeoff analysis, we systematically vary sampling type, mask density, and inpainting model and its parameters. Each configuration is evaluated by computing the deviation of predicted line width from the ground truth line width derived from fully sampled SEM images.

The resulting tradeoff graphs enable the identification of optimal SEM sensing given the required uncertainty bound imposed on the line width measurements. The outcomes of this project will assist in reducing SEM imaging time and electron beam damage while maintaining low uncertainty in critical dimension measurements of ICs.

SURF Student Colloquium

NIST — Gaithersburg, MD

July 29 - 31, 2025

Name: Diana Petrenko

Academic Institution: University of California Berkeley | **Major**: Physics & Data Science

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): PhD

NIST Laboratory, Division, and Group: ITL

NIST Research Advisor: Cyrus Daugherty

Title of Talk: Linking broken trajectories for gene therapy particle tracking

Abstract:

Emerging gene therapies rely on nano-bioparticles engineered to transport genetic material into cells. However, these particles are notoriously difficult to produce uniformly, leading to significant variation in size, behavior, and performance. This heterogeneity can compromise both the safety and success of treatments. To address this challenge, NIST is developing a non-destructive high-throughput light scattering microscope for continuous bioreactor sample monitoring that enables characterization of the physical and dynamic properties of these gene therapy particles. A key step in this analysis is tracking, which is employed to measure the size of these diffraction limited particles. A major limitation to high-throughput tracking is particles overlapping in the field of view, which can cause standard tracking tools to misassign particle identities. In this project, we aim to improve post-overlap trajectory continuity by training a recurrent neural network on simulated particle motion data. The model is designed to learn subtle behavioral patterns to re-identify particles more accurately than existing tools like Trackpy. We also compare this approach to traditional mathematical techniques such as the Kalman filter. These improvements could enable more reliable measurements of particle radii, contributing to high-throughput characterization of gene therapy particles at the single-particle level.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Marianne Nguyen

Academic Institution: University of Maryland, Baltimore County | **Major:** Computer Science

Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	Graduate School for Computer Science and Data Science
NIST Laboratory, Division, and Group:	Information Technology Laboratory; Statistical Engineering Department; Statistical Design, Analysis, and Modeling Group
NIST Research Advisor:	Adam Pintar
Title of Talk:	Calibration and Validation of X-Ray CT Simulation for Advanced Packaging

Abstract:

X-Ray Computed Tomography (XCT) scans of advanced semiconductor packages can reveal internal structure, including defects, nondestructively. In an XCT scan, many two-dimensional X-ray radiographs are acquired at different projections, which are then reconstructed to provide three-dimensional information. For the advanced packaging features known as through silicon vias (TSVs), XCT is particularly useful for detecting voids, cracks, or delamination that may have been introduced during the electrodeposition process. However, measurements of defect size, e.g., void volume, may not be directly realized by XCT reconstructions without either calibration to a known ground truth or at least verification of adequate performance. Simulations can aid both calibration and verification processes, and the aRTist (Analytical Radiographic Testing (RT) Inspection Simulation Tool) software allows users to simulate XCT scans.

In this project, the parameters in the aRTist XCT simulation software were tuned to match target XCT scan data. To tune the simulation parameters, Bayesian Optimization was used to minimize an objective function. The objective function characterized the distance between simulated and target scans with smaller distances indicating higher similarity. For simulation parameters such as exposure time and number of frames to average, full three-dimensional scans of an object were unnecessary; single radiographs of an empty domain were sufficient. The single radiographs were decomposed into a signal part plus a noise part. The signal part is a fitted quadratic surface with the independent variables being the pixel indices and the dependent variable being the grey scale values of the radiograph. The noise part is the residuals from that fitted surface. The distance between two radiographs is taken to be the distance between the signal parts plus the distance between the noise parts. In a test of this approach, a target radiograph with known values of exposure time and number of frames to average was simulated. The algorithm was able to identify the correct exposure time and number of frames to average in the simulated target radiograph in only a few iterations. Extending the algorithm to other important simulation parameters will also be discussed.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Yuna Chun

Academic Institution: Massachusetts Institute of Technology

Major: Computer Science and STS

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): I plan to go to graduate school and pursue a career in academia.

NIST Laboratory, Division, and Group: ITL, Division 771, High Performance Computing and Visualization

NIST Research Advisor: Dr. Justyna Zwolak, Dr. Merritt Losert

Title of Talk: Towards high fidelity localization for latched readouts in quantum dot hybrid qubit systems

Abstract:

Semiconductor gate-defined Quantum dots (QDs) are a promising candidate system for scalable quantum processors. Information may be encoded in QD configurations either by tracking spin states of the nanoparticles or by sensing the presence of individual charges on multi-dot configurations. QD hybrid qubits (QDHQs) promise to combine the advantages of both approaches: the prolonged coherence lifetimes of spin-based encodings, as well as the fast manipulation and readout of charge-based encodings. A particularly fast and high-fidelity readout scheme for hybrid qubits is known as latched readout, where an excited qubit state is latched to a metastable state to enhance the lifetimes of charge states. While promising, latched readout requires the careful specification of a readout window on a charge stability diagram. Such readout points can be tuned up by hand, but in a scalable quantum architecture, this process must be fully automated to be feasible. In this project, we make important progress toward the full automation of latched readout. We demonstrate an automated procedure for localizing and tuning this readout window. Our protocol combines deep neural networks with computer vision and feature extraction techniques for point and line detection to extract the relevant features in a charge stability diagram, allowing us to efficiently determine windows for latched readout.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Olivia Cong

Academic Institution: Dartmouth College | **Major:** Computer Science

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Software Engineer

NIST Laboratory, Division, and Group: Information Technology Laboratory, Applied and Computation Mathematics Divison, Quantum Information Group

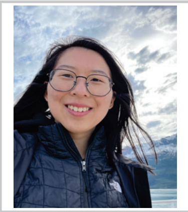
NIST Research Advisor: Lijun Ma

Title of Talk: Quantum Process and State Tomography Modeling in Cesium Vapor Cell Quantum Memory

Abstract:

Quantum memory is essential for quantum communication and networking because it enables the storage and retrieval of quantum states, allowing synchronization between distant nodes. This work presents a simulation study of quantum state tomography (QST) and quantum process tomography (QPT) specifically applied to cesium vapor cell-based quantum memory systems, aiming to deepen understanding of how various parameters influence memory performance. QST is used to reconstruct an arbitrary (or unknown) qubit state by performing measurements in multiple bases. QPT builds upon this foundation by performing QST on multiple tomographically complete input qubit states, followed by measurement of the output states after passing through three different cesium vapor cells, representing distinct quantum channels. A χ-matrix (chi-matrix) representation of each memory process is extracted and visualized to provide an understanding of how specific channels affect memory. Modeling this process is essential for predicting and verifying experimental performance, adding more efficiency and certainty to the laboratory implementation.

Using MATLAB-based simulations, we first model QST though preparation of input states and measurement of output states in the complementary measurement bases (Pauli X, Y, and Z). After implementing QST, this work then progresses to QPT through the propagation of quantum states through vapor cell memory channels, implementing full process tomography to reconstruct the quantum channel matrix describing memory storage and retrieval operations. This simulation uses linear inversion to recover the complete χ-matrix, allowing us to assess the variations in performance for each vapor cell. The simulations also model the effects of noise and optical depth on quantum state propagation, enabling more detailed identification of critical factors affecting memory quality. This modeling effort can improve the design, control, and implementation of quantum memory.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Angela Shen
Academic Institution:	Carnegie Mellon University
Major:	Electrical and Computer Engineering
Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	Masters in Electrical and Computer Engineering
NIST Laboratory, Division, and Group:	Information Technology Laboratory, Applied and Computational Mathematics Division, Quantum Information Group
NIST Research Advisor:	Oliver Slattery and Yicheng Shi
Title of Talk:	Polarization reference frame alignment using the inverse-matrix method

Abstract:

When photons propagate across an optical fiber, their state of polarization undergoes a random unitary transformation. This causes misalignment in the polarization reference frames between the two fiber ends. Such misalignment renders a polarization-encoding based quantum network inoperable, and therefore needs to be actively compensated.

I have developed a method to systematically perform such polarization compensation. Instead of using heuristic methods to iteratively optimize the system, this method executes a fixed number of measurements to fully characterize the fiber, and directly sets an in-line polarization controller to neutralize the fiber transformation. This method can be implemented using both classical or single-photon reference light, and only takes a fixed amount of execution time.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Jack Deye

Academic Institution: University of California, Los Angeles | **Major:** Math of Computation

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): TBD

NIST Laboratory, Division, and Group: Information Technology Laboratory, Applied and Computational Mathematics Division, Mathematical Modeling Group

NIST Research Advisor: Dr. Ryan Evans

Title of Talk: Higher-Order Numerical Methods for Integro-differential Equations in Biological Field Effect Transistors

Abstract:

Biological field effect transistors (Bio-FETs) are bio-electronics that offer novel biomarker measurements and promise to broaden access to crucial medical diagnostic tests. Traditionally, measurement techniques require specialized facilities and expensive equipment; however, Bio-FETs offer rapid, accurate and cost-effective measurements in a hand-held and portable form. In these devices, chemical reactants are injected into a solution-well, where they bind to biochemical gates on the surface of the sensor, which produces an electrical signal. A mathematical model for this process takes the form of an integro-differential equation with a logarithmically singular kernel.

Various quadrature techniques are used to discretize the integral, including Gauss-Legendre quadrature and a modified trapezoid rule with Kress quadrature. This leads to a Nyström scheme, which is then solved using an implicit Runge-Kutta method and a suitable nonlinear solver. Practical applications of the model are discussed as well as comparing the model to experimental data.

Material Measurement Laboratory 2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Material Measurement Laboratory (MML)

<u>Student Names and Talk Titles</u> (in order of presentation)

Ryan C. Giang *(plenary speaker):* (CHIPS) Lifetime Predictions and Cure Kinetics of Semiconductor Packaging Materials via Thermal Analysis

Charles Rhys Campbell: (CHIPS) CrystalGen: Benchmarking GPT, Diffusion, and Flow Models for Atomic Structure Discovery

Ian Fagan: The Challenges of Maintaining Data Infrastructure Systems: A Materials Genome Initiative Case Study

Owen Lin: Atoms to Fields: Bridging Length Scales for Grain Boundary Modeling

Sarika P. Kapadia: Unraveling Soil Microbiome Composition and Interactions: A Network Analysis Approach

Khoa Hoang: Mammalian Cell Counting Techniques Using the NISTCHO Reference Cell Line

Terra Pickett: Use of varying angles and apertures in ATR and Transmission FTIR to Measure Distance of Specific Functional Groups within AMPs

Edgar Robitaille: CompareLR: A Comparative Analysis Tool for Evaluating Probabilistic Genotyping Software Using Likelihood Ratios

Alitza Soiffer: Impact of Structural Motifs in Antimicrobial Peptides on Membrane Interaction and Antibacterial Activity

Grace Boyer: Investigating analytical methods for detection, identification, and quantitation of drug mixtures

Zainab Altamimi: (virtual) QA/QC in Point-of-Care Pharmaceutical Manufacturing and Precision Medicine

Johanna Zimmerli: Optimization of Cryomilling Process for Development of Micro and Nanoplastics Test Materials

Julia Tisaranni: Optimizing the Development of Metal-Organic Frameworks Through Autonomous Design

Shawn Chen: (CHIPS) A Dual Approach to Digital Image Correlation (DIC): Open-Source Benchmarking and Deep Learning

Siena Iavarone-Garza: (CHIPS) Characterizing Residual Stress in Semiconductor Packaging Films Induced by Hygrothermal Cycling

Dante Ribeiro: (CHIPS) Development of a Low Dielectric Epoxy Test Material for Semiconductor Packaging

Leonardo Borchert: (CHIPS) Measuring Interfacial Bonding Strength of Photonic Devices by Indentation-Induced Blistering

Annabel Shim: Microstructural Evolution in Direct Reduction Ironmaking

Avery Ye: Advancements in OCEAN: Curvilinear Real-Space Grids for Core-Level Spectroscopy

Ritika Rajamani: WebFF Molecular Dynamics (MD) Force-Field Repository: Schema Expansion, Programming and Data Testing

Bridget Bidwell: (CHIPS) Accelerated Discovery of Amorphous Dielectric Materials Using Machine Learning and First-Principles Simulations

Nishwanth Gudibandla: Tuning the Magnetic Properties of Two-dimensional (2D) VxTi1-xSe2 Through Alloying

John Kline: Anchoring O_2 A-band Spectra Using an Optical Frequency Comb

Christopher Gutowski: (CHIPS) Probing Molecular Diffusion Into BARC Layers in Advanced Photoresists

Tyra E. Espedal: Measuring Fluorescence Phenomena in Time-Gated Raman Spectroscopy

Samuel Bentz: In-Situ Monitoring of Ceramic Vat Photopolymerizaton 3D Printing

Dylan Roberts: (CHIPS) An Analysis of the Thermal Stability of Magnetic Nanostructures

Lina Stensland: (CHIPS) Exploring chemistry & thickness of tin photoresists for extreme ultra-violet photolithography

Aditya Chezhiyan: Modeling Ion Distributions in Block Copolymers Using Resonant Soft X-ray Scattering

Katia Graciela Gonzalez-Adame: Understanding Density Functional Theory for Copper Electrodeposition Analysis

Aryn Loew: (CHIPS) Step by Step: Investigating the Electrodeposition of Copper

Harkeerith Vij: (CHIPS) Developing Standard Reference Materials for Use in CHIPs Through X-Ray Florescence

Eliana Crew: Development of SAFT-based Coarse-grained Models of Noble Gases and Other Small Molecules for Vapor-liquid Equilibria Simulations

Naman Parikh: Evaluating the Performance of VQE for Quantum-DFT Embedding on Chemical Databases

Preston Yeung: Computational Fluid Dynamics (CFD) Analysis of L-PBF Additive Manufacturing

Trisha Lad: Sample Form Effects in Near-IR Analysis of Post-Consumer Polyolefins for Machine Learning

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Ryan C. Giang

Academic Institution:	University of California, San Diego	**Major:**	Chemical Engineering
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Graduate school for chemical engineering or materials science		
NIST Laboratory, Division, and Group:	MML, 643: Materials Measurement Science, 10: Security Technologies		
NIST Research Advisor:	Ran Tao, Amanda Forster		

Title of Talk: Lifetime Prediction and Cure Kinetics of Semiconductor Packaging Materials via Thermal Analysis

Abstract:

In the Age of AI, we increasingly rely on advanced computing systems for applications ranging from autonomous vehicles to large-scale data analysis. This growing demand is accelerating innovation in advanced semiconductor packaging technologies, especially in 3D heterogeneous integration, which is essential to the performance of AI servers. As these systems become more powerful and compact, polymeric packaging materials—ubiquitous in semiconductor chip assemblies—play a critical role in protecting microelectronic components and ensuring performance, reliability, and long-term functionality. However, combining dissimilar materials in 3D heterogeneous integration introduces significant challenges such as coefficient of thermal expansion (CTE) mismatch and cure-induced shrinkage, which can lead to warpage, internal stress, and reliability concerns in the final package. Understanding cure and decomposition kinetics is essential for mitigating these issues and ensuring consistent performance in this rapidly expanding industry.

In this study, we investigate the cure kinetics (how the material undergoes cross-linking reaction over time and temperature) and thermal stability of a commercial underfill material used in advanced semiconductor packaging. Differential scanning calorimetry (DSC) was employed to characterize key thermal transitions and perform cure kinetics analysis, enabling prediction of the degree of cure under various thermal profiles. Thermogravimetric analysis (TGA) was used to assess thermal stability, decomposition behavior, and material composition. In addition to identifying the onset temperature of degradation, the TGA data—interpreted using appropriate kinetic models—provide valuable insights into the lifetime prediction of the material under varying thermal conditions. These findings support the innovation of thermally robust packaging materials, advancing R&D in next-generation packaging technologies for AI-driven systems operating under elevated-temperature conditions.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Charles Rhys Campbell		
Academic Institution:	West Virginia University	**Major:**	Physics
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	PhD in computational materials science		
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Division 642, Group 5		
NIST Research Advisor:	Dr. Nia Rodney-Pollard		
Title of Talk:	CrystalGen: Benchmarking GPT, Diffusion, and Flow Models for Atomic Structure Discovery		

Abstract:

Generative models are increasingly used in materials science because they can rapidly propose plausible candidate materials for further study. Although several architectures have been introduced, including generative pretrained transformers (GPT), diffusion models, and Riemannian flow matching (RFM) networks, their relative performance on common benchmarks remains unclear. We present the first systematic comparison of three representative models on two public databases using consistent evaluation metrics. AtomGPT, a GPT based model, Crystal Diffusion Variational Autoencoder (CDVAE), a diffusion model, and FlowMM, an RFM model, were trained to reconstruct subsets of the JARVIS Supercon 3D and Alexandria Supercon datasets. We measured the Kullback-Leibler divergence between predicted and target distributions of crystal lattice parameters along with the mean absolute error of individual lattice parameters. We also assessed each model's ability to recover correct space groups, chemical formulas, and Bravais lattices. AtomGPT trained on JARVIS Supercon 3D achieved the lowest average lattice parameter Kullback-Leibler divergence of 0.018 nats, which is 37% lower than the highest value of 0.049 nats obtained by FlowMM trained on Alexandria Supercon. The same AtomGPT configuration reached the lowest average mean absolute error of 0.641 Å for distance parameters and 10.9 ° for angular parameters, whereas FlowMM trained on JARVIS Supercon 3D showed the highest average mean absolute error of 1.09 Å for distance parameters and 20.5 ° for angular parameters. Across both datasets AtomGPT consistently outperformed CDVAE and FlowMM at the cost of substantially longer training and inference times. By establishing this standardized benchmark, we enable more rapid model innovation for future materials-discovery efforts.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Ian Fagan			
Academic Institution:	University of Pittsburgh	**Major:**	Chemical Engineering
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Most likely Graduate School, either in the U.S. or abroad		
NIST Laboratory, Division, and Group:	MML, Materials Science and Engineering Division, Thermodynamics and Kinetics Group		
NIST Research Advisor:	Dr. Carelyn Campbell		
Title of Talk:	The Challenges of Maintaining Data Infrastructure Systems: A Materials Genome Initiative Case Study		

Abstract:

The National Institute of Standards and Technology (NIST) launched the Materials Data Repository (materialsdata.nist.gov) in 2013, a pioneering community-based shared materials data repository, in response to the Materials Genome Initiative. This repository was one of the first to adopt the FAIR (Findable, Accessible, Interoperable, and Reusable) data standards, facilitating international collaboration and data reuse with standardized metadata. The initial repository was based on the D-Space open-source software (https://dspace.org/) that allowed users to group related records together in communities and collections, provided persistent identifiers for each record, and enabled users to share a wide range of file types.

However, sustaining the repository over the past decade has become increasingly challenging, and newer software solutions have emerged. To address this issue, a critical migration project to transfer the existing materialsdata.nist.gov repository from D-Space to the NIST Configurable Data Curation System (CDCS), a more modern and adaptable platform was initiated. This transformation involved developing custom Python scripts for data manipulation, designing schemas, and creating XSL transformation scripts to preserve the structure and content. The deployed customized CDCS instance includes the preservation of key features from the original D-Space repository, including the persistent identifiers, the community and collection structure, the data provenance, and all of the associate files associated with each record.. The records from the Experimental Data and Computational File community collections are used to validate the migration's success, ensuring continuity and enhanced sustainability for the Materials Data Repository.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Owen Lin	
Academic Institution: University of Maryland	**Major: Physics**
Academic Standing (Sept. 2025): Sophomore	
Future Plans (School/Career): Considering career in tech or data science	
NIST Laboratory, Division, and Group: MML, MSED, Thermodynamics and Kinetics Group	
NIST Research Advisor: Anas Abu-Odeh	
Title of Talk: Atoms to Fields: Bridging Length Scales for Grain Boundary Modeling	

Abstract: Grain boundaries, which are interfaces between two crystalline regions with different orientations, can dramatically modify material properties such as strength, electrical conductivity, and mass transport. The ability to model grain boundary motion is necessary for the control of microstructure of polycrystalline materials during processing and operating conditions. Phase-field modeling provides an elegant, continuum approach to simulate the evolution of grain structures, but the approach is currently limited due to the inability to reproduce correct grain boundary energies. In this talk, I provide a pathway to address this problem by taking atomistic data of grain boundaries, and converting local features into a continuum field. I discuss how these fields can be used to address the limitation of phase-field, and conclude with a preliminary attempt to do so using machine-learning

SURF Student Colloquium

NIST – Boulder, CO

July 29 - 31, 2025

Name: Sarika P. Kapadia

Academic Institution: University of Maryland, College Park **Major:** Cell Biology & Molecular Genetics

Academic Standing (Sept. 2025): Graduate

Future Plans (School/Career): Pursue an MD/PhD

NIST Laboratory, Division, and Group: Measurement and Materials Laboratory, Biosystems and Biomaterials Division (644), Complex Microbial Systems Group

NIST Research Advisor: Dr. Carly Muletz-Wolz

Title of Talk: Unraveling Soil Microbiome Composition and Interactions: A Network Analysis Approach

Abstract:

Soil microbiomes play a crucial role in maintaining ecosystem health and function. However, understanding the complex interactions within these microbial communities remains a significant challenge. Traditional methods, such as pairwise interactions, often fall short in capturing the intricate higher-order relationships between microorganisms, as the sheer diversity and complexity of these interactions can be overwhelming. Network analysis offers a promising approach to overcome this limitation, allowing researchers to represent and analyze the complex web of relationships between microbial species and drive hypotheses for microbiome engineering. In this study, we analyzed soil samples from NIST and USDA plots to investigate the composition and diversity of soil microbiomes. Using 16S rRNA gene amplicon sequencing, we characterized the bacterial communities and identified amplicon sequence variants (ASVs), providing a detailed snapshot of the microbial diversity present in these ecosystems. To normalize sequence counts and validate networks, we used internal spike-ins RM8376. We then employed the SPEIC-ESI program to construct networks that reveal the interactions between microbial species, providing insights into the complex relationships within soil microbiomes. Furthermore, we will expand this study by introducing a fluorescent pathogen to examine how microbiome composition relates to pathogen resistance. By shedding light on the intricate interactions within soil microbiomes, this research has the potential to uncover novel mechanisms underlying soil microbiome function and inform strategies for mitigating the impacts of pathogens.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Khoa Hoang		
Academic Institution:	University of Maryland, Baltimore County	**Major:**	BA in Biology
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	To attend medical school and obtain an MD		
NIST Laboratory, Division, and Group:	Material Measurement Lab., Biomolecular Measurement Div., Bioprocess Measurements Group		
NIST Research Advisor:	Dr. Ioannis Karageorgos		
Title of Talk:	Mammalian Cell Counting Techniques Using the NISTCHO Reference Cell Line		

Abstract:

Chinese hamster ovary (CHO) cells are one of the most popular sell lines for the manufacturing of biopharmaceutical products and at the center of a multi-billion dollar industry. CHO cells are genetically designed to produce several grams of a specific target protein. The National Institute of Standards and Technology in collaboration with MilliporeSigma developed a new mammalian cell line (NISTCHO) of interest to the biopharmaceutical and biomanufacturing communities. NISTCHO has been recently released as reference material RM 8675. NISTCHO RM 8675 expresses a non-originator version of the widely used monoclonal antibody molecule reference material, NISTmAb, named "cNISTmAb". Typically, cell lines producing mAbs are not accessible for open access or pre-competitive research. NISTCHO will serve as the first of its kind, open access NIST living reference material for biomanufacturing.

Cell counting techniques are crucial in various scientific and medical fields, enabling accurate determination of cell concentrations and densities. In cell culture, especially in bioprocessing, knowing how many cells are alive vs. dead is essential for optimizing conditions, monitoring cell growth, assessing cell viability, and standardizing experiments. Accurate cell counts are vital in performing cell-based assays and diagnosing and monitoring various diseases. The most common method for cell counting is with a classic hemocytometer. Advancements in imaging technologies have enabled the automation of cell counting, providing improved accuracy and reliability. In this project, we used a variety of cell counters like Vicell XR, ORFLO, and TC-20 to perform measurements on the NISTCHO cell line and tested these technologies.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Terra Pickett

Academic Institution: University of Maryland - College Park	**Major:** Chemical Engineering

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Industry or Graduate School

NIST Laboratory, Division, and Group: Material Measurement Laboratory, Biomolecular Measurement Division, Meuse Group

NIST Research Advisor: Dr. Robert Allsopp

Title of Talk: Use of varying angles and apertures in ATR and Transmission FTIR to measure distance of specific functional groups within AMPs

Abstract:

In an era of growing concerns regarding antimicrobial resistance, antimicrobial peptides (AMPs) provide a promising solution. Most antibiotics are inhibiting substances produced by bacteria for a competitive advantage over other bacteria. Although effective, antibiotics are prone to resistance, since all strains of bacteria have similar cell walls, and substances that are harmful to other bacteria are often harmful to themselves. In contrast, AMPs are naturally occurring in higher organisms and can exhibit more aggressive behavior without threatening the host's survival. AMPs often function by forming structures within bacterial bilayers, disrupting homeostasis through various mechanisms.

In learning more about the various structure-forming mechanisms of specific components in peptides that cause antimicrobial effects, it is essential to study the ensemble of structures within a peptide and how they change when interacting with the bilayer. In this project, we developed attenuated total reflectance and transmission FTIR methods to characterize peptide mechanisms of action. Although it provides less detailed information than alternative techniques such as crystallography and cryo-EM, FTIR is a non-destructive method for studying an in vitro peptide-bilayer system without influencing the peptide ensemble.

Specifically, we developed methods to measure distances between distinct functional groups in a peptide by collecting a series of measurements with varying apertures and angles, each containing different amounts of information about different parts of the peptide-bilayer system. This data was analyzed using two-dimensional correlation spectra where we experimented with several approaches to obtain restraints for simulations, including the use of characteristic asynchronous bands and extracting effective distances from the Beer-Lambert law. The resulting distance information restraints were the basis of simulations of bilayer-peptide complex models. Both the simulations and measurements demonstrated that they can follow the conformational changes throughout the interaction, providing insight into the peptide's mechanism of action, furthering our understanding of AMPs.

SURF Student Colloquium

NIST – Gaithersburg, MD July 29 - 31, 2025

Name: Edgar Robitaille			
Academic Institution:	Johns Hopkins University	**Major:**	Biomedical Engineering
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Med School / PhD / Grad School		
NIST Laboratory, Division, and Group:	MML		
NIST Research Advisor:	Dr. Sarah Riman		
Title of Talk:	CompareLR: A Comparative Analysis Tool for Evaluating Probabilistic Genotyping Software using Likelihood Ratios		

Abstract: DNA profiles generated from evidentiary material can be challenging to interpret manually. Forensic laboratories have implemented probabilistic genotyping software (PGS) to determine possible genotype combinations from these profiles, and assign evidential weight in the form of a Likelihood Ratio (LR) when a person of interest is available. Prior research has shown that different software packages do not always assign equal or similar profile LR values, even when analyzing the same DNA mixture profile. Discrepancies between software outputs could raise concerns among the judicial system regarding the degree of uncertainty and reliability when using PGS to interpret DNA evidence. Here we present the development of CompareLR, a standalone, open-source, and easy-to-use software tool that allows forensic practitioners and researchers to further understand the degree of uncertainty in the statistical models used to assess strength of forensic evidence at the locus and profile LR level. The software allows users to load their own data analyzed in any PGS. CompareLR has the following key features: it (1) generates Receiver Operating Characteristic (ROC) curves at both the locus and profile levels; (2) counts the contributor LRs that are larger than the first observed noncontributor LR value; (3) plots locus-by-locus $\log_2$(LR) values and overall profile $\log_{10}$(LRs) obtained from both the contributor tests and noncontributor tests; (4) quantifies the extent of variation in LR values at both the locus and profile level; (5) identifies samples of which LR differences exceed a user-defined LR threshold; and (6) calculates the Manhattan distance to quantify the level of agreement/disagreement between PGS being compared. In our previous work, a total of 154 two-person, 147 three-person, and 127 four-person mixture profiles of varying DNA quality, DNA quantity, and mixture ratios were deconvolved using two PGS, STRmix and EuroForMix [1]. As a proof-of-concept, this same data will be used as an example to demonstrate the usability, relevance, and accuracy of CompareLR before its public release.

Reference

[1]. S. Riman, H. Iyer, P.M. Vallone. Examining performance and likelihood ratios for two likelihood ratio systems using the PROVEDIt dataset PLoS One, 16 (9) (2021), Article e0256714, 10.1371/journal.pone.0256714

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Alitza Soiffer

Academic Institution: University of Chicago | **Major:** Chemistry

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Undecided, likely pursue a PhD

NIST Laboratory, Division, and Group: MML, Biomolecular Measurement Division, Biomolecular Structure and Function Group

NIST Research Advisor: Ella Mihailescu

Title of Talk: Impact of Structural Motifs in Antimicrobial Peptides on Membrane Interaction and Antibacterial Activity

Abstract:

Antimicrobial resistance arises when excessive use of antimicrobial medications kills susceptible bacteria while allowing resistant strains to survive and proliferate. Over time, this selective pressure drives the evolution of resistance to commonly used treatments. Antimicrobial peptides (AMPs), short chains of amino acids with antimicrobial properties, offer a promising alternative because they often insert into bacterial membranes and disrupt multiple cellular processes, making it more difficult for pathogens to develop resistance through a single mechanism.

This project aims to determine how amino acid sequence motifs found in highly effective AMPs affect both the physical behavior of peptides in lipid membranes and their antimicrobial potency. These motifs were introduced into a template helical peptide that does not exhibit antimicrobial activity, and the resulting designs were analyzed via fluorescence spectroscopy, circular dichroism, and bacterial assays. The fluorescence of the amino acid tryptophan increases in intensity and exhibits a blue shift when in a hydrophobic environment, allowing one to evaluate the degree of peptide interaction with the lipid bilayer based on fluorescence intensity. Circular dichroism spectroscopy provides information on the peptides' secondary structure, which is useful because AMPs often acquire an α-helical structure when embedded in lipid vesicles, whereas those that remain in solution typically form unstructured random coils. Bacterial assays measure the minimum concentration of peptide that inhibits bacterial growth.

By identifying motifs and the associated structures that enhance antimicrobial activity, this research supports the intelligent design of peptides with high antimicrobial efficacy. The resulting data will be used to train an AI model to predict highly potent AMPs for therapeutic applications.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Grace Boyer

Academic Institution: Eastern Kentucky University

Major: Forensic Science and Chemistry

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Grad school for Chemistry

NIST Laboratory, Division, and Group: MML, Materials Measurement Science Division, Surface and Trace Chemical Analysis Group

NIST Research Advisor: Thomas Forbes

Title of Talk: Investigating analytical methods for detection, identification, and quantitation of drug mixtures

Abstract:

The chemical analysis of drugs is a key element for many different communities, including forensics, law enforcement, and public health. These analyses often span detection, identification, and quantification. Traditional analytical methods, such as Liquid Chromatography -Mass Spectrometry (LC-MS) and Gas Chromatography-Mass Spectrometry (GC-MS), often require the samples to be exported to labs with capable technology and have run times that take hours to process. As more mobile and portable analytical instrumentation have developed, analyses can now take place on-site.

This project investigates numerous analytical methods to determine their applicability to the various chemical analysis processes employed by these fields. These methods included, highly mobile, handheld instruments, such as Raman spectroscopy, which is non-destructive and capable of field-use and stand-off analysis, protecting the analyst from any major contact with the unknown substance. We also investigated emerging chromatography-free mass spectrometry systems using direct analysis in real time (DART) ionization – a rapid technique growing in popularity for screening analyses.

Representative drug samples with common additives and excipients were investigated for identification, interference, and quantification. Identifications can be made with commercial or custom internal libraries. Additionally, the accuracy of results from a lower resolution triple quad mass spectrometer (MS) was compared to the accuracy from a higher resolution time of flight (ToF) MS. Included in this, was the exploration of using existing high-resolution mass spectral library search data (NIST/NIJ DART-MS Forensics Database) with low resolution sample data. The effects of drug interactions and interferences were also examined for both mixtures and isobaric species. With the current, rapidly changing world of drug chemistry, developing critical measurement science for emerging analytical techniques and making every effort to minimize analysis time and analyst contact with hazards, allows for faster analysis and safer work environments.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Zainab Altamimi
Academic Institution:	Gannon University
Major:	Biomedical Engineering
Academic Standing (Sept. 2025):	MS1 at Lake Erie College of Osteopathic Medicine (LECOM)
Future Plans (School/Career):	Orthopedics | Engineering
NIST Laboratory, Division, and Group:	MML, Materials Measurement Science Division, Surface and Trace Chemical Analysis Group
NIST Research Advisor:	Thomas P. Forbes
Title of Talk:	QA/QC in Point-of-Care Pharmaceutical Manufacturing and Precision Medicine

Abstract:

Pharmaceutical manufacturing capabilities in hospitals, pharmacies, and other point-of-care (PoC) sites can facilitate emergency preparedness to offset medical disasters and shortage, especially for remote locales. Additive manufacturing, such as semi-solid extrusion and drop-on-demand deposition, allow for greater customization and complexity of pharmaceuticals. Precise dose control improves patient-relevant outcomes through tailoring, tapering, and personalized medicine. As drug distribution increasingly follows a decentralized model it requires the support of on-site chemical analysis to provide quality assurance (QA) and quality control (QC). Developments in portable, cost-effective analytical chemistry equipment empowers distributed manufacturing and PoC sites to adopt pharmaceutical production.

This work examines the ability of several analytical techniques to indicate and quantify the different medications compounded into various delivery vehicles. We employ pre-production QA of stock active pharmaceutical ingredients (API) and post-production QC of final batch samples. Stock APIs (e.g. printer inks), saline solutions, powder mixtures, single-compound tablets, and polypills were investigated by absorbance spectroscopy, vibrational spectroscopy, and mass spectrometry (MS). Measurement challenges grew with formulation complexity. A single polypill can address numerous therapeutic needs like combining statin, anti-platelet, and anti-hypertensive agents for cardiovascular diseases. Interferences or distortions in compound-specific signals are observed when different APIs were present. Investigations followed quantifying single-component samples using UV-Vis and of opioid withdrawal polypills with direct analysis in real time (DART) for chromatography-free triple-quadrupole (TQ) MS. Quantitative methods using Beer-Lambert Law are compared for binary mixtures while results in DART-TQ MS were analyzed for matrix effects such as competitive ionization. Additionally, the detection limits of handheld Raman—offering instantaneous, standoff identification for safe handling—were tested for powder mixtures.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Johanna Zimmerli		
Academic Institution:	Moravian University	**Major:**	Chemistry
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Graduate School for chemistry, work in industry		
NIST Laboratory, Division, and Group:	MML, Materials Measurement Science Division, Nanomaterials Research Group; 643.03		
NIST Research Advisor:	Tae Joon Cho		
Title of Talk:	Optimization of cryomilling process for development of micro and nanoplastics test materials		

Abstract:

Micro and nanoplastics (MNPs) are defined, in part, by their size with microplastics (MPs) ranging from 5 mm to 1 μm and nanoplastics (NPs) being smaller than 1 μm, according to ISO/TR 21960:2020. Since MNPs originate from the degradation of plastic products, their shapes, sizes, and chemical compositions are extremely variable, making them uncontrolled wastes. Validated methods and protocols are essential for accurate chemical analysis, including identification and quantification of MNPs as well as exposure and risk assessments. However, a fundamental challenge is securing the 'test materials' needed to develop methods to better understand the uncertainty associated with conducting the research. From a practical standpoint, it would be a significant challenge to collect and accurately characterize real-world MNP samples from recycling facilities, trash yards, coast, etc. in sufficient mass quantities to study. Additionally, engineered commercially available micro/nanomaterials are typically monodisperse and spherical, unlike those degraded naturally. Therefore, for MNP-related metrology development, MNP test materials designed to incorporate real-world MNP properties rather than engineered micro/nanomaterials would allow for a higher level of analysis, enabling more accurate secondary MNP physicochemical characterization and associated risk assessment.

For this project, I will present our preliminary study on generating MNP research grade test materials (≤ 10 μm) from pristine commercial plastic product (e.g., polyethylene terephthalate; PET) using cryomilling (CM) methods. This approach has been optimized and evaluated for reproducibility of the samples generated, considering critical factors such as CM time, types of milling balls, and plastic properties (e.g., crystallinity), with aids of various characterization techniques including laser diffraction, dynamic light scattering, and scanning electron microscopy.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Julia Tisaranni		
Academic Institution:	University of Maryland - College Park	**Major:**	Chemical and Biomolecular Engineering
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Potentially pursue a masters or work in industry		
NIST Laboratory, Division, and Group:	MML, Materials Measurement Science Division, Data and AI-Driven Materials Science Group		
NIST Research Advisor:	Howie Joress		
Title of Talk:	Optimizing the Development of Metal-Organic Frameworks Through Autonomous Design		

Abstract:

Metal-organic frameworks (MOFs) are highly porous materials consisting of a crystalline network of metal ions and organic linkers. They have shown promise as a material with many applications such as gas storage and separation, catalysis, drug delivery, and much more. In particular, this structure is ideal for the controlled capture and release of gases due to their large internal surface area.

However, there is much we don't know about synthesizing MOFs. In much of the existing literature scientists will specify one formula they found to produce a high-quality MOF. They omit information on undesirable synthesis results even though it could be used to support other synthesis efforts. Having this data could accelerate MOF research efforts. By creating a system that tests a multitude of MOF synthesis parameters, a database can be rapidly created.

This project aims to do this by autonomizing the synthesis of MOFs. For this we chose Cu-BTC, commonly known as HKUST-1 or MOF-199, which is composed of a Cu2+ ion center and benzene-1,3,5-tricarbocylate as its linker. Cu-BTC is relatively easy to synthesize, has good thermal stability, and does not show signs of degradation through adsorption and desorption.

Our MOF robot autonomously preforms the experiment by designing a plan for the reaction and executing the synthesis. Then, we determine the quality of the MOF by analyzing its structure through x-ray diffraction (XRD) and its capacity to adsorb gases through Fourier transform infrared spectroscopy (FTIR). We are developing efficient ways to lessen the required human interaction by easing dry sample transfer to XRD and digitizing gas flow control for FTIR.

By autonomizing the synthesis of MOFs and creating a database of results, researchers will be able to better predict the optimal synthesis conditions for new MOFs.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Shawn Chen		
Academic Institution:	University of Pennsylvania	**Major:**	Computer Science
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	Working in industry; interested in data science and ML		
NIST Laboratory, Division, and Group:	MML, MMSD, Security Technologies		
NIST Research Advisor:	Dr. Alexander Landauer		
Title of Talk:	A Dual Approach to Digital Image Correlation (DIC): Open-Source Benchmarking and Deep Learning		

Abstract:

While many DIC software packages are readily available, they vary significantly in their underlying algorithms and output characteristics, creating a need for a streamlined and standardized approach to compare their accuracy and reproducibility. This work was focused on developing tools to enhance DIC reliability when it comes to its epoxy curing and warpage measurement use cases. This problem was addressed through two distinct efforts.

The first half involved evaluating a range of open-source DIC software tools to assess their accuracy and reproducibility. A custom Python-based graphical user interface (GUI) application was developed using Tkinter and the scientific Python Stack (Numpy, Matpotlib, Scipy, Pandas, Seaborn) to streamline this comparison, allowing users to visualize displacement fields, overlay statistical results, and compute quantitative metrics.

The second half focused on machine learning for uncertainty quantification. A convolutional neural network (CNN), based on pre-existing unpublished code, was designed to perform predictive 2D-DIC uncertainty mapping, generating pixel-wise uncertainty estimates. Additionally, the feasibility of model re-training and transfer learning was explored to reduce computational costs and mitigate bias introduced by the reliance on artificially generated training data and outputs derived from a single DIC software.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Siena Iavarone-Garza

Academic Institution: University of Maryland, College Park | **Major:** Electrical Engineering

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Graduate school / Chip industry

NIST Laboratory, Division, and Group: Materials Measurement Lab, Materials Science and Engineering Div., Functional Polymers Group

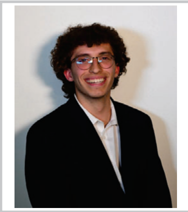
NIST Research Advisor: Stian Romberg, Polette Centellas

Title of Talk: Characterizing Residual Stress in Semiconductor Packaging Films Induced by Hygrothermal Cycling

Abstract:

Epoxy resins are frequently used to provide mechanical support, electrical insulation, and environmental protection in semiconductor packages, such as flip chip and wire bonded assemblies. Changes in humidity and temperature cause cured epoxy resins to expand or contract more than the substrates they protect, creating residual stresses which can cause packages to warp, and in extreme cases delaminate. Understanding how residual stress and warpage develop during hygrothermal cycling in epoxy films will improve predictive models and enhance semiconductor performance, miniaturization, and cost efficiency. The accuracy of predictive finite element models used in industry are based on the material properties used as inputs, meaning that accurate measurements are essential. Unfortunately, to protect their intellectual property, material suppliers do not reveal much about how their material behaves. This places the responsibility of characterization on their customers, the semiconductor packaging companies, who could benefit from standardized techniques to most effectively conduct these measurements. We support the effort to build these standards using a model epoxy resin film, comprised of diglycidyl ether of bisphenol F (DGEBF) resin and diethyl toluene diamine (DETDA) hardener, the foundational component for many commercial polymeric packaging materials. We characterize the moisture uptake and expansion of this material using a Vapor Sorption Analyzer (VSA). MatLab is used to calculate the moisture diffusivity and saturated mass of films at different relative humidities. Thermomechanical Analysis (TMA) is used to quantify dimensional expansion due to temperature cycling, which provides a measurement of the coefficient of thermal expansion (CTE). Finally, we employ an ellipsometer to measure the dimensional expansion of the epoxy film coated on a diced silicon wafer under varying hygrothermal conditions.

Keywords: Semiconductor Packaging Materials; Hygrothermal Cycling; Residual Stress; Flip Chip; Thermosets.



SURF Student Colloquium

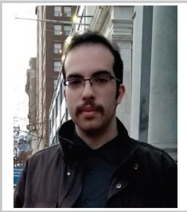
NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Dante Ribeiro
Academic Institution:	The Pennsylvania State University
Major:	Materials Science and Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate school for Materials Science and Engineering. Perhaps with an interest in polymers or optics.
NIST Laboratory, Division, and Group:	Materials Measurement Lab, Materials Science and Engineering Division, Functional Polymers group.
NIST Research Advisor:	Andrew Korovich
Title of Talk:	Development of a low dielectric epoxy test material for semiconductor packaging.

Abstract:

Modern semiconductor manufacturing and packaging has a critical need for well-defined and characterized test materials, as emerging technologies are utilizing finer spacings between interconnects as well as 3D architectures that are more sensitive to stress and warping induced during the curing of packaging materials. Additionally, the operating frequencies of processors and data signaling continue to grow faster, highlighting a need for materials with low dielectric constants (Dk) and dielectric losses (Df). We investigate three materials composed of bisphenol F diglycidyl ether (DGEBF) epoxy resin; one cured using solely an aromatic amine, diethyl toluene diamine (DETDA), another cured with a mixture of DETDA and 4,4′-Hexafluoroisopropylidene diphthalic anhydride (6FDA), and a third with methylhexahydrophthalic anhydride (MHHPA). The introduction of bulkier substituent groups, or functional groups with lowering polarizability, and the addition of nano/micro filler materials are targeted methods to lower dielectric properties. The DGEBF/DETDA, DGEBF/MHHPA, and DGEBF/DETDA/6FDA mixtures measured Dk values of 2.500, 2.570, and 2.527 respectively and Df values of 0.0797, 0.0898, and 0.0774 respectively. Both formulations with DETDA present have more ideal dielectric loss values while all have similar dielectric constants. Additionally, we investigate the effect of curing time on the dielectric properties of the resulting material; shorter cure times resulting in an incomplete cure could result in a larger number of polarizable functional groups available in the material that can both affect the dielectic loss, as well as attract moisture, further influencing the dielectric properties.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Leonardo Borchert

Academic Institution: The George Washington University | **Major:** Aerospace Engineering

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Masters in Engineering Management & PHD in Aerospace. Specializing in forms of propulsion.

NIST Laboratory, Division, and Group: Materials Measurement Lab., Div. 643, Nanomechanical Properties Group

NIST Research Advisor: Yvonne Gerbig

Title of Talk: Measuring Interfacial Bonding Strength of Photonic Devices by Indentation-Induced Blistering

Abstract:

In the semiconductor industry, advanced packaging technologies, such as wafer-to-wafer (W2W) or die-to-wafer (D2W) integration, are currently being developed to improve their scalability and efficiency. W2W involves bonding entire processed wafers, while D2W bonds individual die (or chiplets) to a target wafer. For the bonded structures to withstand subsequent processes like grinding, dicing, and packaging, it is essential to optimize the bonding process and ensure its reliability. This, in turn, requires the measurement of the interfacial bonding strength. However, methods commonly used for W2W bond strength measurements, such as the Maszara test, cantilever beam test, or four-point bending test, are not applicable to die-level bonding. For D2W integration, indentation-based approaches are currently being evaluated as an alternative methodology for various semiconductor device structures. When combined with mechanics-based models, indentation can be used to assess bonding strength of thin films by inducing well-defined delamination areas (blisters), where the film detaches from the substrate.

This project evaluates the suitability of indentation-induced blistering for measuring the bonding strength of the interface between a gallium arsenide (GaAs) layer and silicon oxide (SiO2) substrate of a photonic device. An analytical framework was developed to determine the bonding strength based on dimensional measurements of the induced blisters and force-displacement curves collected during indenting the GaAs/SiO2 structure. To ensure reproducibility and scalability, this framework is supported by the development of custom software that automates data analysis and visualization, enabling high-throughput characterization of multiple samples and tests.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Annabel Shim		
Academic Institution:	The Ohio State University	**Major:**	Materials Science and Engineering
Academic Standing (Sept. 2025):	Graduated with undergraduate degree in spring of 2025		
Future Plans (School/Career):	PhD in Materials Science		
NIST Laboratory, Division, and Group:	MML, Materials Science and Engineering Division, Thermodynamics and Kinetics Group		
NIST Research Advisor:	Andrew Iams		

Title of Talk:	Microstructural Evolution in Direct Reduction Ironmaking

Abstract:

The iron and steel industries are undergoing a period of transformation, driven by the need to diversify production methods, modernize legacy infrastructure, and strength global supply chains. As a result, alternative ironmaking technologies are gaining attention. Direct reduction ironmaking (DRI) offers a promising alternative to the conventional blast furnace processes. The DRI process utilizes hydrogen exclusively as the reducing agent, potentially enabling a greener iron production pathway. Despite its potential, the fundamental mechanisms driving the hydrogen reduction process remain complex and not fully understood. This study investigates the phase transformations and microstructural evolution of DRI iron ore pellets at various stages of reduction. The findings offer critical insights into spatial variations of microstructure and phases, contributing to a deeper understanding of the reduction mechanisms and addressing challenges associated with this alternative ironmaking approach.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Avery Ye
Academic Institution:	Johns Hopkins University
Major:	Biomedical Eng. and Computer Science
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate school in biomedical engineering
NIST Laboratory, Division, and Group:	MML, Materials Measurement Science Division, Microscopy and Microanalysis Research Group
NIST Research Advisor:	John Vinson
Title of Talk:	Advancements in OCEAN: Curvilinear Real-Space Grids for Core-Level Spectroscopy

Abstract:

The electronic structure of a material determines key properties such as conductivity, magnetism, and chemical reactivity. Core-level spectroscopy provides element-specific information about these structures around a given absorption site, such as changes in bonding and the local environment. Because experimental spectra can be difficult to interpret, first-principles calculations are often used to simulate and understand the underlying electronic behavior. The OCEAN package is an open-source tool for computing core-level spectra using Density Functional Theory (DFT) and the Bethe-Salpeter Equation (BSE) within a pseudopotential framework. However, its reliance on uniform real-space grids is computationally inefficient for systems that require large simulation cells for accurate modeling but contain only a localized region of interest, such as heterogeneous catalysts or aqueous systems.

To address this, we have extended OCEAN to support curvilinear real-space grids, potentially improving computational efficiency. This includes a routine for generating non-uniform grids from uniform inputs and modifications across the codebase to accommodate non-uniform coordinate mappings.

I will briefly discuss the generation of curvilinear grids in response to atomic positions and outline the code changes necessary to support non-uniform grid points. I will also show preliminary results highlighting the dependence of calculated x-ray spectra on real-space grid sampling.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Ritika Rajamani
Academic Institution:	Swarthmore College
Major:	Computer Science
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Masters in Computer Science
NIST Laboratory, Division, and Group:	Materials Measurement Laboratory, Materials Science and Engineering Division, Functional Polymers Group
NIST Research Advisor:	Dr. Frederick Phelan
Title of Talk:	WebFF Molecular Dynamics (MD) Force-Field Repository: Schema Expansion, Programming and Data Testing

Abstract:

WebFF is an online repository for Molecular Dynamics (MD) force-field (FF) data, designed to support the Materials Genome Initiative (MGI) for organic and soft materials. It is built using the NIST Configurable Data Curation System (CDCS), which leverages XML for data representation. This system comprises three key elements: an XML schema (.xsd), which defines the data's structure; the XML document (.xml), which stores specific data records; and Extensible Stylesheet Language Transformation (XSLT), used to convert XML data into other formats. XSLTs can be integrated into the Curator application to provide seamless data download in formats required by third parties. Another important aspect of this work is the Python programming language which are used to create XML documents that follow the structure of the WebFF schema. In this presentation, several use cases which involve the creation of XLSTs for data export from the WebFF repository will be described. First, in partnership with Scienomics Inc., an XSLT is being developed for converting data in the WebFF schema format to the schema format used in their software environment. This work is progressing layer by layer starting with more simple coarse-grained force-field potentials and working our way up through the Class 1 and Class 2 atomistic formats. The development and testing of this XSLT has necessitated the curation of several force-fields used in the Scienomics software package. This conversion was a prerequisite to give us working data for verifying the accuracy of the transformation. The curation task resulted in several fortuitous outcomes. One was the addition of updates to our WebFF schema which facilitate XSLT development and output. In addition, I worked on enhancements of WebFF Python tools which are used for building templates for data entry and for creating XML data documents. Finally, in another use case a new XSLT was developed to convert WebFF XML docs into the common VEGA molecular dynamics force-field format (XML to text), and discussions are underway with the academic based Multiscale Polymer Toolkit (MuPT) team about developing an XSLT for their data representation.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Bridget Bidwell

Academic Institution: University of California, Los Angeles

Major: Applied Mathematics

Academic Standing(Sept. 2025): Senior

Future Plans (School/Career): I plan to continue studying math in graduate school.

NIST Laboratory, Division, and Group: Material Measurement Laboratory, Materials Science and Engineering Division, Thermodynamics and Kinetics Group

NIST Research Advisor: Daniel Wines

Title of Talk: Accelerated Discovery of Amorphous Dielectric Materials Using Machine Learning and First-Principles Simulations

Abstract:

Amorphous materials such as a-Si, SiO_2, and HfO_2 are crucial to current microchip technologies. Amorphous structures are difficult from a modeling perspective because they involve density functional theory (DFT) or molecular dynamics (MD) simulations with larger amounts of atoms and longer equilibration times than standard crystalline materials, resulting in significant computational costs. We are interested in identifying new amorphous materials with high-κ dielectric properties, which are desirable for their high capacitance and commonly used as gate dielectrics, as well as materials with low-κ dielectric properties, valued for their ability to reduce parasitic capacitance and typically employed as interlayer dielectrics. We propose a streamlined workflow using machine learning and DFT to identify amorphous materials with these properties. From the JARVIS-DFT database, we extract candidate materials containing elements found in known dielectrics used in the semiconductor industry. We then use machine learning force fields (MLFFs) to create amorphous structures using melt/quench simulations. After confirming these structures are amorphous, we use the Atomistic Line Graph Neural Network (ALIGNN) to predict the dielectric constants of each material and identify candidates with these desirable quantities. While the ALIGNN model has been previously trained and evaluated on crystalline materials, it has not been evaluated for its performance on amorphous materials. Finally, we perform MD melt/quench simulations and run DFT and density functional perturbation theory (DFPT) calculations on these final candidate structures to validate our workflow. We aim to demonstrate the effectiveness of using machine learning to accelerate the identification of amorphous dielectric materials and to provide insights into its applicability for modeling amorphous structures, supporting the discovery of materials for next-generation microelectronics.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Nishwanth Gudibandla
Academic Institution:	University of Washington — **Major:** Applied Mathematics
Academic Standing (Sept. 2025):	First-year Graduate Student
Future Plans (School/Career):	Finish a PhD in Applied Mathematics
NIST Laboratory, Division, and Group:	Materials Measurement Lab, Material Science & Engineering Division, Thermodynamics & Kinetics Group
NIST Research Advisor:	Daniel Wines
Title of Talk:	Tuning the magnetic properties of two-dimensional (2D) VxTi1-xSe2 through alloying

Abstract:

Monolayer transition metal dichalcogenides (TMDs) are a prominent class of two-dimensional (2D) materials, exhibiting electronic and magnetic properties that make them suitable for various technological applications, including spintronics. VSe2, a TMD that displays strong ferromagnetism with a predicted Curie temperature above 200 K, is of particular interest. The presence of a competing charge density wave (CDW) phase in this material adds complexity to understanding the interplay between its various magnetic states. Our previous computational work using Density Functional Theory (DFT) demonstrated that the magnetic properties of 2D VSe2 are highly tunable with strain. Specifically, we found that small amounts of positive biaxial strain enhance the stability of the ferromagnetic state. Monolayer TiSe2, another TMD, has a larger in-plane lattice constant than VSe2, suggesting that substituting V with Ti could induce the desired strain and increase the ferromagnetic state's stability in monolayer VSe2. To investigate this, we developed a computational workflow that combines DFT calculations with Cluster Expansion (using the JARVIS-tools and icet software packages) to automate the generation, analysis, and prediction of the energetic stability and magnetic properties of VxTi1-xSe2 alloys. The resulting calculations will provide high-quality reference data for experimentalists characterizing VxTi1-xSe2 for spintronics applications. Furthermore, this workflow is designed to be reusable for high-throughput analysis of binary alloys in future studies.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

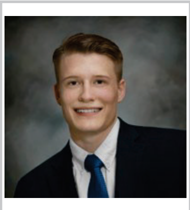
Name:	John Kline
Academic Institution:	Benedictine College
Major:	Electrical Engineering, Physics
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Likely Graduate School
NIST Laboratory, Division, and Group:	Materials Measurement Laboratory, Chemical Sciences Division, Optical Measurements Group
NIST Research Advisor:	Dr. Erin Adkins

Title of Talk:	Anchoring O_2 A-band spectra using an optical frequency comb

Abstract:

The O_2 A-band is frequently used to determine airmass in satellite and remote sensing applications. To achieve the necessary mission accuracies, a comprehensive spectroscopic model with small, well-characterized uncertainties in the physics-based model parameters is essential. A recent review of pressure shifting parameter values for the O_2 A-band [1] highlighted the need for further studies due to discrepancies in the literature. The NIST Optical Measurements group recently added optical frequency comb referencing capabilities to the existing O_2 A-band cavity ring-down spectrometer. This summer's research aimed to leverage the higher fidelity frequency axis provided by this addition to obtain precise spectroscopic reference measurements of parameters most likely to improve significantly in precision due to the reduced absolute frequency uncertainty: pressure shifting parameters and line centers. Analysis of the initial measurements revealed a bias between the measured line centers and those in the high-resolution transmission molecular absorption database (HITRAN), which was four times larger than the reported uncertainties, prompting additional measurements focused on line centers.

[1] Stevenson, L. E., Laughner, J. L., Okumura, M., Hodges, J. T., & Adkins, E. M. (2025). Contributions of argon, nitrogen, and oxygen to air broadening in the oxygen A-band, Journal of Quantitative Spectroscopy and Radiative Transfer, 342, 109480.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Christopher Gutowski

Academic Institution: University of Notre Dame | **Major:** Electrical Engineering

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Masters in Engineering

NIST Laboratory, Division, and Group: MML, Materials Science and Engineering Division (642), Polymers Processing Group (06)

NIST Research Advisor: Matthew A. Wade

Title of Talk: [CHIPS] Probing Molecular Diffusion Into BARC Layers in Advanced Photoresists

Abstract:

The demand for increasingly more powerful computer chips with higher transistor densities has driven advancements in the field of photolithography, where light is applied to a photoresist to transfer nanoscale patterns onto silicon substrates. To minimize reflections during exposure and improve pattern fidelity, a thin Back Anti-Reflective Coating (BARC) layer is applied to the substrate prior to the photoresist. However, small molecules can diffuse from multi-component photoresists into this coating, leading to local concentration gradients that impact transferred pattern fidelity and therefore transistor performance. In this work, in-house measurements were utilized to assess the movement of these materials between layers, highlighting the impacts of film preparation on layer thickness and density, two indicators of concentration variation. To achieve this, ellipsometry and X-ray reflectivity (XRR) were used to compare as-coated and treated films of BARC and photoresist against bilayer samples coated with BARC and photoresist. Ellipsometry was performed to obtain an initial measurement of film thickness and model structure which were then applied to XRR data analysis to verify film thickness and determine density. From these measurements, variations were observed between these fitted values, suggesting possible diffusion of molecules into the BARC layer. Further investigations will be carried out with soft x-ray measurements to confirm these results.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Tyra E. Espedal

Academic Institution: Massachusetts Institute of Technology **Major:** Physics; Electrical Science &

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Graduate school with a focus on materials and devices.

NIST Laboratory, Division, and Group: Material Measurement Laboratory (MML), Materials Science and Engineering Division (MSED), Group 6

NIST Research Advisor: Julie Rieland

Title of Talk: Measuring Fluorescence Phenomena in Time-Gated Raman Spectroscopy

Abstract:

While fluorescence is a major interference in Raman scattering measurements, it can reveal useful information about a studied sample if isolated. By computationally separating fluorescence and Raman contributions in time-domain TimeGate (TG) Raman measurements, we can independently analyze fluorescence contributions.

To validate the TG Raman for fluorescence measurements, we study three well-characterized fluorophores in epoxy: rhodamine B and 6G, as well as a cross-linked structure equivalent to rhodamine B. We observe fluorescence emission profiles and decay lifetimes that align with literature reports. Moreover, our time-resolved measurements show other features that demonstrate the potential utility of TG Raman instrumentation for fluorescence measurements. First, we observe significant and reproducible photobleaching, demonstrated by a decrease in peak intensity. We also find that photobleaching causes a linear increase in fluorescence lifetime, likely associated with oxidation of the fluorophore. Additionally, in some samples, we identify a second peak with a consistent delay in the time-domain Raman spectrum after the first peak, likely caused by aspects of the optical setup and excitation geometry. An observed change in the Raman/fluorescence signal composition from the first peak to the second indicates underlying physical processes that may facilitate more effective measurement.

Our findings suggest that the time-domain signal in a TG Raman measurement carries physically meaningful information about both Raman characteristics and fluorescence, as well as possible physical phenomena in the optical setup and its interaction with the sample. Through a systematic study of photobleaching and concentration effects across multiple fluorophores, we leverage this separation approach to explore signal origins and processes beyond traditional Raman analysis.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Samuel Bentz

Academic Institution: University of Maryland, College Park **Major:** Mechanical Engineering

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Get more involved in undergraduate research, possibly grad school

NIST Laboratory, Division, and Group: Materials Measurement Laboratory, Materials Measurement Science, Materials Structure and Data

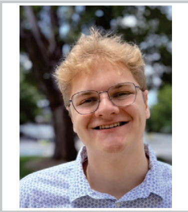
NIST Research Advisor: Russell Maier & Samuel Hales

Title of Talk: In-Situ Monitoring of Ceramic Vat Photopolymerizaton 3D Printing

Abstract:

Various industries including aerospace, refractory, and chemical processing require materials that are resilient in extreme conditions. Ceramics are often the material of choice to meet these demands as they have high hardness, high heat resistance and excellent chemical resistance. However, the same mechanical properties that make ceramics so desirable also make them difficult to process using traditional subtractive techniques. Additive manufacturing (3D printing) ceramics opens the door to forming complex geometries and making smaller production quantities more economical. Even so, unique challenges facing ceramic 3D printing such as rough surface quality, delamination between layers, undesirable porosity, and warping during post processing have slowed commercial adoption of the technique. Understanding the interactions between feedstock, print parameters, and post processing conditions can help determine methods to reduce and identify defects.

One method of ceramic additive manufacturing known as vat photopolymerization involves using UV light to selectively cure layers of ceramic particles suspended in a photocurable resin. The printed parts are then debinded and sintered in an furnace to achieve a dense ceramic part. Due to the layer-by-layer nature of the process, defects such as layer delaminations and inter-layer porosity are common. This project involves equipping the build platform of a consumer vat photopolymerization 3D printer with a load cell in order to monitor the forces involved throughout the printing process. The effect of various factors such as vat film preparation and print geometry orientation on separation force is evaluated. The force when the build platform is submerged into the resin vat is also analyzed to understand the role of wait time in the printing process. SEM imaging is used to evaluate the quality of the parts. Collected data will be used to optimize printing parameters with the goal of reducing defects while increasing print speed.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Dylan Roberts		
Academic Institution:	George Washington University	**Major:**	Computer Engineering
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Graduate Degree in Computer Engineering		
NIST Laboratory, Division, and Group:	MML, 642, Functional Nanostructured Materials Group		
NIST Research Advisor:	Dr. Daniel Gopman		
Title of Talk:	An Analysis of the Thermal Stability of Magnetic Nanostructures		

Abstract:

Patterned magnetic nanostructures (or nanomagnets) are fundamental in emerging memory technologies, particularly in spin transfer torque random access memory (STT-RAM). STT-RAM utilizes these magnetic elements as the digital storage element that encodes ‘1’ and ‘0’ values as bit cells in applications where non-volatility, high-speed, and low-power are critical. This technology is poised to replace embedded FLASH and embedded SRAM in mass market applications like IoT/wearables and embedded automotive microcontroller units (MCUs).

This technology faces a significant hurdle, particularly for automotive MCUs, as written bits can lose their stored digital state at elevated temperatures. This creates a risk for a complete chip failure if the memory exceeds a specific temperature, or an acceleration of accumulated bit errors at elevated temperatures. This challenge has posed a significant barrier to wide-scale industry adoption as manufacturers are wary of putting out products that may not be completely reliable. The exact thermal stability of these patterned magnetic elements depends on many factors, including elemental makeup and the shape of the device. Notably, research into techniques for characterizing the thermal stability of these components is limited, making it challenging for manufacturers to predict the stability of their devices without making them and testing them in operando, a costly endeavor in both time and manufacturing alike.

We seek to add to the existing research canon by characterizing the thermal stability of a perpendicularly magnetized CoFeB thin film using atomic force microscopy (AFM) and magneto-optical Kerr effect microscopy (MOKE). We magnetically align the material using an electromagnet and then heat the material to various temperatures before analysis to determine the thermal stability of the CoFeB thin film.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Lina Stensland

Academic Institution: Tufts University | **Major:** Mechanical Engineering

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Graduate School

NIST Laboratory, Division, and Group: MML, Materials Science and Engineering Division (642), Polymers Processing Group (06)

NIST Research Advisor: Trey Diulus

Title of Talk: Exploring chemistry & thickness of tin photoresists for extreme ultra-violet photolithography

Abstract:

The computing power of a microchip is directly related to the number of transistors available for computation. The amount of transistors manufacturers can fabricate on a chip is determined by the precision achieved through photolithography; a process in which a pattern is transferred onto a substrate via exposure of a photosensitive thin-film to light. Traditional photolithography uses carbon-based photoresists with deep ultraviolet light (DUV), which has a wavelength of around 193 to 365 nm. Currently, semiconductor manufacturers are aiming to shrink microchip features to sub-10 nm using photolithography, requiring a much smaller wavelength to achieve the necessary resolution. Extreme ultraviolet light (EUV), which has a wavelength of 13.5 nm, has been recently implemented, however, traditional carbon-based photoresists have poor sensitivity with EUV because carbon has a low photon absorption cross section at the higher energy light. Instead, tin-oxide resists are a promising replacement because tin has a high photon absorption cross section at 13.5 nm, while additionally tin can be synthesized into a wide range of organometallic clusters that can be deposited onto substrates via wet chemistry. This project seeks to learn more about this photoresist through characterization of spin coated thin films with various concentrations, irradiation exposure levels, and annealing temperatures. Silicon wafers are spun coat with a butyl-tin oxide hydroxide that is dissolved in n-butanol using 10-30 mg/mL mass concentration. Samples were measured with optical ellipsometry to measure thin film thickness, x-ray reflectivity (XRR) to determine density and roughness, and Fourier transform infrared spectroscopy (FTIR) and x-ray photoelectron spectroscopy (XPS) to track chemical changes. Anneals were executed above the water and n-butanol desorption temperatures (110 and 150 °C, respectively), at industry hard bake temperature (180 °C), and well above the hard bake (250 °C). Overall, this project provides a basic understanding of how concentration correlates to film thickness and showcases a change in ligand chemistry upon annealing.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Aditya Chezhiyan

Academic Institution: University of California, Santa Barbara **Major:** Physics

Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Graduate School for Materials Science
NIST Laboratory, Division, and Group:	Materials Measurement Laboratory, Division 642.06, Polymers Processing Group
NIST Research Advisor:	Priyanka Ketkar and Dean DeLongchamp
Title of Talk:	Modeling Ion Distributions in Block Copolymers Using Resonant Soft X-ray Scattering

Abstract:

Block copolymers (BCPs) comprise two or more distinct polymer chains that are covalently connected. These materials can assemble into highly tunable structures upon nanoscale phase separation of the component chains, leading to applications in semiconductor lithography and ion/electron conduction. A common BCP of interest is polystyrene-block-poly(methyl methacrylate) (PS-b-PMMA). Doping it with an ionic liquid such as 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl) (EMIM TFSI) has demonstrated enhanced assembly and improved performance in the above applications. In these ion-doped systems, an important aspect to understand is the distribution of the ions, which will impact the local structure and processing characteristics.

This project aims to quantify component distributions in PS-b-PMMA doped with EMIM TFSI and elucidate the underlying physics. Thin-film samples have been probed with resonant soft X-ray scattering (RSoXS), which is sensitive to the local structure via the energy-dependence of each component's soft X-ray absorption. Hypothetical compositional models can be inputted into the NIST RSoXS Simulation Suite (NRSS, https://github.com/usnistgov/NRSS) to generate simulated RSoXS patterns. Comparing the simulated and measured patterns allows us to validate our compositional models. This work will give insight into the connections between BCP assembly and resulting properties as well as inform future simulation development.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Katia Graciela Gonzalez-Adame
Academic Institution:	University of North Georgia
Major:	Matheimatics, Chemistry
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Graduate School
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Materials Science and Engineering Divison
NIST Research Advisor:	Michael Woodcox, Kathleen A. Schwarz
Title of Talk:	Understanding Density Functional Theory for Copper Electrodeposition Analysis

Abstract:

I used electronic structure methods to develop an understanding of copper electrodeposition for vias in computer chips. I first focused on numerical methods applicable to the study of electronic systems. I started with simple one-particle calculations and built up to numerical modeling of interactions in many-electron systems such as atoms and modules. Then, with my new background in electronic structure methods, I performed DFT calculations to study the interactions between copper and chloride atoms, as these atoms are key to copper electrodeposition.

First, to deepen my understanding of Density Functional Theory (DFT), I constructed a DFT code that solves an approximation to the Schrödinger equation to find the electronic density. I learned how DFT codes construct the Kohn-Sham equations, calculate the Kohn-Sham potential, and account for exchange-correlation energy. The process allowed me to develop many valuable skills, including programming in Python, troubleshooting and improving codes, numerical analysis, and interactive coding with Jupyter notebook.

Additionally, I gained hands-on experience using the DFT code, Quantum ESPRESSO (QE), to analyze materials at the atomic scale and using Linux to submit and manage computational jobs on a supercomputer. With QE, I simulated copper metal steps on Cu(100) with a c(2x2) adlayer of Cl. To ensure the reliability of my calculations, I identified a k-point grid and energy cutoff that converged my unit cell energy. In addition, I learned about reciprocal space, Fourier transforms, and Fast Fourier Transforms to achieve greater insight into k-points and energy cutoffs. I also performed geometry optimization on the unit cell to determine the most stable arrangement of the atoms so I could build supercells and steps. I then used VESTA to visualize the optimized crystal structures of the unit cell, super cells, and steps. Lastly, I learned about using scanning tunneling microscopes (STM) to identify the surface structures.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Aryn Loew

Academic Institution: Colorado School of Mines | **Major:** Ceramic Engineering

Academic Standing (Sept. 2025): Incoming first-year graduate student at the University of Oxford.

Future Plans (School/Career): I plan to pursue my DPhil (PhD equivelant) in Materials at Oxford, where I will be synthesizing and characterizing ceramic fibers for water purification.

NIST Laboratory, Division, and Group: Materials Measurement Lab, Materials Science and Engineering Division, Electrochemistry

NIST Research Advisor: Dr. Kathleen Schwarz, Dr. Michael Woodcox, and Dr. David Raciti

Title of Talk: Step by Step: Investigating the Electrodeposition of Copper

Abstract:

Copper connections for integrated circuit boards are often created using electrodeposition. Ideally, copper connections are electrodeposited on silicon wafers through a localized deposition process that produces minimal grain boundaries. If the deposition mechanism was better understood, we could achieve more precise electrodeposition, improving circuit board performance and reducing costs. Using a combination of theoretical and experimental approaches, we probed the evolution of copper surfaces during electrodeposition.

Through Density Functional Theory (DFT) calculations, we modeled copper steps and applied surface charges and chloride adsorbates to simulate electrochemical conditions. We compared the distance between the top layer of copper and the chlorine adatom, the Fermi energy, and the Bader charges to understand how the surface changes under different conditions.

To observe the surface evolution of copper in an electrolyte, we synthesized silica-coated gold nanoparticles for use in Shell-Isolated Nanoparticle-Enhanced Raman Spectroscopy (SHINERS). SHINERS can give bond vibrational frequency information which can be compared across different potentials and used to validate theoretical models.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Harkeerith Vij		
Academic Institution:	Cal Poly, San Luis Obispo	**Major:**	Materials Engineering
Academic Standing (Sept. 2025):	Graduated Class of 2025		
Future Plans (School/Career):	Pursuing a PhD in Materials Science		
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Materials Measurement Science Division, Microscopy and Microanalysis Research Group		
NIST Research Advisor:	Dr. Donald Windover		

Title of Talk:	Developing Standard Reference Materials for Use in CHIPs Through X-Ray Florescence

Abstract:

Thin film metrology is rife with difficulties due to its atomic scale and ease of contamination. Additionally, it is extremely difficult to share knowledge and advancements across foundries. This is due to tool calibration for thin film materials being performed through internal, machine specific standards, which diminishes the accuracy of data transferred. Our group aims to address this with the creation of research grade test materials (RTGMs) that can be proliferated throughout the CHIPS ecosystem, which will provide a method of standardization across industry.

These materials will be characterized through a variety of techniques, including X-Ray Reflectivity (XRR), X-Ray Diffraction (XRD), X-Ray Photoelectron Spectroscopy (XPS) and X-Ray Fluorescence (XRF) to determine the properties of the film. This project focuses on monitoring the films with XRF.

The films were previously analyzed over a period of 8 years through XRR to determine their thickness. However, XRR covers the entire 10 mm x 10 mm sample area, reducing the resolution of the measurement. Micro-XRF allows us to more accurately study the heterogeneity of the film using an X-ray beam of 25 μm in diameter. Many small measurements can be taken across the sample to profile thickness variation throughout. This data will then be applied to the longitudinal study to verify the XRR results.

This heterogeneity approach will also be applied to new films being deposited within the NIST CNST and diced during the summer. Diced portions of these new wafers will form the first set of RGTMs for thin film properties. Each piece will have a grid of measurements taken on it to fully characterize the heterogeneity of these new samples.

To ensure the reproducibility of this analysis a Jupyter Notebook has been built through a CondaForge environment. This notebook allows the data to be processed through Python, SciPy, and LM Fit, which are commonly used and well-maintained characterization packages. This avoids use of proprietary software native to the XRF machine. The Jupyter Notebook as well as the environment file will both be shared to all recipients of the reference materials through a METIS repository. By doing so we enable researchers to process data exactly as we did the reference sample, aiding in the accuracy of their calibrations.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Eliana Crew

Academic Institution: University of Pittsburgh | **Major:** Engineering Science

Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Doctoral Program
NIST Laboratory, Division, and Group:	MML, Chemical Science Division, Chemical Informatics Group (646-04)
NIST Research Advisor:	Dr. Alexandros Chremos
Title of Talk:	Development of SAFT-based coarse-grained models of noble gases and other small molecules for vapor-liquid equilibria simulations

Abstract:

We developed coarse-grained (CG) models of four noble gases (neon, argon, krypton, and xenon) and a small number of refrigerant and flammable gases to accurately describe the vapor-liquid equilibria (VLE) as single components and, in the case of the former, their binary mixtures. To achieve this aim, we utilized an equation of state (EoS), namely the Statistical Associating Fluid Theory (SAFT), to provide predictions of the thermodynamic phase behavior of the systems of interest and estimations of the molecular parameters of the CG models. In this framework, the molecules are described as single-site particles interacting with the Mie potential. The developed models were evaluated by Monte Carlo flat-histogram simulations, demonstrating excellent agreement with experimental data across a broad range of temperatures and pressures. Moreover, our models provide a significant improvement from models found in the literature, most of which use a subset of the Mie potential, i.e., the Lennard-Jones potential. Our work highlights the efficacy of combining experimental data, theoretical EoS modeling, and molecular simulations, enabling the translation of theoretical predictions and models into simulation models without further parameter adjustment while preserving thermodynamic consistency.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Naman Parikh

Academic Institution:	Carnegie Mellon University	**Major:**	Physics/Computer Science
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	PhD in computational materials science or working in industry as a computational scientist		
NIST Laboratory, Division, and Group:	Material Measurement Laboratory, Division 642, Group 5		
NIST Research Advisor:	Dr. Nia Rodney-Pollard		

Title of Talk: Evaluating the Performance of VQE for Quantum-DFT Embedding on Chemical Databases

Abstract:

This study explores the use of quantum computing for chemical and materials energy calculations by benchmarking a hybrid quantum-classical workflow. The Variational Quantum Eigensolver (VQE) is a prominent algorithm for determining ground state energies of molecular systems on near-term quantum devices, balancing algorithmic efficiency with hardware constraints. We adapt and extend an existing quantum-DFT embedding framework and apply it to a broad set of molecules from the Computational Chemistry Comparison and Benchmark Database (CCCBDB). Simulations are conducted using both ideal (statevector) and noisy (qasm) quantum backends, including IBM noise models, to assess performance under realistic conditions. Preliminary results from the ideal simulator show strong agreement with classical reference data, while noisy simulations highlight the challenges posed by current quantum hardware. We also examine the impact of varying basis sets and active orbital spaces on overall performance. Initial hardware executions are ongoing, but this work demonstrates the potential of VQE for accurate quantum chemical modeling and provides a foundation for broader deployment on near-term quantum devices.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Preston Yeung

Academic Institution: Stony Brook University

Major: Mechanical Engineering

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Complete undergraduate degree and possibly a master's; work in the aerospace industry

NIST Laboratory, Division, and Group: Material Measurement Laboratory
Materials Science and Engineering Division, Mechanical Performance Group (642)

NIST Research Advisors: Dilip K. Banerjee and Shengyen Li

Title of Talk: Computational Fluid Dynamics (CFD) Analysis of L-PBF Additive Manufacturing

Abstract:

Laser Powder Bed Fusion (L-PBF) Additive Manufacturing (AM) is a type of 3-D printing technology that uses a high-powered laser to selectively melt and fuse fine metal powder layer by layer to build a solid, three-dimensional object. It enables the creation of complex, high-performance components with intricate geometries that would otherwise be difficult to manufacture using traditional methods. The process begins by spreading a thin layer of metal powder, often only a few micrometers in thickness, over a base platform. The laser then scans the surface of the desired part, traveling over the powder in select areas. During this process, the powder is rapidly melted by the laser and quickly becomes solidified as it cools, bonding to the layer beneath it to form a solid structure. This process can be repeated for a multilayer deposition.

This project aims to fully utilize the capabilities of Ansys Fluent, a computational fluid dynamics (CFD) software, to simulate this additive manufacturing process. Ti-6Al-4V, a titanium alloy known for its high strength-to-weight ratio and ability to withstand high temperatures, was chosen as the powder material. Several lasers with varying power levels and spot radii were used in this project, with the goal to study how the laser parameters influence the powder melt pool dynamics and the associated material response. Parameters such as the temperature contours and velocity fields of the melt pool were analyzed to study fluid flow patterns and heat distribution within the deposited layers.

AdditiveFOAM, an open-source CFD software, was also used to simulate the effects of varying laser heat flux inputs on output temperature and cross-sectional melt pool geometry. The material used for the powder melt pool was Inconel 625, a nickel-based alloy with a significantly higher density than Ti-6Al-4V. The resulting data from these simulations were exported to a Jupyter Notebook, where a Python-based custom code was used to generate images of the mesh along with melt pool temperature fields. Understanding thermal behaviors in the built part is essential for optimizing print quality, minimizing defects, and improving the reliability of the additive manufacturing process in the engineering industry.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Trisha Lad

Academic Institution: University of Illinois Urbana-Champaign **Major:** Chemical Engineering

Academic Standing (Sept. 2025): Sophomore

Future Plans (School/Career): Specialize in Nanotechnology/Materials Chemistry, Graduate School

NIST Laboratory, Division, and Group: MML, Division 642, Group 1

NIST Research Advisor: Sara Orski

Title of Talk: Sample Form Effects in Near-IR Analysis of Post-Consumer Polyolefins for Machine Learning

Abstract:

The increasing global demand for polyolefin plastics has contributed to persistent plastic waste accumulation in landfills and the environment. Near-infrared (NIR) spectroscopy is widely used in recycling facilities for rapid identification and sorting of plastics due to its non-destructive, high-throughput capabilities. However, conventional NIR systems face limitations in distinguishing between subclasses of polyolefins, such as high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), polypropylene (PP), leading to contamination in recyclate streams and lower-quality recycled products. This project integrates machine learning with NIR spectroscopy to enhance classification accuracy and address these limitations. Specifically, we investigate how instrument resolution impacts model performance by comparing data from a high-resolution Fourier-transform (FT) NIR spectrometer with data from a portable handheld reflectance NIR device. Our study expands existing work by incorporating not only well-characterized commercial polymer pellets but also real-world post-consumer recycled (PCR) materials such as plastic parts and flake materials. Including these diverse, heterogeneous materials strengthens the relevance of our findings and allows us to evaluate how model predictions hold up under conditions more representative of industrial recycling streams. Principal component analysis (PCA) and multivariate modeling are used to evaluate how measurement configuration and resolution affect clustering and predictive accuracy. Ultimately, this work helps identify the practical limitations and adjustments needed for machine learning models to accommodate different instruments, material forms, and recycling environments, enabling more consistent and accurate sorting of polyolefins and supporting the development of a more sustainable circular plastics economy.

NIST Center for Neutron Research 2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

The NIST Center for Neutron Research (NCNR)

<u>Student Names and Talk Titles</u> <u>(in order of presentation)</u>

Xuliana O *(plenary speaker):* ROADBot: Autonomous Optimization of Compositionally Diverse Lipid Bilayers on Solid Supports

Clara Do: Effects of Mixing, Aging and pH on Lipid Nanoparticle RGTM

Abigail Lapadula: Rheology and Nanostructure of Hydroxypropyl Methylcellulose at High-Shear Rates

Eric Welp: Piezostrain behavior and Magnetoelectric Coupling in Co/PMN-PT structures

Henry Pires-Tolson: Magnetic Properties of Chemically-tuned Nickel Compounds

Taian Chen: Remote Camera for Reactor Latch Inspection, and Other Reactor Engineering Projects

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Xuliana O
Academic Institution:	Virginia Commonwealth University
Major:	Physics, Biology
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Applying to Fall 2026 Grad Schools, long-term goal university professor and researcher
NIST Laboratory, Division, and Group:	NCNR, Div 610.02, Neutron Condensed Matter Science Group
NIST Research Advisor:	David Hoogerheide and Megan Mitchell
Title of Talk:	ROADBot: Autonomous optimization of compositionally diverse lipid bilayers on solid supports

Abstract:

The expanding antibiotic resistome demands innovation into the creation and discovery of antimicrobial agents. The ROADMAP (Reflectometry driven Optimization And Discovery of Membrane Active Peptides) project at NIST aims to use the structural data of neutron reflectometry (NR) and artificial intelligence to assist American industries in this endeavor by narrowing the possible membrane active peptide sequences for use in antibiotic treatments. One part of the ROADMAP project is building an automated, parallelized lipid bilayer creator, ROADBot, that can form compositionally diverse lipid membranes using a solvent-exchange method. For this project, I used ROADBot to explore the effects of lipid composition, lipid concentration, flow rate, and salinity on bilayer formation using an array of quartz crystal microbalances with dissipation monitoring (QCM-D) to monitor bilayer quality. An autonomous experimentation loop based on Gaussian process regression was used to efficiently explore this complex parameter space. Lipids were chosen to be mixtures of lamellar, zwitterionic DOPC; nonlamellar, zwitterionic DOPE; and anionic POPG. I found that the optimal lipid concentration to form single, complete lipid bilayers depended strongly on the lipid composition. The flow rate dependence was weak; salinity had a strong effect on DOPE and POPG lipids, but not DOPC. Finally, I will discuss some of the lessons learned from operating ROADBot, from visual monitoring of the QCM-D flow cells to statistical methods to compute variance.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Clara Do
Academic Institution:	University of Massachusetts Amherst
Major:	Biomedical Engineering, Applied Math
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate School or pharmaceutical R&D
NIST Laboratory, Division, and Group:	NCNR, Neutron Condensed Matter Science Group Div 610.02
NIST Research Advisor:	Dr. Chelsea Edwards
Title of Talk:	Effects of Mixing, Aging and pH on Lipid Nanoparticle RGTM

Abstract:

Despite increasing prevalence of lipid nanoparticle (LNP) therapeutics, many questions regarding the influence of different variables on their final structure remain. LNP formulations contain five chemical components selected from preexisting literature, where the physical characteristics and unique applications are typically already well studied. However, the procedures from which the final LNPs are obtained introduces many variables that may alter the intended LNP structure. Here, we aim to systematically understand the impact that synthesis and storage conditions have on time-dependent structure of the NIST/IBBR LNP research-grade test material (RGTM) with polyadenylic acid (polyA) RNA as cargo. By varying the pH and mixing modality, we isolate the effects of the polyA charge fraction and the rate of mass transport during non-solvent precipitation on the resulting LNP structure and aging. We use Dynamic Light Scattering (DLS) to measure size distributions of the LNPs at various age times, investigate their morphology using cryo-EM, and quantify cargo encapsulation efficiency. We compare results as a function of storage temperature. Overall, our results complement existing understanding of the NIST/IBBR LNP RGTM, bettering our understanding of variables that may affect RGTM use, and highlight the importance of understanding the effects of variables beyond composition and chemistry that may affect LNP structure.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Abigail LaPadula		
Academic Institution:	University of Maryland, College Park	**Major:**	Chemical Engineering
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Graduate School		
NIST Laboratory, Division, and Group:	NIST Center for Neutron Research (NCNR), Div. 610, Neutron-Condensed Matter Science Group		
NIST Research Advisor:	Ryan Murphy		
Title of Talk:	Rheology and Nanostructure of Hydroxypropyl Methylcellulose at High-Shear Rates		

Abstract:

Hydroxypropyl methylcellulose (HPMC) is a cellulose-derived viscosity-modifying polymer used in a wide variety of applications, including food, agriculture, pharmaceuticals, adhesives, cleaning products, and construction materials. HMPC is known to self-assemble into thermoreversible fibers in water, leading to gelation. As a non fossil fuel-derived polymer, HPMC is a renewable and biocompatible source that is biodegradable at the end of its use. This prevents polymer build-up, which is especially significant in industrial applications as it can result in clogged systems and product quality issues. Some of the many applications of HPMC require performance at high-shear rates, and therefore it is important to determine its high-shear behavior.

Rheometry is an experimental method used to analyze the deformation and flow-characteristics of materials. Rotational rheometry utilizes torque to assess properties at low-shear rates, whereas capillary rheometry uses pressure-induced flow through capillary tubing to determine high-shear properties. Additionally, small-angle neutron scattering (SANS) can be paired with rheometry to assess the nanostructure of a sample and its changes due to shear flow.

This project aims to use rotational rheometry to determine the gelation temperatures and low-shear viscosities of HPMC with regard to concentration, molecular weight, degree of substitution, and temperature. Further, fitting SANS data will assist in discovering the nanostructure for different temperatures and concentrations. In the future, a capillary rheometer will be utilized to discern the high-shear viscosity as a function of the same processing variables to assess the properties of HPMC at a wide range of shear rates. Additionally, Capillary RheoSANS (CRSANS) will help to determine the impact of flow on the nanostructure of HPMC at high-shear rates.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Eric Welp

Academic Institution: The Pennsylvania State University | **Major:** Physics and Engineering Science

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Pursuing a PhD in Physics or Materials Science

NIST Laboratory, Division, and Group: NIST Center for Neutron Research, Div. 610, Condensed Matter Science Group

NIST Research Advisor: Shane Lindemann

Title of Talk: Piezostrain behavior and magnetoelectric coupling in Co/PMN-PT structures

Abstract:

Magnetoresistive Random Access Memory (MRAM) structures ideally enable non-volatile, high speed computer memory using giant magnetoresistance, the change of resistance in spin-valve structures caused by electron spin-dependent scattering at the interfaces of alternating magnetic and nonmagnetic films. The development of improved MRAM devices relies on high efficiency control of the magnetic moments utilizing mechanisms such as strain-mediated converse magnetoelectric coupling, which manipulates the magnetic moments in films with strain generated by a piezoelectric crystal under application of voltage.

Relaxor ferroelectrics such as (1-x)Pb(Mg1/3Nb2/3)O3-(x)PbTiO3 (PMN-PT) have been studied for their high piezoelectric strain, with focus on the anisotropic in-plane strain perpendicular to the applied electric field. This project aims to control the alignment of the magnetic moments of cobalt layers grown on PMN-PT crystals using the voltage-induced in-plane strain. We investigate the strain behavior of the PMN-PT using X-ray diffraction and strain gauges, including that behavior's variance between individual crystals and the changes over time experienced as a result of the strong history dependence of the crystals. We also use magnetic hysteresis measurements to investigate the coupling of the PMN-PT strain to the cobalt magnetic behavior, including coupling to structures of two cobalt films for applications in future MRAM devices.

Supported by the magnetic response measured by polarized neutron reflectometry, these studies will create a better understanding of the piezoelectric response and coupling, and guide the future development of high efficiency MRAM devices based on strain-mediated magnetoelectric coupling.

SURF Student Colloquium

NIST – Gaithersburg, MD

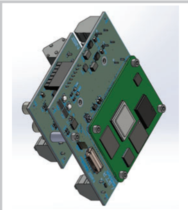
July 29 - 31, 2025

Name:	Henry Pires-Tolson		
Academic Institution:	University of Maryland at College Park	**Major:**	Physics
Academic Standing (Sept. 2025):	Senior		
Future Plans (School/Career):	Graduate studies in physics		
NIST Laboratory, Division, and Group:	NIST Center for Neutron Research, Division 610, Group 2		
NIST Research Advisor:	Nicholas Butch		
Title of Talk:	Magnetic properties of chemically-tuned nickel compounds		

Abstract:

Nickel is in a small collection of elemental metals to display ferromagnetic order. Modifying nickel chemically can vary its magnetic properties. I am synthesizing nickel compounds with an arc furnace in this study. The aim of the study is to study a series of nickel compounds with variable chemical compositions with the magnetic properties varying controllably. I will discuss sample synthesis and characterization using x-ray diffraction, magnetometry, and electrical resistivity measurements.

I am currently investigating having a scandium nickel compound series with the scandium being substituted with varying levels of yttrium. A specific scandium nickel stoichiometry hasn't been determined yet due to struggles with the synthesis process. I will also go over the binary phase diagram for scandium nickel compounds to show my process in synthesizing scandium nickel compounds.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Taian Chen

Academic Institution: University of Maryland, College Park **Major:** Electrical Engineering

Academic Standing (Sept. 2025): Freshman with Advanced Status (A.S. General Engineering from Montgomery College)

Future Plans (School/Career): Finish B.S., continue working at NIST, eventually attend grad school.

NIST Laboratory, Division, and Group: NIST Center for Neutron Research, Reactor Operations and Engineering

NIST Research Advisor: Andrew Main, Sam MacDavid, James Whipple, Sahar Rubin

Title of Talk: Remote Camera for Reactor Latch Inspection, and Other Reactor Engineering Projects

Abstract:

The National Bureau of Standards Reactor (NBSR) is a tank-type research reactor, that serves as the neutron source for the NIST Center for Neutron Research, and has operated since 1967. It uses fuel elements that are designed to be inserted into a grid array of slots inside the reactor, and then secured in place using a latching mechanism on each fuel element.

On February 3rd, 2021, upon attempting to restart the NBSR after routine refueling and maintenance, an incident occurred that led to damage to one of 30 fuel assemblies. Subsequent investigation revealed that the affected assembly was not properly secured inside the reactor, and upon shifting, cut off the flow of coolant, resulting in partial melting of the assembly. As part of recovery and corrective efforts following February 3rd, it was proposed that a new inspection tool be designed, for visually verifying the proper insertion and latching of fuel assemblies inside the reactor, in order to prevent a similar incident from occurring again in the future.

The second revision of this proposed Latch Inspection Tool has now exited the design phase, and is ready for prototyping. Key points of discussion include overcoming challenges imposed by tool deployment restrictions, adapting to the unique operating conditions inside a nuclear reactor, and the application of controls against system hazards to protect operational safety.

* * *

This talk also includes a brief summary of two other ongoing engineering projects, regarding the overhauls of the Tritium Monitoring System and the Process Automation and Control (PAC) room.

Physical Measurement Laboratory 2025

Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Physical Measurement Laboratory (PML)

<u>Student Names and Talk Titles</u> <u>(in order of presentation)</u>

Meagan Porter: The Absolute Flux Calibration of Stars

Lucy Collins: Improving Spectral Irradiance Responsivity Calibration with the FLUX Instrument

Grayson Garner: Durability of silicon optic surface treatment for extreme ultraviolet scatterometry

Kylil Orr: High Speed Arduino Servo

Oren Friedlin: Robust and Efficient Wavelength Conversion for Hybrid Quantum Networks

Benjamin Pittelkau: Simulation-Based Design of a Plasmonic Schottky Detector for Mid-IR Opioid Detection

Ruben Dasgupta: Probing Photonic Crystal Mirror Performance

Lan Le: Automating Optofluidic Flow Metrology Calibration through Optimization

Luca Caruso: Cell Migration Assays in Microfluidic-based Systems for Studies of Cancer Aggressiveness

Stephen Chen: Developing Fast Readout for High Vacuum Optomechanical Pressure Sensors

Ramon Perez: Chemical Enhancement of MgF from a CBGB Source via Laser Excitation

Jeyadave Nuntha Kumar: Computational and Experimental Evaluation of Anemometer Blockage in a Benchtop Wind Tunnel

Pragya Natarajan: SLowFLowS: Simulating Thermal Effects in Rate-of-Rise Standards Using COMSOL

Grant Chapman: Laser Locking to Distinct Spectral Peaks

Thea Bielejec: Off-axis Holographic Imaging of Marangoni Surface Waves on a Shallow Ferrofluid Layer

Ramakrishnan Gopinath: Advancing Magneto-Optical Spectroscopy through Automation of Spatial, Temperature and Field Mapping

Arden Dombalagian: Sub Microgram Mass Measurement and Analysis

Kira Yuen: Improving Commercial Viability of a Kibble Principle Torque Standard

Juandiego Astudillo: Numerical Simulation of Heat Transfer in Cryogenic Silicon to Inform Design of a Novel Quantum Sensor

Tarun Jacob: Monte Carlo Modeling of Ionization Chambers for Brachytherapy Dosimetry

Ravi Jain: Simulation of Subkelvin Transition Edge Sensors for the True Becquerel Project

Christopher Kniss: Reducing Thermal Load: Wireless Interconnects Inside the Cryogenic Chamber

Jameson Lau: Developing Reflow Solder Packaging for Cryogenic Devices to Improve Fidelity

Jack Stawasz: Measuring the Kerr Effect in Silicon via Ultrafast Spectroscopy

Ariam Yohannes: Predicting Atomic-Scale Device Properties using IBM Heron v2 Digital Quantum Simulators

Nathan Gehl: Improving Nanoscale Electrical Devices for Use in Quantum Sensing Regimes

Marios Kalpakis: Associative Memories in Temporal Networks

SURF Student Colloquium

NIST – Gaithersburg, MD July 29 - 31, 2025

Name:	Meagan Porter
Academic Institution:	Austin Peay State University
Major:	Physics
Academic Standing (Sept. 2025):	Graduated May 2025
Future Plans (School/Career):	Ph.D. in Space Sciences from the Florida Institute of Technology (FIT)
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Sensor Science Division, Remote Sensing Group
NIST Research Advisor:	Dr. Susana Deustua
Title of Talk:	The Absolute Flux Calibration of Stars

Abstract:
Current astronomical irradiance scales are based on spectrophotometric measurements of Vega (Alpha Lyrae) that were recorded in the 1970's and 1980's. The published uncertainties for these data are of order a few percent. There is now a need for more accurate, sub-percent, irradiance measurements in astronomy, in areas such as dark matter and dark energy, exoplanet studies, and stellar astrophysics over a wide spectral range. Technology has advanced in metrology enabling high accuracy, detector-based irradiance calibration. We present irradiance spectra of the NIST STARS CAS spectrograph calibrated to a known artificial star. This calibration uses two simultaneous measurements to simulate a NIST calibrated telescope and observatory telescope observing the same star. Improved atmospheric corrections, advanced spectrometer performance, improved temperature controls, along with better stray light and linearity corrections will ensure the long-term reliability and scientific utility of these measurements.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Lucy Collins

Academic Institution: University of Notre Dame | **Major:** Physics

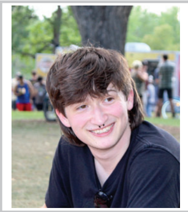
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate degree in astrophysics
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Sensor Science Division, Remote Sensing Group
NIST Research Advisor:	Joseph P. Rice
Title of Talk:	Improving Spectral Irradiance Responsivity Calibration with the FLUX Instrument

Abstract:

Spectral irradiance, referred to as flux by astronomers, is a crucial measurement for astrophysics research. It is defined as the power received from a light source, per unit area, per spectral bin. Measuring a source's flux is integral for studying an astronomical object, but the calibration uncertainty of the instruments used is becoming a limitation for modern astrophysics research, often depending on "standard stars" having relatively large uncertainty. The NIST Stars project focuses on improving our SI-traceable calibration procedures, with the goal of producing low uncertainties in flux measurements and more accurate standards.

A crucial part of the calibration process involves using a well-known light source to calibrate spectrographs. Historically, type FEL lamps, with accurately calibrated irradiance, are used. However, a relatively long traceability chain is required to calibrate these lamps, and the uncertainties are higher than desired. In this talk we consider an alternative method — replacing the FEL lamp with a tunable line source, possibly offering lower measurement uncertainty, greater portability, and a more efficient process. We describe both the traditional calibration procedure using FEL lamps and this alternative — using the Field-deployable Low Uncertainty Transfer (FLUX) instrument — to calibrate spectrographs. The FLUX instrument uses a supercontinuum source, then selects specific wavelengths with a laser line tunable filter (LLTF) monochromator, producing a signal at thousands of wavelengths, one at a time, so that we may measure a spectrograph's response for each. This process is repeated for a precisely calibrated trap detector, so by comparing the responses, we can calculate the responsivity of the spectrograph at each wavelength.

By calibrating spectrographs with both the traditional (FEL lamp) process and the FLUX instrument, we compare the results and determine if FLUX is a viable alternative.



SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Grayson Garner		
Academic Institution:	Colorado State University	**Major:**	Physics
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	Work in applied atomic physics		
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Sensor Science Division, Optical Radiation Group		
NIST Research Advisor:	Stephanie Moffitt		
Title of Talk:	Durability of silicon optic surface treatment for extreme ultraviolet scatterometry		

Abstract:

The ability to measure small and complex features on the next generation of computer chips relies on the development of new measurement tools. Extreme ultraviolet (EUV) scatterometry is a tool that has been in development to assist in the progress of the semiconductor industry. One key innovation of EUV scatterometry is the ability to control the polarization of light in the 50 nm to 150 nm wavelength range though specialized reflective optics. Silicon mirrors were chosen for their high reflectivity and low amplification of signal noise throughout the necessary wavelength range.

However, silicon has a well-established native oxide layer that hinders the performance of these mirrors. The removal of native oxide has been explored in the past but the durability of treatment, or regrowth rate, had not been as extensively investigated. In addition, silicon surface treatment equipment has greatly improved since the last published studies of silicon oxide removal for EUV performance [1]. A more applicable examination into surface treatment methods and oxide regrowth was needed.

In this project, we tested the effectiveness and longevity of various surface treatment methods, which included HF dipping and vapor etching. After treatment, the oxide thickness on the silicon surface was tracked continuously through ellipsometry and x-ray photoelectron spectroscopy (XPS) for up to two months. The effectiveness of different storage methods was also investigated through a commercial food grade vacuum sealer to simulate rough vacuum, and an ultrahigh vacuum test stand. We found a significant and counterintuitive difference between the oxide growth of samples depending on both surface treatment and storage method.

[1] R. Soufli, E. M. Gullikson, Appl. Opt. 36, 5499-5507 (1997)

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Kylil Orr

Academic Institution: University of Maryland | **Major:** Computer Science

Academic Standing (Sept. 2025): Junior 3rd year undergraduate

Future Plans (School/Career): Pursue a Bachelors ’s in Computer Science and become a Specialist in the federal or private sector

NIST Laboratory, Division, and Group: Physical Measurement Laboratory (PML), 685, 9

NIST Research Advisor: Kevin Douglass

Title of Talk: High-Speed Arduino Servo

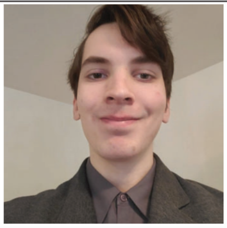
Abstract:

Goal:

NIST is developing a new, robust, and portable pressure standard to streamline and ultimately improve the Air Force readiness by reducing the calibration chain and eliminating the need to send devices for recalibration. A key aspect of this project uses first principles quantum mechanics to accurately calculate gas refractive index, enabling a quantum-based, optical refractometer standard that will result in the elimination of mercury-based barometers world-wide.

Mission

This research focuses on building a real-time deployable Quantum based standard with key goals of reducing cost and complexity. A critical aspect of the device operation is laser stabilization to a Fabry-Perot Cavity using a commercial PID servo. For this project we aimed to develop a low cost PID servo implemented on embedded hardware using the Qnimble. The underlying hardware takes advantage of Qnimble’s hybrid digital-analog architecture, offering the high performance of traditional FPGAs while simplifying the development process. Qnimble’s code can be written and developed in C/C++ using the Arduino™ IDE eliminating the need for complex FPGA programing. Because the code runs directly on the Arduino CPU without an operating system, the system maintains both speed and simplicity. We have developed the code and implemented a PI servo system for laser stabilization. We will demonstrate the performance of the system for locking to both a low and high finesse cavity.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Oren Freidlin

Academic Institution: University of Maryland: College Park | **Major:** Electrical Engineering

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): To pursue a masters/doctoral degree with a focus on Quantum Engineering

NIST Laboratory, Division, and Group: Physical Measurement Laboratory: Microsystems & Nanotechnology: Photonics and Optomechanics (681)

NIST Research Advisor: Jordan Stone

Title of Talk: Robust and Efficient Wavelength Conversion for Hybrid Quantum Networks

Abstract:

For quantum networks to support applications such as secure quantum communication, distributed quantum computing, and quantum-enhanced sensing, they must connect devices that often operate at different optical wavelengths. chip-integrated microresonators are a promising platform for addressing this challenge by enabling efficient on-chip wavelength conversion (WC), allowing seamless and scalable transfer of quantum information between components like fiber optic cables and quantum processors. However, to achieve a high throughput of WC devices requires rapid and comprehensive device characterization.

As part of this effort, I developed an experimental protocol for measuring microresonator dispersion, including the accurate determination of eigenfrequencies. Specifically, I set up a tunable laser system alongside an Mach-Zehnder interferometer and data acquisition (DAQ) system. By scanning the wavelength and measuring the resulting interference patterns, I obtained a precise record of wavelength versus time, which, when mapped to resonator transmission, will be used to calculate eigenfrequencies and dispersion. This characterization is critical to obtain design feedback for optimization of WC performance, an essential step toward building scalable, high-performance quantum networks.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Benjamin Pittelkau

Academic Institution: Virginia Tech **Major:** Electrical Engineering

Academic Standing (Sept. 2025): First Year MS Graduate Student

Future Plans (School/Career): Pursue a master's degree and research related to bio-optoelectronic devices.

NIST Laboratory, Division, and Group: Physical Measurement Laboratory, Microsystems and Nanotechnology Division, Photonics and Optomechanics Group

NIST Research Advisor: Henri Lezec

Title of Talk: Simulation-Based Design of a Plasmonic Schottky Detector for Mid-IR Opioid Detection

Abstract:

The ongoing opioid crisis necessitates the development of compact, selective, and sensitive chemical sensors for analysis in-the-field. This research explores the development of a plasmonic-electronic sensing platform for opioid detection using mid-infrared (mid-IR) light. The final device will employ a transmission-mode plasmonic grating resonator (T-PGR) integrated with a Schottky junction, leveraging strong spectral selectivity to act as a built-in optical filter for molecular sensing. The T-PGR design offers tailored resonance within the 5 – 11 μm window, making it well-suited for detecting the vibrational fingerprints of opioid compounds. To validate the feasibility of plasmon-induced carrier collection and streamline early-stage fabrication, we first investigated metallic slit arrays coupled with a Schottky junction. These simpler structures serve as a proof-of-concept for plasmon detection, allowing rapid iteration and measurement. Electromagnetic and optoelectronic simulations were conducted using Lumerical FDTD and CHARGE tools to model electromagnetic field profiles, carrier generation rates, and resulting photocurrents under mid-IR illumination. Slit array designs achieved up to ~80% transmission efficiency and exhibited distinct resonance behavior, confirming their suitability for near-term fabrication. Following successful experimental validation of the slit array system, fabrication of the full T-PGR device will proceed. This layered approach de-risks fabrication challenges while enabling the realization of a compact, spectrally selective sensor for chemical classification of opioids.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Ruben Dasgupta
Academic Institution:	University of Maryland College Park
Major:	Physics and Chemistry
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Physics PhD
NIST Laboratory, Division, and Group:	PML, Microsystems and Nanotechnology, Photonics and Optomechanics
NIST Research Advisor:	Dr. John Lawall
Title of Talk:	Probing Photonic Crystal Mirror Performance

Abstract:

Photonic Crystal mirrors have unique optical properties due to their patterned structure, offering applications in optomechanics and chip-scale laser technology. In this project, we develop multiple experimental technologies required to probe the performance of such crystals. First, we set up a scanning microscope that images a wafer containing hundreds of individual photonic crystals with different geometries on its surface. A Python program and associated graphical user interface select the crystal with the best performance by controlling the 2-dimensional (X-Y) motion and generating a Raster Scan of the wafer while simultaneously sampling an optical signal. Second, two ultra-low linewidth 1560 nm lasers were studied and beat together to analyze their relative frequency stability. We determine their Allan deviations calculated from a programmed frequency counter for long interrogation times and an oscilloscope for short ones, due to dead time issues with the frequency counter. Finally, we constructed a Fabry-Perot cavity with a photonic crystal as the input coupler, for which we found the finesse as a function of cavity length. From this we infer the reflectivity of the photonic crystal mirror.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Lan Sy Le

Academic Institution: University of Marlyland | **Major:** Bioengineering

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Medical School

NIST Laboratory, Division, and Group: PML, 681, 05

NIST Research Advisor: Dr. Gregory Cooksey

Title of Talk: Automating Optofluidic Flow Metrology Calibration through Optimization

Abstract:

The accuracy of flow measurements below the microliter per minute scale is greatly impacted by physical limitations, such as uncertainties induced by evaporation and thermal effects. In contrast to commercial flow meters, we have constructed a highly accurate flow meter that can resolve nanoliter per minute flows dynamically through the photobleaching of a fluorescent dye. This optofluidic flow meter is a microfluidic chip that incorporates an optical measurement region to deliver a dosage of laser light onto fluorescent dyes in flow. Through a calibration relating the height of a water column to a known flow rate, a master dosage curve can be scanned and used to convert fluorescence emitted from the measurement region to flow rates. We have shown that the dosage relationship can be used to relate fluorescence intensity to report flows down to 1 nL/min with roughly the same 5% relative uncertainty as the calibration at 1 µL/min.

My project is to create an automation package that can adaptively calibrate the instrument with minimal user input and convert the calibration to real-time measurements of flow. Currently, the flow meter requires manual determination of both the water column's zero flow height (H0) and the fluidic resistance, which determines the scaling of the calibration in the flow meter. To find H0, I am implementing an algorithm to find the point where fluorescence between and upstream and downstream collector is balanced (the point where advection is zero and fluorescent molecules enter the measurement region equally from both directions), By the end of the project, I hope to report on use of the flow meter to measure to the instability in a flows caused by the formation of nanodroplets in microfluidic chips utilized to study chemical reactions.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Luca Caruso

Academic Institution: George Washington University | **Major:** Biomedical Engineering

Academic Standing (Sept. 2025): First-year Graduate Student

Future Plans (School/Career): I will pursue a M.S. in Biomedical Engineering at George Washington University

NIST Laboratory, Division, and Group: Physical Measurement Laboratory, Microsystems and Nanotechnology Division, Biophysical and Biomedical Measurement Group

NIST Research Advisor: Dr. Darwin R. Reyes and Dr. Aditya Rane

Title of Talk: Cell Migration Assays in Microfluidic-based Systems for Studies of Cancer Aggressiveness

Abstract:

Organ-on-a-chip (OoC) systems are in-vitro microfluidic-based platforms that can support primary, immortalized, and pluripotent stem-derived cells in culture for therapeutic and diagnostic research. These platforms are capable of more accurately representing in-vivo conditions than conventional 2D cell monoculture methods. One application for OoC systems is the study of cell migration in cancer cells of varying aggressiveness. Traditional assays to determine cell migration use a porous membrane separated by two chambers (i.e., Boyden chamber or transwell) or a cell culture well where a scratch provides the means to measure cell migration when cells migrate to “seal” the scratch or wound. These two examples, and many others, are limited to endpoint measurements, which provide only a snapshot in time of these processes. Alternatively, an OoC environment with integrated sensors can acquire real-time impedance measurements of cell behavior by monitoring and displaying data continuously and in a dynamic way. Therefore, the focus of this project is to characterize the effect of drugs that inhibit cell migration in healthy and cancerous renal cell lines (RPTEC and 786-O, respectively) and to quantify their differences in aggressiveness using an OoC platform with integrated electronic sensors. To accomplish this, drug concentrations were first tested within traditional cell culture well plates to optimize the drug concentrations at which cells would show changes in cell migration. Drug concentrations from 0 µM to10 µM (i.e., 0.01, 0.1, 0.5, 1.0, and 10 µM) were assayed with an exposure time of 48 hours. A viability assay was done to determine cell survival based on the varying drug concentrations. Next, wound healing scratch assays and transwell migration assays were performed to observe cell migration on a conventional plate and a porous PET membrane, respectively. ImageJ/Fiji was used to count cells and determine scratch coverage. Results showed that cell viability decreased with an increased Cytochalasin D drug concentration in the cancerous cells. In the scratch assay, the cancerous cells were not able to close the wound with Cytochalasin D concentrations of 0.5 µM and greater. The healthy cells did not close the

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Stephen Chen			
Academic Institution:	Massachusetts Institute of Technology	**Major:**	Physics, Mathematics
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	PhD in physics		
NIST Laboratory, Division, and Group:	PML, Sensor Science Division, Fundamental Thermodynamics Group		
NIST Research Advisor:	Daniel Barker		
Title of Talk:	Developing Fast Readout for High Vacuum Optomechanical Pressure Sensors		

Abstract:

Damping-based optomechanical pressure sensors have very slow readout rates in high vacuum (1e-6 Pa to 0.1 Pa), making them impractical for applications in industry. Our optomechanical sensors compute pressure from observations of the gas-induced damping rate of their mechanical oscillator. We develop a continuous readout system for optomechanical sensors that significantly improves the readout rate. We characterize the uncertainties and stabilities for sensors using our readout system across a range of sampling times and pressures. We find that there is a trade-off between readout rate and uncertainty, with the lowest uncertainty occuring for sampling times on the order of the characteristic damping time. Our improved readout rates could ease adoption of optomechanical sensors in critical industries, including semiconductor manufacturing and spaceflight.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Ramon Perez
Academic Institution:	Indiana University
Major:	Physics
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Graduate School
NIST Laboratory, Division, and Group:	PML, Sensor Sciences Division, Fundamental Thermodynamics Group
NIST Research Advisor:	Eric Norrgard
Title of Talk:	Chemical Enhancement of MgF from a CBGB source via Laser Excitation

Abstract:

Cryogenic buffer gas beams (CBGBs) are an important starting point for many cold molecule experiments, ranging from precision measurements to ultracold molecule production through direct laser cooling. However, CBGB sources of molecules have lower fluxes than their atomic counterparts, and would benefit from methods to produce more molecules. In this project, we attempt to enhance the production of MgF from a CBGB source by exciting the metal atom precursor Mg to an excited metastable state via laser excitation. By promoting Mg to an excited state, we may considerably modify the reaction dynamics with the fluorine donor SF6, yielding additional pathways to produce MgF. This presentation will showcase the implemention this chemical enhancement technique as well as its effectiveness.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Jeyadave Nuntha Kumar

Academic Institution: University of Maryland | **Major:** Aerospace Engineering

Academic Standing (Sept. 2025): Graduated

Future Plans (School/Career): Pursue a PhD in engineering with a focus on computational fluid dynamics (CFD) research to enter academia as a research scientist.

NIST Laboratory, Division, and Group: Physical Measurement Laboratory, Sensor Science Division, Fluid Metrology Group

NIST Research Advisor: Christopher Crowley

Title of Talk: Computational and Experimental Evaluation of Anemometer Blockage in a Benchtop Wind Tunnel

Abstract:

Airspeed measurement devices, commonly known as anemometers, must be calibrated to ensure accurate velocity readings. Such devices are calibrated to accurately measure velocity when placed in a freestream environment. To that end, most anemometers are calibrated in wind tunnels, where only some approximation of a true freestream can be realized. During calibration, the test anemometer is typically placed downstream of a reference device that provides the "true" airspeed. However, both the wind tunnel walls and the presence of the anemometers themselves can disturb the flow field and affect the reference reading. This disturbance introduces a systematic calibration error known as the blockage effect. Here, I discuss the role of the blockage effect in a small, benchtop wind tunnel, where these disturbances are particularly pronounced. To characterize the extent of the effect, I performed three-dimensional computational fluid dynamics (CFD) simulations of the test section, which were validated with velocity measurements in the test section vertical midplane obtained via Particle Image Velocimetry (PIV). The blockage effect was further demonstrated by the influence of the test anemometer on the upstream velocity as measured by Laser Doppler Velocimetry (LDV). We found that the extent of the blockage effect scales linearly with the diametrical length scale of the anemometer and can introduce a calibration bias of up to 10%. This characterization informs the selection of a correction factor that effectively mitigates the calibration bias. We also found that the blockage caused by the wind tunnel itself can be decoupled from that of the anemometers, which allows us to develop a correction procedure that can be applied by other labs performing calibrations in small wind tunnels.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Pragya Natarajan	
Academic Institution: George Washington University	**Major: Physics, Minor: Public Policy**
Academic Standing (Sept. 2025):	**Senior**
Future Plans (School/Career):	**PhD in Astrophysical Instrumentation**
NIST Laboratory, Division, and Group:	**Physical Measurement Laboratory, Fluid Mechanics, Fluid Metrology Group**
NIST Research Advisor:	**Dr.Aaron N. Johnson**
Title of Talk:	SLowFLowS: Simulating Thermal Effects in Rate-of-Rise Standards using COMSOL

Abstract:

The NIST Semiconductor Low Flow Standard (SLowFLowS) uses the Rate-of-Rise (RoR) method to measure mass flow from 0.025 sccm to 1000 sccm of gases. In the RoR method, a steady flow of gas enters an evacuated vessel of known volume, and the mass flow rate is determined by tracking the linear increase in gas density in the vessel over time. This increase in density is a function of pressure and temperature, and while pressure can be measured dynamically using fast-response transducers, temperature presents a well-known challenge: the work of compression. Commonly referred to as flow work, this process causes the gas temperature to vary both temporally and spatially during filling. To address this, NIST designed the SLowFLowS collection tank, a system consisting of long, slender tubes that promote conduction as the dominant heat transfer mode. This tank sits in a forced-convection air bath that enables the gas inside the tubes to reach a steady-state temperature profile that can be accurately predicted analytically by measuring the vessel's external wall temperature. This geometry allowed us to develop a thermal model that predicts a preliminary change in temperature due to flow work, and then the measured temperature change is extrapolated from pressure sensors.

Although the thermal model has been experimentally verified for this geometry, making Computational Fluid Dynamics (CFD) simulations to visualize thermal effects over various flow rates and gas species using COMSOL Multiphysics can help further test the model and provide guidance for future projects. COMSOL Multiphysics' CFD module proved its utility for SLowFLowS as it confirmed the model across various flow rates and gas species and provided insight on its limitations.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Grant Chapman
Academic Institution:	University of Maryland - College Park
Major:	Astrophysics and Mathematics
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Grad school in Physics
NIST Laboratory, Division, and Group:	PML, Quantum Measurement Division, Laser Cooling and Trapping Group
NIST Research Advisor:	Ian Spielman
Title of Talk:	Laser Locking to Distinct Spectral Peaks

Abstract:

A common method used today to study atoms is to cool them down to sub-1K temperatures, minimizing their atomic motion. One technique which NIST pioneered was the use of laser light to cool atoms, taking advantage of the electronic transitions in the atoms to reduce their speed and thus their temperature. In order to do this, the laser frequency needs to be precisely tuned to the atomic resonance, and needs to be stable.

This summer, we implemented a technique to lock a laser to such an atomic reference using an electro-optical modulator (EOM) to generate frequency sidebands which can then be locked to a spectral peak. An advantage of this method is that we can position these sidebands relatively far from the actual laser frequency, and so can lock to a distant signal. This is particularly useful in the case where the desired atomic reference frequency is known, but difficult to get a strong signal to lock to. Another advantage of this system is that we are able to use fiber-optics rather than free-space beams, which are more robust to environmental changes.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Thea Bielejec

Academic Institution: Purdue University | **Major:** Physics

Academic Standing (Sept. 2025): Junior

Future Plans (School/Career): Graduate School

NIST Laboratory, Division, and Group: Physical Measurement Laboratory, Quantum Measurement Division, Laser Cooling and Trapping Group

NIST Research Advisor: Ian Spielman

Title of Talk: Off-axis Holographic Imaging of Marangoni Surface Waves on a Shallow Ferrofluid Layer

Abstract:

This project explores how a shallow classical fluid, subject to optical forcing, exhibits dynamics similar to those of quantum fluids. Our current focus is on demonstrating the ability to excite and image surface waves using laser-driven Marangoni convection. The long term goal is to simulate the superfluid behavior of Bose-Einstein condensates with the addition of real-time optical feedback..

The experimental system consists of a thin layer of ferrofluid in a temperature-controlled aluminum dish. A focused green laser locally heats the fluid, creating a surface tension gradient and inducing outgoing convective flow via the Marangoni effect. This optical forcing produces surface deformations that we track using off-axis digital holography, an interferometric technique that enables single-shot measurement of both the amplitude and phase of a probe laser beam. In this setup, a red imaging laser is split into probe and reference beams. These beams interfere on a sensor, producing a spatially modulated hologram. By isolating the off-axis diffraction order in the Fourier domain and applying inverse FFT-based convolution, we reconstruct the complex optical field. Phase unwrapping then yields micrometer-scale surface height maps of the fluid interface. Angular averaging of these maps produces 1D radial height profiles suitable for spectral analysis.

To ensure consistent forcing, we implemented a servo-based analog power-lock system using photodiode feedback. This stabilized the green laser′s output during pulsed operation and enabled synchronized pulse sequences with camera triggers. This allowed us to transition from isolated, single-pulse experiments to extended multi-pulse sequences with tunable duration and frequency. The resulting surface excitations were reproducible, and the data were analyzed and compared to predictions from shallow water theory.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Ramakrishnan Gopinath

Academic Institution: Arizona State University **Major:** Electrical Engineering

Academic Standing (Sept. 2025): Incoming second year student at Arizona State University

Future Plans (School/Career): Finish Bachelor's degree in Electrical Engineering focusing on either Power Systems, RF/Antennas, or Control Systems.

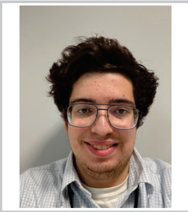
NIST Laboratory, Division, and Group: 684.05

NIST Research Advisor: Dr. Angela Hight Walker

Title of Talk: Advancing Magneto-Optical Spectroscopy through Automation of Spatial, Temperature, and Field Mapping

Abstract:

Raman and photoluminescence (PL) spectroscopy are powerful optical techniques used to probe the vibrational and electronic properties of materials. While Raman spectroscopy measures inelastic scattering of light by phonons, PL captures light emission from excited electronic states. Together, they reveal critical insights into the structural, electronic, and excitonic behavior of two-dimensional (2D) materials. A home-built magneto-optical measurement platform has been developed to perform Raman and PL measurements under variable temperature, magnetic field, laser excitation wavelength, and power, with full XYZ spatial control. The system also includes eight electrical contacts that enable quantum Hall transport measurements to be performed simultaneously with optical spectroscopy. Polarization control is achieved using two motorized half-wave plates and two fixed polarizers, enabling angle- and helicity-resolved optical measurements. The setup integrates a magneto-cryostat for cryogenic temperature and magnetic field control with nanopositioners for precise motion along the X, Y, and Z axes. Automated system control was developed using LabVIEW to coordinate motion and data acquisition across all dimensions. A Z-scan routine moves the sample through user-defined focus positions, allowing spectral acquisition at each point for depth profiling or focus optimization. For lateral scanning, a 2D XY mapping routine uses a snaking raster pattern that efficiently covers rectangular regions by alternating X-direction movement after each Y step. At each position, LabSpec software triggers spectral collection, generating high-resolution spatial maps with minimal manual intervention. Temperature and magnetic field control are also automated. Users can define sequences to step through these conditions, enabling synchronized Raman or PL measurements at each point. All field, temperature, and position data are recorded alongside the spectra for detailed analysis. The system was tested using a variety of samples, including calibration standards such as silicon and quartz, and research-grade 2D semiconductors such as organic/inorganic hybrid perovskites. Automated scans confirmed the accuracy



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Arden Dombalagian

Academic Institution: Georgetown University | **Major:** Physics

Academic Standing (Sept. 2025): First Year Graduate Student

Future Plans (School/Career): Graduate School, Experimental Physics Researcher

NIST Laboratory, Division, and Group: Physical Measurement Laboratory, Quantum Measurement Division, Mass and Force Group

NIST Research Advisor: Gordon Shaw

Title of Talk: Sub Microgram Mass Measurement and Analysis

Abstract:

The measurement of objects at extremely small scales is essential to many applications such as medicine, device technology, and more. As a result, it is beneficial to find consistent methods to measure extremely light masses with high precision. To do so, we used an optomechanical sensor to measure the masses of sub microgram scale objects. A mass is deposited on the sensor, and then the sensor vibrates. The motion of a fused silica paralellogram flexure harmonic oscillator is excited with an integrated piezoelectric actuator and read out with a laser doppler vibrometer. The resonant frequency is tracked with a phase-locked loop to determine the change in frequency as small objects are placed on the oscillator. The mass of the objects can be determined from the resonant frequency change using a calibration procedure.

The main aspect of the project was to see how movement of the mass on the sensor affects the measured resonant frequency, and how to potentially eliminate the movement to stabilize the frequency and subsequent mass measurements.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Kira Yuen
Academic Institution:	University of Maryland, College Park
Major:	Mechanical Engineering
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Entering the engineering workforce
NIST Laboratory, Division, and Group:	PML, Quantum Measurement Division, Fundamental Electrical Measurements
NIST Research Advisor:	Zane Comden
Title of Talk:	Improving Commercial Viability of a Kibble Principle Torque Standard

Abstract:

The Electronic NIST Torque Realizer (ENTR) is a device used to realize torque up to 1 N m and calibrate torque measuring tools to 0.1% uncertainty or better using an adaptation of the Kibble Principle. ENTR is currently a work in progress alongside a major tool and calibration systems manufacturer with the goal of commercial sale to sectors including automotive, aerospace, and the Department of Defense.

To acheive this goal, the electrical measurement components must be calibrated every 6 months to account for long-term voltmeter drift such that the uncertainty of the measurement is kept sufficiently low. We desire less than 5E-5 drift for voltage measurement on a timescale of years to reduce or completely eradicate the need for regular voltmeter calibrations. We test a Texas Instruments REF54 voltage standard with stated uncertainties at 1E-6 level drift or better over years as a potential reference for voltage measurements. To confirm the performance, we measure the long-term voltage output of the REF54 over 2 months and note how voltage changes with temperature. Voltage and temperature measurements are taken every 60 seconds for this 2-month period using two 3457A multimeters and a negative thermal coefficient thermistor.

When using torque tools, there is usually a given uncertainty from the manufacturer (~5%). In addition, some tools may be much better or worse than others in terms of repeatability which makes it important to compare how different tools perform on ENTR throughout its development. We compare the measured max torque value against the tool setpoint. We show results of multiple torque maximum calculation methods such as utilizing a moving average filter or fitting a polynomial to estimate the peak and present the performance and uncertainty of each. Of the methods tested, the polynomial fit returns the most repeatable results for maximum torque measured as well as lowest uncertainty in the determination of the maximum.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	JD Astudillo
Academic Institution:	Florida Atlantic University
Major:	Electrical Engineering/ Physics
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	Graduate School (Electrical Engineering)
NIST Laboratory, Division, and Group:	Physical Measurement Lab / Radiation Physics Division / Neutron Physics Group
NIST Research Advisor:	Tom-Erik Haugen
Title of Talk:	Numerical Simulation of Heat Transfer in Cryogenic Silicon to Inform Design of a Novel Quantum Sensor

Abstract:

A novel quantum sensor that can measure individual charged particles, called a Charged Particle Thermal Kinetic Inductance Detector (CP-TKID), is being developed at NIST to probe physics beyond the Standard Model. A TKID is a cryogenic sensor made of a superconducting resonator circuit on a pure silicon base; it converts incident energy to heat and reads out as a change in resonator frequency. Unlike traditional TKIDs, which measure photons, CP-TKIDs are larger by four orders of magnitude so that they can fully absorb charged particles. To date, the Neutron Physics Group and the Quantum Sensors Division have built and tested the first Charged Particle Thermal Kinetic Inductance Detector. TKIDs have the advantage of being easily multiplexed so they are ideal candidates for scaling up to large-area experiments with thousands of detectors. As we design the first array of these CP-TKIDs, we must make a tradeoff in deciding how closely to arrange the individual sensors. Placing them close together increases the fill fraction and detection efficiency, but can result in crosstalk between adjacent pixels due to heat transfer. We present a detailed study of heat transfer in cryogenic silicon using COMSOL Multiphysics® software to investigate how the amplitude and decay time of the temperature signal depend on the location of the energy deposit. This is the first numerical simulation of the thermal behavior of CP-TKIDs and provides insights for future designs and ongoing array prototyping.

SURF Student Colloquium

NIST – Gaithersburg, MD

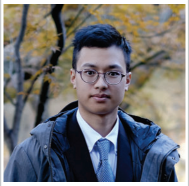
July 29 - 31, 2025

Name:	Tarun Jacob
Academic Institution:	University of Pennsylvania
Major:	Electrical and Bioengineering
Academic Standing (Sept. 2025):	Sophomore
Future Plans (School/Career):	To pursue a Ph.D. in Biomedical Engineering to create innovative medical diagnostics.
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Radiation Physics Division, Dosimetry Group
NIST Research Advisor:	Csilla Szabo-Foster
Title of Talk:	Monte Carlo Modeling of Ionization Chambers for Brachytherapy Dosimetry

Abstract:

Radiation therapy using small, encapsulated implantable sources—known as brachytherapy—is an effective method for treating various types of cancer. The National Institute of Standards and Technology (NIST) upholds the U.S. primary standard for radioactive source strength (air-kerma strength) for low-dose-rate (LDR) photon-emitting brachytherapy sources. Ionization chambers are valuable tools in radionuclide metrology and radiation dosimetry, where the electrical current can be related to a source activity or air-kerma strength. Monte Carlo simulations are a powerful method for predicting the response of a specific chamber.

This project focuses on developing Monte Carlo models of two key ionization chamber systems used in brachytherapy dosimetry: the Wide-Angle Free-Air Chamber (WAFAC) and a well-type ionization chamber. The WAFAC serves as the U.S. primary standard instrument for calibrating brachytherapy sources in terms of air-kerma strength. The objective is to simulate these instruments and their responses to brachytherapy sources using TOPAS, a Geant4-based platform. By modeling these instruments, we aim to quantify their responses and improve calibration accuracy, particularly for anisotropic sources that deviate from point-like or uniform emission. The study will also investigate the use of spectral energy characteristics from gamma detectors to measure source parameters. Eight radionuclides with various decay emissions, as well as twelve monoenergetic photon sources (10–400 keV) were assessed. This work contributes to reducing uncertainties in brachytherapy source strength measurements and may help harmonize international dosimetry practices where differing standards exist.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Ravi Jain
Academic Institution:	Duke University
Major:	Physics
Academic Standing (Sept. 2025):	Senior
Future Plans (School/Career):	Pursue graduate education in Physics or Material Science
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Radiation Physics Division, Radioactivity Group
NIST Research Advisor:	Dr. Max Carlson
Title of Talk:	Simulation of Subkelvin Transition Edge Sensors (TES) for the True Becquerel Project

Abstract:

The True Becquerel (TrueBq) project is an attempt to efficiently identify radionuclides and determine the massic activity (Bq per gram) of samples. TrueBq uses cryogenic Transition Edge Sensors (TESs) to measure the Decay Energy Spectrum (DES) of radioactive samples. Using the transition temperature of a superconducting layer, TESs transduce sub-mK temperature changes into a current signal. By enclosing radioactive samples within a radiation-absorbing material in thermal contact with the TES, decay events can be studied as heat pulses with the advantage of low background and high energy resolution.
Numerous phenomena have appeared in experimental data that simple analytic models of the TES cannot address. These include "chip hits," when a gamma or beta particle hits the silicon TES chip, and "flux jumps," when a fast rising edge causes the Superconducting Quantum Interference Device (SQUID) feedback loop to change its baseline. To better understand these effects, we developed digital thermal models of two TES designs in COMSOL, allowing us to simulate position-dependent decay events and better capture non-uniform temperature gradients across the device.
We first validated our non-linear thermal conductivity and heat capacity models by comparing 1D and 2D COMSOL simulations to Python simulations. We then recreated the TES chip geometry in COMSOL, implementing Electron-Phonon coupling at metal-silicon interfaces and simulating the limiting cases of idealized Electro-Thermal Feedback (ETF) and no ETF in the TES. We validated the model by comparing simulation data to experimental heater power curves, Nyquist plots, and pulses. We simulated a variety of different chip hit events, confirming the nature of anomalous pulses. We plan to use these results to inform future design decisions around chip geometry, heat sinking, and thermal connection between TES and absorber.

SURF Student Colloquium

NIST – Gaithersburg, MD

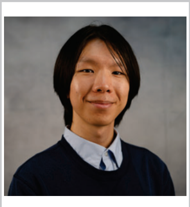
July 29 - 31, 2025

Name:	Christopher Kniss
Academic Institution:	Stevens Institute of Technology (SIT)
Major:	Computer Engineering
Academic Standing (Sept. 2025):	Incoming first year graduate student in the University of Massachusetts Amherst
Future Plans (School/Career):	Beginning my Electrical and Computer Engineering Ph.D. at the University of Massachusetts Amherst
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Nanoscale Device Characterization Division, Advanced Electronics Group
NIST Research Advisor:	Dr. Pragya Shrestha
Title of Talk:	Reducing Thermal Load: Wireless Interconnects Inside the Cryogenic Chamber

Abstract:

Quantum computing systems rely on qubits that operate at millikelvin temperatures to preserve quantum states, making thermal management a critical design constraint. Control and readout electronics are typically placed at the 4 K stage of a dilution refrigerator to minimize latency and signal degradation, but even at this stage, the available cooling power is severely limited. Conventional wired interconnects between room temperature and cryogenic stages introduce significant thermal load through direct conduction, restricting system scalability and overall performance. Wireless radio-frequency (RF) interconnects offer a promising solution by severing this conduction path and enabling higher I/O bandwidth through reduced cabling and high-speed multiplexing. To explore this approach, we present the design of a custom twin printed circuit board (PCB) platform for evaluating a half-duplex 60 GHz millimeter-wave transceiver chip using four-level pulse amplitude modulation (PAM4) under cryogenic conditions.

The experiment characterizes signal fidelity and power consumption as a function of inter-transceiver spacing and operating temperatures ranging from room temperature down to approximately 4 K. By analyzing the transceiver pair in various operating conditions, we aim to advance the development of cryogenic I/O systems which exhibit heightened scalability, high-bandwidth, and significant thermal load reduction in comparison to conventional wired interconnects.



SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Jameson Lau
Academic Institution:	University of Maryland, College Park
Major:	Electrical Engineering
Academic Standing (Sept. 2025):	Junior
Future Plans (School/Career):	TBD
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Nanoscale Device Characterization Division, Atom Scale Device Group
NIST Research Advisor:	Joshua M. Pomeroy
Title of Talk:	Developing Reflow Solder Packaging for Cryogenic Devices to Improve Fidelity

Abstract:

I successfully bonded custom silicon chips to commercial printed circuit boards (PCBs) using reflow soldering. This process can increase fidelity for high frequency measurements.

Wire bonding, the current packaging method, performs poorly at the high frequencies of quantum devices due to unmatched impedances in the fine wires. Reflow soldering, a standard industry method, solves this, but thermally mismatched materials at cryogenic temperatures cause mechanical stress in the solder joint.

The goal of this project is to use reflow soldering to consistently produce strong, low resistance bonds between silicon chips and PCBs which cool down without breaking. I am designing a reflow process in a commercial reflow oven by varying time, temperature, and solder quantity. This process will then be applied to thermally matched ceramic PCBs, reducing stress to reach cryogenic temperatures intact. This talk will present the development process and evaluate the potential for practical use.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Jack Stawasz

Academic Institution:	College of William & Mary	**Major:**	Physics & Computer Science
Academic Standing (Sept. 2025):	Junior, Class of 2027		
Future Plans (School/Career):	Graduate School and/or Software Development in Physics		
NIST Laboratory, Division, and Group:	PML, Nanoscale Device Characterization Devision (683), Nanoscale Spectroscopy Group		
NIST Research Advisor:	Jared Wahlstrand and Chad Cruz		
Title of Talk:	Measuring the Kerr Effect in Silicon via Ultrafast Spectroscopy		

Abstract:

Third-order nonlinear optical susceptibility describes how an intense light field alters a material's polarizability and refractive index. Understanding this material property is important for photonics applications such as frequency combs. We aim to precisely measure the two fundamental constants that characterize this nonlinear response: n2, describing Kerr-induced light phase shifts, and , describing two-photon-absorption-induced light amplitude shifts. In this experiment, we measure this response in silicon, a highly absorbing and commercially vital semiconductor with applications in integrated photonics.

We send 200fs pump and supercontinuum probe laser pulses through a thin sample of silicon to measure the differences between modulated and unaffected pulses as a function of wavelength. Optical alignment is automated by raster scanning the pump laser across the sample to optimize spatial overlap with the probe beam and improve the accuracy of the pump irradiance measurement. Data analysis is performed in Julia, where a model handling multiple reflections within a thin sample is fitted to processed spectrometer data to extract the variables needed to calculate the refractive index and absorption coefficient changes. With our highly precise setup, we intend to set the standard for n2 and measurements to improve the effectiveness of up-and-coming technology relying on nonlinear optics.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name: Ariam Yohannes

Academic Institution:	Stony Brook University	**Major:**	Physics
Academic Standing (Sept. 2025):	Sophomore		
Future Plans (School/Career):	PhD		
NIST Laboratory, Division, and Group:	PML, Nanoscale Device Characterization Division, Atom Scale Device Group		
NIST Research Advisor:	Dr. Eric D. Switzer		
Title of Talk:	Predicting Atomic-Scale Device Properties Using IBM Heron v2 Digital Quantum Simulators		

Abstract: At atomic and mesoscopic scales, classical quantum simulators (CQS) have advanced our understanding of strongly correlated fermionic systems, unveiling properties of phases such as Mott insulating behavior and superconductivity. However, exponential growth in the Hilbert space restricts CQS approaches, like exact diagonalization and quantum Monte Carlo, to systems comprising roughly 10 to 100 particles, which is insufficient for realistic nanoscale device modeling. Digital quantum simulators (DQS), such as noisy-intermediate scale quantum (NISQ) devices, offer a potential alternative by simulating fermionic Hamiltonians through quantum many-body wavefunction evolution. Despite this promise, DQS faces ongoing challenges in error correction and mitigation, while also requiring careful benchmarking against established CQS results and other approaches such as analog quantum simulators.

In this work, we benchmark DQS against CQS for the extended Fermi-Hubbard (eFH) model with extended Coulombic interactions, a system particularly challenging for classical methods. Employing a particle-norm-conserving *ansatz* optimized for the Fermi-Hubbard Hamiltonian, we use the Variational Quantum Eigensolver (VQE) algorithm to investigate the ground-state energy landscape for three- and four-site systems across multiple interaction regimes. Our VQE results obtained from experiments on IBM Heron v2 NISQ quantum processors achieve ground-state energies within a few percent of values obtained from our CQS methods via exact diagonalization and classical simulations of quantum circuits, particularly when extended interactions are weak compared to onsite interactions. Additionally, we evaluate resource constraints associated with simulating real-time evolution in the eFH model, introducing a cost function to quantify quantum circuit resource usage. Using a second-order Suzuki-Trotter decomposition and a dynamic convergence detection method to extend a recently developed particle-norm-conserving *ansatz*, we successfully reduce required quantum resources while maintaining accurate eigenenergy predictions. Collectively, these findings demonstrate the feasibility of hybrid quantum-classical approaches for strongly correlated fermionic simulations and suggest practical strategies for resource-efficient circuit design on near-term quantum devices.

SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name:	Nathan Gehl
Academic Institution:	The University of Chicago
Major:	Physics, Mathematics
Academic Standing (Sept. 2025):	Second Year
Future Plans (School/Career):	Attend graduate school in Physics
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Nanoscale Device Characterization Division (683), Nanoscale Spectroscopy Group (683.12)
NIST Research Advisor:	Emily Bittle
Title of Talk:	Improving Nanoscale Electrical Devices for Use in Quantum Sensing Regimes

Abstract:

Nitrogen vacancies (NVs) in diamond predictably respond to magnetic fields and therefore are increasingly being used as quantum sensors. NVs are used for non-invasive, extremely local, magnetic field sensing, but also show promise for larger scale applications such as global positioning. While NV sensor technology is lab proven, improvements need to be made to decrease the cost and size of devices to enable widespread adoption. We seek to improve readout of NV sensors using photocurrent detection of magnetic resonance (PDMR) which simplifies the readout of NV sensors when compared to traditional methods such as optically detected magnetic resonance (ODMR). To do this, we are working to optimize photocurrent detection and general device efficacy by examining the device dependence on the shape, size, contact spacing, and orientation. Devices were prepared on synthetic CVD grown diamonds using lithographically defined gold and aluminum contact metals. We measured current as a function of applied voltage with and without optical stimulus of the device, giving us readings of the photocurrent and the effective device resistance. This was complemented by an examination of the local charge distribution surrounding our devices using the decomposition of photoluminescence spectra described in Alsid et al (2019). Together, these measurements highlighted discrepancies between expected and observed behavior, enabling further investigation of specific devices and the unknown factors that influence device performance. While our current work is still largely exploratory, the refinement of photocurrent detection using low voltage helps to inform future device design to improve general NV sensor efficacy and scalability.

Alsid, S. T., Barry, J. F., Pham, L. M., Schloss, J. M., O³ Keeffe, M. F., Cappellaro, P., & Braje, D. A. (2019). Photoluminescence decomposition analysis: a technique to characterize N-V creation in diamond. Physical review applied, 12(4), 044003.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Marios Kalpakis		
Academic Institution:	University of Maryland, College Park	**Major:**	Computer Science and Math
Academic Standing (Sept. 2025):	Junior		
Future Plans (School/Career):	I plan to go to graduate school.		
NIST Laboratory, Division, and Group:	Physical Measurement Laboratory, Nanoscale Device Characterization Division, Alternative Computing Group		
NIST Research Advisor:	Matthew Daniels		
Title of Talk:	Associative Memories in Temporal Networks		

Abstract:

Associative memories are pattern storage and retrieval systems where, given an input, the system will output the "closest" stored memory, analogous to finding the minima in some energy landscape. Such systems were proposed by Hopfield in 1982, for deterministic Ising models, called Hopfield networks.

In our group, we have been exploring temporal neural networks, a type of spiking neural network where information is encoded explicitly in the relative timing of neural signals. This biologically inspired form of computation is predicted to be fast, energy efficient, and realizable in modern silicon chips. In addition to storing information in relative signal phases, these networks also allow the act of "doing nothing" as a valid operation.

We can think of each volley of spikes output from our system as a vector and ask: if given some initial spiking configuration, can we make our system settle into a predetermined firing pattern? In other words, can such systems act as associative memories that remember temporally precise firing sequences?

In this talk, we answer in the affirmative, and demonstrate how max-plus (tropical) algebra naturally expresses the leading order dynamics of temporal networks. In particular, we show that the eigenspaces of tropical operators encode attractors, saddle points, and repellers of temporal memories. In addition, we describe a simple algorithm to construct a tropical operator from a collection of desired temporal memories.


NIST
TECHNOLOGY PARTNERSHIPS
OFFICE

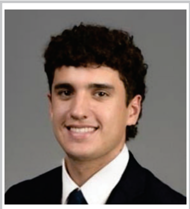
Summer Undergraduate Research Fellowship (SURF) - 2025 Participants

Technology Partnership Office (TPO)

Student Names and Talk Titles (in order of presentation)

Jackson Brunner: Resolving discrepancies in federal agency data

Angela Guan: Fight or Flight: Unique trends in federal research commercialization



SURF Student Colloquium

NIST – Gaithersburg, MD
July 29 - 31, 2025

Name: Jackson Brunner

Academic Institution: University of Maryland, College Park **Major:** Information Science

Academic Standing (Sept. 2025): Senior

Future Plans (School/Career): Work in the analytics field, potential masters later on

NIST Laboratory, Division, and Group: Technology Partnerships Office (TPO)

NIST Research Advisor: John Bittman

Title of Talk: Resolving Discrepancies in Federal Lab Data

Abstract:

Inaccurate or incomplete federal datasets can limit transparency and disrupt collaboration between agencies involved in research, development, and technology transfer. Two such datasets - the Federal Laboratory Consortium (FLC) organization list and the National Science Foundation's (NSF) data - are designed to catalog federal research organizations, yet contain notable inconsistencies in names, structure, location, and overall representation.

To address this, I led a data reconciliation effort involving cleaning, organizing, and classifying over 1,500 records between the FLC and NSF datasets. I designed a match classification system using color-coded and formatting-based labels to categorize records as exact matches, partial matches, unmatched entries, or sub-agencies missing from one dataset. I added addresses for unmatched NSF entries, missing FLC entries, and verified/flagged several based on confidence level.

My final report will include detailed summary statistics, a cleaned and annotated master file, and visual dashboards that highlight agency-level discrepancies and address completion rates. Future tools used include Excel for pivot-driven analysis and Power BI for potential geospatial and categorical visualizations. I will also propose a long-term monitoring approach to help the FLC and NSF better align their data moving forward.

This project supports NIST's goals of improving interagency data quality and provides real-world experience in data reconciliation, metadata structuring, and visual communication. The methods and outcomes are directly applicable to public-sector analytics, digital infrastructure projects, and open government data initiatives.

SURF Student Colloquium

NIST – Gaithersburg, MD

July 29 - 31, 2025

Name:	Angela Guan
Academic Institution:	Northwestern University
Major:	Chemical Engineering, Music
Academic Standing (Sept. 2025):	Graduate Student
Future Plans (School/Career):	Ph.D., Mechanical Engineering | I'd love to pursue a career as a professor or in R&D!
NIST Laboratory, Division, and Group:	Technology Partnerships Office (TPO)
NIST Research Advisor:	John Bittman
Title of Talk:	Fight or Flight: Unique Trends in Research Commercialization

Abstract:

For every $1 invested in federal R&D, approximately $5 is returned in economic benefits. This impact is empowered by technology transfer legislation, which provide avenues to push federal research into industry. However, the details of the tech transfer process are expansive and intricate.

Here, we illuminate major trends in research commercialization- specifically, how does tech transfer vary across disciplines? This work comprises 1) high-level data analysis and 2) in-depth case study of a successful tech transfer. In the former, we process data from the Federal Laboratory Consortium and federal agencies to evaluate the commercialization paths of various sectors. In the latter, we analyze past awardees of Excellence in Technology Transfer to identify successful techniques for maximizing economic impact. Essentially, we seek to infuse a colloquial narrative in this colloquium that will equip aspiring researchers and entrepreneurs to trump commercial hurdles.