

NNCI REU Convocation

2024

Abstract Book

University of Nebraska - Lincoln

Lincoln, Nebraska

August 4-6, 2024

Hosted by the

Nebraska Nanoscale Facility (NNF)



Welcome and thank you for joining us for the 2024 NNCI REU Convocation!

We are pleased to celebrate the endeavors of the 90 undergraduate researchers participating this year.

The Nebraska Nanoscale Facility (NNF) is one of 16 National Science Foundation supported user facility sites at universities across the US. These 16 sites are collectively known as the

National Nanotechnology Coordinated Infrastructure (NNCI). With the pooled resources of these 16 multidisciplinary user facilities, the NNCI can aid any user in finding just the right tools and experts needed to further research and innovation and development at the nanoscale.



NNF’s facilities include:

Electron Nanoscopy Instrumentation (ENIF)

Nanomaterials & Thin-Films (NTFF)

Nanofabrication Cleanroom (NCF)

Surface & Materials Characterization (SMCF)

X-Ray Structural Characterization (XRSCF)

Nano-Engineering Research Core Facility (NERCF)

Laser Nanofabrication and Characterization

Low-Dimensional Nanostructure Synthesis

XRF – X-Ray Structural Characterization

XPS–Surface and Materials Characterization

https://nanoscale.unl.edu/

**Speaker Bios**

*In order of appearance*

## Welcome from NCMN & NNF Director

## Dr. Christian Binek, NCMN & NNF Director, and Professor, Charles Bessey Professor in the Department of Physics and Astronomy, University of Nebraska-Lincoln

## Dr. Christian Binek earned his Ph.D. from the University of Duisburg-Essen in Germany in 1995, followed by a Habilitation in 2001. His primary research interests focus on magnetic interface effects, especially electrically controlled magnetism and spintronics, as well as fundamental thermal physics. In 2013, Dr. Binek was a Visiting Professor at nanoGUNE in San Sebastian, Spain and became an IKERBASQUE Fellow of the Basque Foundation for Science.

## Since 2019, Dr. Binek has been the Director of the Nebraska Center for Materials and Nanoscience and the Nebraska Nanoscale Facility, an NSF-funded regional center of excellence in nanoscience and nanotechnology and one of the 16 sites constituting the National Nanotechnology Coordinated Infrastructure. In 2020, he became the Scientific Director of the NSF-funded $20M Center on Emergent Quantum Materials and Technologies (EQUATE). As of 2023, he also co-leads the $4.7M UNL Grand Challenges Catalyst Grant on Quantum Approaches addressing Global Threats.

## Welcome and NNCI Overview from NNCI Director

## Dr. David Gottfried, Regents Researcher and Senior Assistant Director, Institute for Electronics and Nanotechnology, Georgia Institute of Technology

David Gottfried received a Bachelor of Science in chemistry from the University of Michigan and continued his Ph.D. studies in physical chemistry at Stanford University under a National Science Foundation graduate fellowship. He was a European Molecular Biology Organization post-doctoral fellow at the Weizmann Institute of Science before beginning research and teaching in biophysics at the Albert Einstein College of Medicine. In 1999 he moved to the Georgia Tech Research Institute where he designed and tested optical sensors for chemical and biological agents with food safety, environmental, and homeland security applications. Dr. Gottfried joined the Microelectronics Research Center in 2007, where he was a technical liaison and biomedical domain expert for the NSF-funded National Nanotechnology Infrastructure Network. Beginning in 2012 he served as a member of the Advanced Technology Team in the Institute for Electronics and Nanotechnology (IEN) and then became Senior Assistant Director for IEN Nanotechnology Programs in 2016. He is currently the Director of the Southeastern Nanotechnology Infrastructure Corridor (SENIC), which is a member site of the National Nanotechnology Coordinated Infrastructure (NNCI), and is also Director of the NNCI Coordinating Office. Dr. Gottfried was selected as a Fellow of the American Chemical Society in 2012 and the American Association for the Advancement of Science in 2018. In 2021 he was named a Regents Researcher by the Board of Regents of the University System of Georgia.

**NNI/NNCO Overview**

Dr. Quinn Spadola, NNCO Deputy Director

Dr. Quinn Spadola is the Deputy Director of the National Nanotechnology Coordination Office (NNCO). She is motivated by a desire to broaden participation in the STEM workforce. She sees nanotechnology as a powerful tool to engage and excite future STEM professionals as well as to bring together agency representatives, academics, and members of industry to tackle challenges such as climate change and pandemic preparedness. Prior to returning to the NNCO she was Associate Director for Education and Outreach for the National Nanotechnology Coordinated Infrastructure (NNCI), a network of open nanotechnology laboratory user facilities supported by the National Science Foundation, and the Director of Education and Outreach for the NNCI site at the Georgia Institute of Technology. Dr. Spadola began her time at the NNCO as an AAAS Science and Technology Policy Fellow in 2014. After her fellowship, she served as Education and Outreach Coordinator and Technical Advisor to the Director until 2018. She received her Ph.D. in physics from Arizona State University and her MFA in Science and Natural History Filmmaking from Montana State University.

**Keynote - Flash Joule Heating by Dr. James Tour**

Dr. James Tour, Professor of Chemistry, Professor of Materials Science and Nanoengineering at Rice University

James M. Tour, a synthetic organic chemist, received his Bachelor of Science degree in chemistry from Syracuse University, his Ph.D. in synthetic organic and organometallic chemistry from Purdue University, and postdoctoral training in synthetic organic chemistry at the University of Wisconsin and Stanford University. After spending 11 years on the faculty of the Department of Chemistry and Biochemistry at the University of South Carolina, he joined the Center for Nanoscale Science and Technology at Rice University in 1999 where he is presently the T. T. and W. F. Chao Professor of Chemistry, Professor of Computer Science, and Professor of Materials Science and NanoEngineering. He has over 800 publications, over 130 patents, and an h-index = 173 with ~140,000 citations. In 2021, he won the Oesper Award from the American Chemical Society which is awarded to “outstanding chemists for lifetime significant accomplishments in the field of chemistry with long-lasting impact on the chemical sciences.” In 2020, he became a Fellow of the Royal Society of Chemistry and, in the same year, was awarded the Royal Society of Chemistry’s Centenary Prize for innovations in materials chemistry with applications in medicine and nanotechnology. He was inducted into the National Academy of Inventors in 2015. Tour was named among “The 50 Most Influential Scientists in the World Today” by TheBestSchools.org in 2019; listed in “The World’s Most Influential Scientific Minds” by Thomson Reuters ScienceWatch.com in 2014. Tour was named “Scientist of the Year” by R&D Magazine, 2013. He was twice awarded the George R. Brown Award for Superior Teaching at Rice University.

Described will be ultrafast heating and cooling routes to synthesize graphene and other 2D materials, carbon nanotubes, heteroatom substituted carbons and many inorganics, all in gram to ton scales.  Using the same approaches, ultrafast routes to the selective extraction of metals in electronic waste, industrial waste and metal ores, the degradation of PFAS, soil remediation and battery anode and cathode recycling will be discussed.

**Applying for NSF Graduate Fellowships**, and **An International Summer Research Experience in Japan**

Dr. Lynn Rathbun, Laboratory Manager, Cornell Nanoscale Facility

Historical tracking data since 1997 predicts that 75% of you will go to graduate school with 50% of you eventually earning a Ph.D.  We will talk about funding for graduate school (You get PAID!!). In particular, we will talk about the NSF Graduate Fellowship Program, the largest of the national competitive fellowship programs, and the surprising things that determine a winning application. Lastly, I will invite you all to apply for a special NNCI internship next summer at a National Laboratory in Japan.

Dr. Rathbun is the Laboratory Manager at the Cornell Nanoscale Facility. He obtained a B.S. in Physics from The Ohio State University in 1971, an M.S. in Physics from the University of Illinois in 1973, and a Ph.D. in Physics from the University of Illinois in 1979. He has been at CNF (and its predecessors) since 1979. From 2002-2015 he was Program Manager/Asst. Director of the National Nanotechnology Infrastructure Network (NNIN), the predecessor to NNCI.  In 1997, under NNUN (the predecessor to NNIN) he originated the concept of a network wide REU program and established the network REU convocation. He has been to almost all REU convocations since then. As part of NSF reporting activities, he has conducted extensive longitudinal tracking of the education and career paths of a large percentage of NNUN/NNIN/NNCI REU participants from 1997-2015.

**2024 NNCI REU Convocation Schedule**

**Sunday, August 4**

12:00-9:00 p.m. **Check-In**

Students to Knoll Residential Center at 440 N 17th St

Sponsors to the Graduate Hotel at 141 N 9th St

6:00-8:30 p.m. **Registration, Welcome Dinner, and Speaker**

Willa Cather Dining Center,Red Cloud Ballroom

 Professor Christian Binek, Director of NCMN and NNF

**Monday, August 5**

7:00 a.m. **Breakfast**

Students can eat at Cather Dining Center and sponsors at the Graduate Hotel

All daytime conference events Monday & Tuesday will take place in the **City Campus Union** at 1400 R St

7:45 a.m. **Registration** (for those who didn't register on Sunday)

City Campus Union, outside Auditorium

8:15 a.m. **Welcome and Logistics**

Auditorium

 Professor Christian Binek, Director of NCMN and NNF

 Jenna Huttenmaier, Education & Outreach Coordinator

8:30 a.m. **NNCI Welcome & Overview**

Auditorium

Dr. David Gottfried, Director, NNCI Coordinating Office

8:45 a.m.  **NNCO Overview**

Dr. Quinn Spadola, Deputy Director, National Nanotechnology Coordination Office

9:00-10:57 a.m. **NNCI REU Convocation Concurrent Presentations Sessions A, B, C** (30 students)

 Heritage, Regency A, & Regency B-C

11:00 a.m. **Lunch**

Platte River Room

11:15 a.m. **Keynote Speaker**

Platte River Room

Dr. James Tour, Professor of Materials Science & NanoEngineering, Rice University

12:20 p.m. **Set Up Posters**

Jackie Gaughan Multicultural Center (connected to the Union), Rooms 202 and 212

1:00-2:57 p.m. **NNCI REU Convocation Concurrent Presentations Sessions D, E, F** (30 students)

Heritage, Regency A, & Regency B-C

3:30-5:30 p.m. **Poster Session**

Jackie Gaughan Multicultural Center (connected to the Union), Rooms 202 and 212

5:45 p.m. **Dinner and Browsing at University of Nebraska State Museum - Morrill Hall**

Morrill Hall, 645 North 14th Street

7:30 p.m. **Climbing Wall on Campus with Dairy Store Ice Cream**

UNL Outdoor Adventures Center, 930 N 14th St

**Tuesday, August 6**

7:00 a.m. **Breakfast**

Students can eat at Cather Dining Center and sponsors at the Graduate Hotel

8:00-10:49 a.m. **NNCI REU Convocation Concurrent Presentations Sessions G, H, I** (30 students)

 Heritage, Regency A, & Regency B-C

11:00 a.m. **Lunch**

Platte River Room

11:15 a.m. **Lynn Rathbun, NSF Graduate Fellowship Application Process & Japan Research Program**

Platte River Room

12:30 p.m. **Group Photo**

 City Campus Union

1:00 p.m.-3:00 p.m. **UNL REU Symposium,** Centennial

 -OR-

 **Stadium & Keegan Research Center Tour,** departing from City Campus Union

3:30 p.m. **Career and Grad School Panel / Closing**

Regency

5:00 p.m. **NNCI REU Convocation Officially Adjourns**

**Optional: Catch Shuttle to Lancaster County Super Fair**

Carnival, Indoor and Outdoor Beer Gardens, BMX Stunt Bike Show, Mutton Bustin’, Live Shark Encounter, and More!

8:00 p.m. **Depart Super Fair for the Graduate and Knoll, drop-off**





**Student Abstracts**

*Organized by Session*

Parallel A1

Student’s name: Mary Gorman

Home institution: Southwestern College

NNCI site: SDNI @ UC San Diego

REU Principal Investigator: Dr. Nicole Steinmetz – Department of NanoEngineering, UC San Diego

REU Mentor: Yvonne Ma - Department of NanoEngineering, UC San Diego

Contact: marygracewithaspace@gmail.com

Title: **Chemical modification of a filamentous plant virus**

Abstract: Potato virus X (PVX) is a filamentous plant virus that has demonstrated anti-tumor immunity in

multiple tumor models. To further enhance the bioavailability of PVX we are following a

previously published strategy to crosslink the coat proteins with polymers. Bioconjugation is

used to conjugate PEG polymers to PVX. PEGylated PVX will be characterized with gel

electrophoresis, fast protein liquid chromatography (FPLC), dynamic light scattering (DLS), and

transmission electron microscopy (TEM), followed by thermal stability and mechanical property

measurements.

Parallel A2

Student’s name: Farah Lino

Home Institution: University of West Florida

NNCI Site: RTNN @ NC State University

REU Principal Investigator: Dr. Xiaotong Li – Department of Chemistry, NC State University

REU Mentor: Allen Liu and Dr. Xiang-bin Han - Department of Chemistry, NC State University

Contact: farah.beth927@gmail.com

Title: **Synthesis of multilayer 2D chiral perovskites**

Abstract: Multilayer 2D hybrid perovskites have proven to be promising materials in semiconductor applications due to their balanced stability and properties. In contrast to 3D perovskites, the inorganic layers of 2D hybrid perovskites are separated by large organic cations called spacers, which shield the structure from environmental degradation, thereby improving its structural tunability and functionality. The chirality of the organic spacer cation also introduces new chiroptical properties into the material; however, the incorporation of chiral spacer cations into 2D hybrid perovskites has been reported for only two organic cations to date. Using known predictors of successful incorporation of organic spacer cations, we explored the combination of new chiral organic spacers and A-site cations to synthesize multilayer 2D hybrid perovskites and investigated their chiroptical properties. The structures of the materials were initially characterized by powder X-ray diffraction, and their optical properties were measured using UV-Vis absorption spectroscopy and circular dichroism.

Parallel A3

Student’s name: Tyler Lai

Home Institution: University of California, Berkeley

NNCI Site: KY Multiscale

REU Principal Investigator: Dr. Xiao-an (Sean) Fu

REU Mentor: Wendell Pimentel-Almedia

Contact: tylai316@berkeley.edu

Title: **PFAS Detection using Microfluidic Sensors**

Abstract: Per- and polyfluoroalkyl substances (PFAS) are chemicals found in numerous consumer products, including fast food wrappers, non-stick pans, and carpet antistains. Due to widespread consumer use, PFAS chemicals have contaminated many water supplies across the United States. Exposure to PFAS chemicals has been shown to disrupt human organ function, cause cancer, and decrease vaccine efficacy. These PFAS chemicals have similar molecular structures to fatty acids and confuse many cells within the human body. Confused cells take in these PFAS molecules believing they are taking in fatty acids. PFAS health effects are incredibly long lasting because there is no biological process within the human body capable of breaking down these chemicals. PFAS is known to be a forever chemical, once it has contaminated a system, it takes an extremely long time to break down naturally, if at all. Current on-site PFAS sensors for water are unable to reach detection limits set by the Environmental Protection Agency (EPA). With the current standardized technology, time-consuming and expensive off-site testing is required in order to meet the detection standards set by the EPA. This work constructs a fast and affordable on-site microfluidic sensor that measures extremely low PFAS concentrations using electrical impedance. The sensor advances environmental monitoring technology; it protects public health through rapid on-site detection of PFAS at a fraction of the cost.

Parallel A4

Student’s name: Adam Aharonoff
Home Institution: New York University
NNCI Site: MANTH @ UPenn
REU Principal Investigator: Professor Igor Bargatin – Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
REU Mentor: Tom Celenza - Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
Contact: ahadam@seas.upenn.edu
Title: **Optimizing the Propulsion of 3D Photophoretic Lightflyers for Applications on Mars**

Abstract: This research focuses on the development and optimization of 3D photophoretic propulsion systems for lightflyers, aiming to improve their efficiency and performance in extraterrestrial environments. Photophoretic propulsion harnesses momentum transfer from light-induced temperature gradients on a lightflyer's surface, generating lift in low-pressure conditions (1-100 Pa). This study examines the impact of hexagonal channel dimensions—specifically hexagon diameter and channel height—on hemispherical lightflyers, to identify the optimal configuration for maximizing propulsion efficiency. Furthermore, this research experimentally investigates the jet propulsion effect induced by closing the hemispheres by 1/4π radians.

Parallel A5

Student’s name: Elizabeth Quansah
Home Institution: University of Illinois at Urbana-Champaign
NNCI Site: CNF at Cornell University
REU Principal Investigator: Sadaf Sobhani, Department of Mechanical and Aerospace Engineering, Cornell University
REU Mentor: Giancarlo D'Orazio, Department of Mechanical and Aerospace Engineering, Cornell University
Contact: emq24@cornell.edu
Title: **Optimizing the Propulsion of 3D Photophoretic Lightflyers for Applications on Mars**

Abstract: This paper suggests mechanisms for producing silica glass, silicon carbide, or silicon oxycarbide microscale electrospray emitters for spacecraft propulsion systems. The following research is conducted in an effort to replace the tungsten needles currently being used as emitters. This work relies on two-photon photolithography for the additive manufacturing of green bodies that will subsequently undergo thermal processing to produce glass or ceramic. The process begins with GP Silica resin, preceramic polymer Starfire SMP-10, and preceramic polymer Starfire SPR-688. Six different resins are made by mixing Starfire SMP-10 and Starfire SPR-688 with three different photoinitiators, 4,4’-Bis(diethylamino)benzophenone, 2-Isopropylthioxanthone, or (±)-Camphorquinone. Conversion of these six resins, along with the GP Silica resin, into distinct, emitter-shaped green bodies with features on the scale of nanometers is carried out using the Nanoscribe Photonic Professional GT2, a two-photon photolithography printer with a 780nm femtosecond laser. Through optimizing the printing parameters on the Nanoscribe for each resin, successful micro-additive manufacturing of reliable green bodies is achieved. Each green body undergoes thermal processing tailored to its composition in order to produce its corresponding material: glass, silicon carbide ceramic, or silicon oxycarbide ceramic. Microstructure and phase analysis of the resulting structures is performed using a Scanning Electron Microscope and X-ray diffractometer. For each material, a comparison of the effects of using a 2.54 gigahertz, 1 kilowatt microwave furnace to the results of traditional pyrolysis in a Nabertherm furnace is presented. Adjusting the printing parameters on the Nanoscribe along with the thermal processing steps and techniques for each material produces noteworthy characteristics of the emitters.

Parallel A6

Student’s name: Nathaniel Tomas

Home Institution: University of Minnesota Twin Cities

NNCI Site: RTNN @ NC State University

REU Principal Investigator: Franky So

REU Mentor: Jingshan Chai

Contact: nathantomas28@gmail.com

Title: **Effects of Substrate on Crystallization and Superfluorescence of Quasi-2D Perovskite Thin Film**

Abstract: Superfluorescence (SF) has historically been observed under extremely strict conditions. Polycrystalline perovskite thin films are a promising platform for optoelectronics and potential room-temperature SF emission applications. However, these films are highly sensitive to different processing conditions, such as compositional factors, substrate effects, and processing environments. These processing conditions can significantly affect film quality which greatly influences carrier recombination and transport, affecting SF behavior. This study examines the impact of processing conditions on room-temperature SF in lead halide hybrid perovskites. We observed poor surface coverage in CsPbBr3 thin films compared to (PEABr)0.4CsPbBr3 films when fabricated without ultraviolet ozone (UVO) treatment on the substrate. To further investigate this phenomenon, we studied the effects of UVO treatment on the quality of (PEABr)0.4CsPbBr3 thin films. Increasing UVO treatment time not only enhances the hydrophilicity of the hydrophobic glass substrate but also leads to changes in the distribution of low-dimensional phases. These changes potentially influence the material's SF performance. We propose these changes result from changing chemical interactions between the substrate surface and the bulky organic cation in the perovskite due to varying UVO exposure time. Understanding the effects of processing conditions on a material’s ability to emit SF is crucial for guiding the development of SF-emitting materials.

Parallel A7

Student’s name: Ryugo Shimamura

Home institution: The University of Tokyo

NNCI site: SENIC @ Georgia Institute of Technology

REU Principal Investigator: Dr. Michael Filler and Dr. Eric Vogel - Georgia Institute of Technology

REU Mentor: Daniel Aziz - Georgia Institute of Technology

Contact: rshimamura169@g.ecc.u-tokyo.ac.jp

Title: **Dopant-Selective Patterning Methods to enable Massively Parallel Fabrication of Silicon Nanowire Electronics**

Abstract: Rapid progress in semiconductor technology relied on miniaturization of transistors, but as channel dimensions approach the atomic scale, efforts for miniaturization are becoming less economic. Using doped silicon nanowires (SiNW) as electronic components is a viable option, since they can be produced in a massively parallel manner. To realize this concept, patterning methods that allow for surface functionalization of SiNW sidewalls are essential, but since conventional photolithography methods are not compatible with scalable parallel manufacturing, novel methods are needed. Promising results has been shown using PMMA polymer, combined with a doping-dependent etching of Silicon that allows PMMA to be removed from less doped regions selectively. This work covers three contributions. First, relationship between SiNW growth conditions and selectivity of etching is presented. Substrates for growth, gas flow rate and growth temperature are the key factors to a successful patterning. Secondly, a design for testing SAM(Self-Assembled Monolayer)-initiated polymerization effectively, which incorporates multiple characterization schemes such as scanning electron microscopy (SEM), atomic force microscopy (AFM), reflectometry and ellipsometry has been created. Lastly, analysis of polymer removal from differently doped silicon will be presented to show masking of desired regions. Above contributions will enhance understanding of key processes, promising to build a foundation for scalable patterning of electronic nanostructures.

Parallel A8

Student Name: Hannah Murai

Home Institution: Liberty University

NNCI site: MONT @ Montana State University

REU Principal Investigator: Dr. Wataru Nakagawa - Department of Electrical and Computer Engineering, Montana State University

REU Mentor: Dr. Wataru Nakagawa - Department of Electrical and Computer Engineering, Montana State University

Contact: hannahmurai32@gmail.com

Title: **Measurement of the accuracy of a polarimetric optical system to characterize the wavelength dependence of a thin-film latching garnet Faraday rotator**

Abstract: A polarimetric optical system's sensitivity to changing states of polarization affects the accuracy of its measurements. To quantify how accurately we can measure the changed state of polarization that is induced by a device under test (for example, a metamaterial), it is necessary to test the limits of the optical system in detecting any change in the state of polarization. The accuracy of our optical system in detecting small changes in the angle of polarization demonstrates its limitations for future measurements. We investigate our optical system's sensitivity to changes in the angle of linearly polarized light by utilizing the properties of a thin-film latching garnet Faraday rotator. This magneto-optic device can be used to non-reciprocally rotate the angle of polarization of linearly polarized light by nominally 45° at the operating wavelength of 1550 nm. We used a tunable diode laser to sweep the wavelength of the incident light from 1500 nm to 1580 nm to measure the Faraday rotation angle’s spectral dependence. We observed this dependence to be linear, achieving >5° change in Faraday rotation angle over the tested 80-nm wavelength range. This discovered relationship can be used to induce small changes in the Faraday rotation angle, thus allowing us to finely control the angle of polarization of the light transmitted by the Faraday rotator.

Parallel A9

Student’s name: Darian Rosales

Home Institution: Mesa Community College
NNCI Site: NCI – SW @ ASU/NAU
REU Principal Investigator: Dr. Miguel Jose Yacaman, Northern Arizona University

REU Mentor: J. Jesus Velazquez Salazar, Northern Arizona University
Contact: Darianmrosales@gmail.com

Title: **Silver Nanostructures: Exploration of Synthesis and Oxidation Resistance**

Abstract: Silver nanowires are robust nano structures which contain many inherent unique material properties. The properties of these nano structures can vary with shape and size, such as displaying antibacterial, antiviral, or anti-fungal behaviors as well as conducting electricity. Due to the wide range of novel properties found in silver nanowires, there are numerous potential applications across the semiconductor, medical, and flexible/wearable electronics industries. The experiment sought to explore reliable synthesis methods of silver nanowires and determine which synthesis parameters were most crucial for homogeneous nanowire production. The nanowire attributes analyzed for consistency were the morphology, length, and diameter. The primary synthesis method used was the polyol method. Once uniform silver nanowires were generated, they were then coated in a layer of nickel. Scanning electron microscopy images were developed to gather data on the nanowire synthesis attributes, and transmission electron microscopy images were generated for analysis of the nickel outer coating. The goals of the experiment were to showcase a reliable methodology for producing homogenous silver nanowires, and to illustrate how silver nanowires can be coated by nickel to improve oxidation resistance.

Parallel B10

Student’s name: Olivia Caldwell

Home Institution: Western Washington University

NNCI Site: SDNI @ UC San Diego

REU Principal Investigator: Dr. Alina Schimpf – Department of Chemistry, UC San Diego

REU Mentor: Hang Yin- Department of Chemistry, UC San Diego

Contact: caldweo@wwu.edu

Title: **Exploration into modifications of PbS nanocrystals through isocyanide ligands**

Abstract: Canonical semiconducting quantum dots have attracted much interest for use in optical or optoelectronic technologies due to their tunable band structure, which can be influenced by crystal size and/or attached ligands. For example, it has been shown for PbS quantum dots that the dipole moment of bound ligands can tune the valence and

conduction bands. It was previously demonstrated that sterically bulky m-terphenyl isocyanide ligands could select for Au nanospheres of different sizes by modifications to the flanking side rings of the ligand. This research aims to extend isocyanide binding to PbS quantum dots, with the goal to tuning the optical and electronic properties. These studies will offer insight into a new strategy for tunable quantum dot materials.

Parallel B11

Student’s name: Marcelo Rodriguez

Home Institution: University of Texas Rio Grande Valley

NNCI Site: KY Multiscale @ University of Louisville

REU Principal Investigator: Dr. Kevin Walsh, Assoc. Dean of Research, Speed School of Engineering, University of Louisville

REU Mentor: HDr.Thomas Berfield- Assoc. Prof. of Mechanical Engineering Department, University of Louisville

Contact: marsrod03@gmail.com

Title: **Mechanical Performances of High Entropy Alloys fabricated through Additive Manufacturing**

Abstract: Refractory high entropy alloys have excellent mechanical properties, such as thermal stability, high yield strength, and creep resistance. They are seen as promising replacements for nickel-based superalloys like Inconel 625 and are essential in advanced applications. However, research into refractory high entropy alloys (RHEAs) has faced significant challenges over the years, such as difficulties in machining, brittleness at room temperature, and availability of powder feedstocks in additive manufacturing. Utilizing the Amazement RePowder system, novel powders can be created through a plasma and ultrasonic atomization approach. This method enables the alloying of custom materials and their transformation into spherical powders suitable for additive manufacturing. Using the atomization system, the sonotrode frequency is adjusted to 40 kHz producing powders approximately 40 microns in diameter, making them suitable for laser bed fusion. The collected powders will be characterized for size distribution and morphology, and their elemental composition will be analyzed using SEM-EDX microscopy. Once the alloy compositions are fabricated using additive manufactured, they undergo extensive testing to assess ductility, predicted solidus, and hardness. These additive-manufactured alloys are then compared to similar traditionally manufactured alloys to evaluate their overall performance. This summer’s research aims to develop refractory high-entropy alloy systems to enhance performance at extreme temperature environments.

Parallel B12

Student’s name: Owen Nettles

Home Institution: University of Pennsylvania

NNCI Site: MANTH @ UPenn

REU Principal Investigator: Dr. Anthony Sigillito, Department of Electrical and Systems Engineering, University of Pennsylvania

REU Mentor: Noah Johnson, Department of Electrical and Systems Engineering, University of Pennsylvania

Contact: onettles@nd.edu

Title: **Process optimization for silicon spin qubits**

Abstract: Quantum computers have the potential to solve a class of problems that classical computers can not. In order to algorithmically solve these problems, quantum computers need millions to hundreds of millions of qubits. However, the current largest quantum computer only has about a thousand qubits and it is unclear what the best platform is to scale by orders of magnitude. Spin qubits in silicon are a promising candidate as silicon electronics have already demonstrated outstanding scalability. To create a spin qubit, we need to isolate an electron and store information in its spin. One step of this process is creating a heterostructure that confines electrons into a two dimensional layer called a quantum well layer. To ensure that the information stored inside each qubit is robust, the quantum well layer must be pristine. We can create high quality quantum well layers while growing the substrate, but a necessary annealing step during device fabrication can cause crystal dislocations at the boundary of the well layer, degrading the device quality. We hypothesize that lowering the anneal temperature will reduce the likelihood of dislocations. Here, we investigate the magnetotransport properties of hall bar devices annealed at different temperatures with the aim of identifying an optimal temperature for qubit fabrication. Our measurements give us direct insight on material parameters that impact qubit performance, such as valley splitting, mobility, and quantum lifetime.

Parallel B13

Student’s name: Monique Kubovsky

Home Institution: University of Florida

NNCI Site: RTNN @ Duke University

REU Principal Investigator: Dr. David B. Mitzi - Department of Chemistry and Department of Mechanical Engineering and Materials Science, Duke University

REU Mentor: Migon Choi - Department of Mechanical Engineering and Materials Science, Duke University

Contact: mkubovsky@ufl.edu

Title: **Understanding Dimensionality and Connectivity of Mixed-Cation Hybrid Perovskites**

Abstract: Perovskites are being increasingly studied due to their promising applications in solar cells, LEDs, and photodetectors; low-dimensional hybrid perovskites, in particular, exhibit fluorescence and exciton effects, as well as low defect densities. Introducing large cation spacers between the inorganic layers in low-dimensional perovskites plays a pivotal role in determining dimensionality by affecting the degree of connectivity and distortion, influencing bond angles and lengths. Being able to manipulate the dimension and connectivity of perovskites allows for the tuning of the material’s properties, aiding in their applications to electronics. Despite the organic cation spacer’s importance, there has been limited attention given to investigating how mixing the organic spacers will impact perovskite structure. In this study, we aim to understand the nature of dimensionality and connectivity within hybrid halide perovskites with mixed organic cations. We chose to mix branched aliphatic cations, that were known to yield one-dimensional face-sharing and one-dimensional corner-sharing structures depending on the cation to lead iodide ratio, to understand if the resulting phases would be altered. The slow evaporation method was used for synthesizing single crystal perovskites with mixed cations, followed by powder x-ray diffraction and single crystal x-ray diffraction to determine the dimension and connectivity the crystals yielded. We observed that the cation that is more favorable than the other to crystalize with the inorganic precursor tends to crystalize first, determining the crystal’s dimension and connectivity. However, when the two cations have similar tendencies to crystalize, we may see cation mixing within the crystals, suggesting that new structures, different from the pure cation structures, can be synthesized. This study allows us to better understand the impact on the structure choice of dimension and connectivity that organic cations produce in metal-halide perovskites. More informed control of low-dimensional perovskite structures will lead to property tunability of low-dimensional perovskites.

Parallel B14

Student’s name: Richard Remias

Home Institution: University of Rhode Island

NNCI Site: CNF @ Cornell University

REU Principal Investigator: Dr. Judy Cha, Materials Science and Engineering, Cornell University

REU Mentor(s): Quynh Sam & Khoan Duong, Materials Science and Engineering, Cornell University

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Title: **Nanomolding of Topological Materials for Interconnect Applications**

Abstract: The increasing resistivity of copper (Cu) interconnects with decreasing dimensions poses many challenges for the continued downscaling of integrated circuits and computer chips. At the nanoscale, electron scattering at grain boundaries and surfaces of the interconnects causes an increase in resistivity leading to higher energy consumption and signal delay in computer chips. Conversely, topological materials may show decreasing resistivity with decreasing size at nanoscale dimensions due to their topologically protected band structures that are predicted to suppress electron scattering. Thus, transport studies of topological materials at the nanoscale are critical to find alternative metals to Cu interconnects. Nevertheless, current nanowire synthesis methods such as molecular beam epitaxy (MBE) and chemical vapor transport (CVT) struggle to create uniformly sized nanowires. We use nanomolding to fabricate nanowires of topological materials, where a bulk material is pressed into a porous anodic aluminum oxide (AAO) mold to create high aspect ratio nanowires. To promote more facile nanomolding and to prevent oxidation of the molded nanowires, we coat the AAO mold pore walls with a thin film of aluminum nitride (AlN). The CNF’s Oxford FlexAl atomic layer deposition (ALD) tool is used to deposit precise and uniform films due to its self-limiting reactions. Through energy dispersive X-ray spectroscopy (EDX), we determine the infiltration depth of AlN in our pores. Additionally, InBi is a topological material which may exhibit interesting quantum properties at few-layer thicknesses. We use nanomolding to compress InBi into thin flakes by encapsulating the InBi with hexagonal boron nitride (hBN). The CNF’s AFM Veeco Icon tool is used to determine the resulting thickness of the InBi flake.

Parallel B15

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Title: **Vat Photopolymerization of All-Aromatic Polyimides**

Abstract: Ranging from aerospace to automobiles to medical applications, polymers have grown to play a significant role in the future of scientific development. Because of this, research in various high performance engineering polymers, such as polyimides, is attracting attention to further optimize the structure-property-processing understanding of these polymers in the aforementioned fields. In order to explore the polyimide field further, on a micron and nano scale, this research project focuses on synthesis and characterization of all-aromatic polyimide precursors, along with understanding the behavior of the imide and carbonized forms. For context, polyimides, due to their highly aromatic nature, are known for stability at high temperatures and in various chemical environments, thus making them optimal polymers in high stress applications. Previously, the Long group has successfully synthesized the polyimide precursor using 4-Aminophenyl ether (ODA) or Diphenyl Sulfide (DDS), which are photoactive and can be UV cured into complex geometries using vat photopolymerization and two-photon polymerization additive manufacturing techniques. With this previous research, we aim to extend the knowledge base of all-aromatic polyimides to further advance its multifaceted uses in different industries.

Parallel B16

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Title: **Multilayered Conductive Nanofiber Mats for Enhanced Filtration**

Abstract: Active microfluidic nanoparticle separation techniques, such as ultracentrifugation have no mechanism of sorting particles by their intrinsic electric properties and are limited by batch filtration. Dielectrophoresis (DEP) aided filtration offers a continuous throughput with the capability of sorting particulates which are nearly identical in size but differ in their electric properties. Polyacrylonitrile (PAN) nanofiber mats with mean fiber diameters 300-500 nm and mat thickness ~100 μm were prepared by electrospinning an 8% wt. solution of PAN dissolved in N, N -Dimethylformamide (DMF). Between the spinneret and collector plate, a voltage of 17 kV, distance of 18 cm and humidity of 25-30% were held constant. After electrospinning, the mats were stabilized at 240°C for 2 hours to ensure evaporation of all remaining solvent. Mats were coated on each side with ~160 nm Cr/Au via sputter deposition. An electrical connection to each face of the mat was required to induce attractive DEP forces between nanoparticles and fibers. The subsequent sputtered mats were then integrated into a liquid-tight flow device. Applying an alternating current signal to the mat while in the flow device is believed to entrap nanoparticles within the outer topography of the mat. Quantification of fluorescent particle entrapment is desired in future trials. Integration of our high-throughput mats may prove to increase the filtration rate of nanoparticles by at least an order of magnitude over current DEP-aided techniques.

Parallel B17

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Title: **Understanding heating in R2R perovskite annealing**

Abstract: Perovskites are a unique class of materials which can exhibit numerous physical phenomena which make them suitable for a wide variety of technological applications, including spintronics, photodetectors and solar cells. Perovskites can exhibit photovoltaic properties and thus are promising for reducing the cost and increasing the widespread use of commercial solar cells. While much of the basic science regarding perovskite use in solar cells is either established or is an area of ongoing research, the research into the scalability of these materials is catching up. One key benefit of this material is that it is conformal to any type of substrate, allowing it to be deposited on flexible materials. To ensure perovskites can be successfully scaled to the consumer level, the manufacturing processes surrounding the commercial fabrication of flexible perovskite solar cells (PSCs) must be designed. One such technique for thin film manufacturing is known as roll-to-roll, or R2R. R2R involves layering the thin-films of interest on a long flexible substrate that can be continuously moved and rolled, in a conveyor-belt style. While common in other thin-film technological manufacturing processes like in organic photovoltaics and thin-film batteries, R2R is still under development for use with perovskite materials. There are several challenges in adapting the R2R process to flexible PSC fabrication, including incorporating the necessary annealing step for crystallizing the precursor solution into perovskite film. The current annealing process involves inefficient time constraints for complete precursor conversion to perovskite. To address this, a new annealing process was designed, implemented, and tested, and the resulting perovskite films characterized. The perovskite films produced using this new annealing method were shown to be of suitable quality for photovoltaic devices.

Parallel B18

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Title: **Atomic-Scale Imaging of Hydrogen in Metals Using Atom Probe Tomography**

Abstract: The United States sustains an annual direct cost of $276 billion due to corrosion, with hydrogen embrittlement (HE) standing out as a significant and costly form of material degradation, posing a risk to critical infrastructure including bridges, buildings, or pipelines. Additionally, hydrogen as a clean energy carrier requires materials that are resistant to HE. Hydrogen embrittlement is a phenomenon in which mobile hydrogen atoms permeates a material, causing significant deterioration of its mechanical properties, potentially leading to catastrophic structural failure. Understanding and mitigating this phenomenon is crucial for the durability and service life of structural components. One challenge in understanding the HE mechanisms is the difficulty in visualizing the distribution of hydrogen within the microstructure of a material. This study employs atom probe tomography (APT) to characterize on an atomic-scale the distribution of hydrogen in 3D printed (additively manufactured) stainless steel. APT provides an atomically resolved 3D image by analyzing individual atoms’ chemical identity and original position in a needle-shaped specimen of the material. Specialized computer programs are used to visualize the positions of the atoms within the sample. This information permits correlating the distribution of hydrogen atoms with microstructural features. The objective is to identify specific microstructural locations in the stainless steel to determine how H interacts with and embrittles a material at the atomic scale. Understanding these micro-nano mechanisms enables the implementation of effective manufacturing and processing strategies that enhance the performance and durability of materials in demanding environments, ultimately leading to more robust and cost-effective solutions.

Parallel C19

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Title: **Optimizing Annealing Conditions for Ohmic Contacts**

Abstract: As ultra-wide bandgap semiconductor research progresses, the need for reliable, low-resistivity ohmic contacts becomes more essential. To ensure high contact quality and reproducibility, process conditions must be carefully optimized. This project specifically analyzed the impact of various annealing temperatures on a Ta/Al/Ni/Au metal stack to minimize contact resistance. Previously, annealing at 830 °C under N2 ambient showed lateral metal diffusion, known as contact spreading, leading to the transistor short-circuiting and preventing the measurement of contact resistance. GaN pieces were first coated with photoresist, onto which transfer length method patterns were transferred using the GCA AS200 i-line stepper. The SC4500 Odd-Hour evaporator was then used for e-beam evaporation of 20 nm tantalum, 150 nm aluminum, 50 nm gold, and 50 nm nickel. After liftoff, the samples were analyzed and measured under the Zeiss Supra Scanning Electron Microscope. The samples were then annealed in N2 ambient at temperatures ranging from 300 °C to 800 °C. Using the SEM and its Energy Dispersive Spectroscopy, the spreading of the metals was measured. Lastly, using the transfer length method, the optimal annealing conditions for the lowest contact resistance were found.

Parallel C20

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Title: **THz Nanophotonics**

Abstract: As Nanophotonic devices continue to advance, reducing their volume becomes a key objective. However, in order to achieve high absorption, considerable thickness is often necessary. Producing thin metal films capable of such absorption can have a variety of applications primarily with detectors and sensors, but accurately fabricating these films is incredibly difficult. Additionally the properties of thin metals often vary greatly from those of their bulk counterparts. To address these issues and create a device with substantial absorption capabilities a three layer metal structure was fabricated. In order to determine the most optimal thicknesses of each layer a Comsol simulation was utilized. We concluded that in order to minimize reflection and therefore maximize absorption a base layer of Gold, followed by an Silicon Dioxide spacer, a layer of Germanium, and a top patterned layer of Gold would be most favorable. We adjusted several variables such as thickness of each layer and the dimensions of our pattern to attain best results. After fabrication was completed we conducted reflection measurements and compared our results to those of the simulation. These promising results offer new insights about the absorption capabilities of thin metal films.

Parallel C21

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Title: **Circular Dichroism in Achiral-Chiral Mixed Cation Two-Dimensional Hybrid Perovskites**

Abstract: The utility of hybrid perovskites in optoelectronic devices is largely due to their extensive tunability. For instance, specific components of a perovskite can be tailored to introduce the chiroptical properties necessary for application in spintronics and circularly polarized light sources. Chiral organic spacer cations are often used to impart the desired chiroptical properties to hybrid perovskites, and recently, this premise has been extended to achiral-chiral mixed cation systems. Hybrid perovskites with a mixture of achiral and chiral organic spacer cations have produced circular dichroism (CD) signals with a different sign and magnitude than the related perovskite system containing only the chiral cation. This project aims to explore this phenomenon in more detail by analyzing mixed cation perovskite thin films of various chiral cations and achiral-chiral ratios. Absorbance, X-ray diffraction, and circular dichroism will be used to gain insight into the excitonic properties, novel mixed cation phases, and CD transformation for each cation pair and ratio. Uncovering the mechanisms that lead to changes in the CD signals of mixed cation systems will provide another method to tune the chiroptical properties of hybrid perovskites.

Parallel C22

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Title:  **Impact of conjugation chemistry on the pharmacokinetics of a peptide-polymer in traumatic brain injury**

Abstract: Traumatic brain injury (TBI) is caused by an impactful external force on the head, which can result in death or acute and chronic neuropathologic damage and dysfunction. Currently there are no therapeutics that treat the underlying cause of disease progression. Major obstacles preventing the clinical translation of novel therapeutics are undesirable pharmacokinetics and limited accessibility to the brain. Nanomaterials can be readily modified in their size, charge, and physicochemical properties to improve the pharmacokinetics of therapeutics to allow for greater transport into the brain. CAQK (Cys-Ala-Glu-Lys) is a peptide sequence that has been shown to have both targeting and therapeutic potential in a mouse model of TBI following systemic intravenous administration. However, the peptide pharmacokinetics are poor, thereby limiting its clinical translation. In this work, we synthesized CAQK-targeted polyethylene glycol (PEG) nanomaterials to improve the peptide pharmacokinetics. We utilized three different conjugation chemistries: maleimide-thiol, dibenzocyclooctyne (DBCO)-azide copper-free click chemistry, and N-succinimidyl-3-(2-pyridyldithio)propionate (SPDP)-thiol. We then assessed the impact of conjugation chemistry on the pharmacokinetics of the peptide in a mouse model of TBI by measuring the blood half-life and biodistribution in the injured brain parenchyma. By systematically evaluating the advantages and limitations of these conjugation strategies, we identified the optimal approach to increasing peptide accumulation and retention within the injured brain.

Parallel C23

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Title: **Optimizing Fabrication Methods for Cost-Effective Monolithic Perovskite Solar Cells**

Abstract: One of the main challenges of perovskite solar cells is that they are more complex and expensive to fabricate. Typical perovskite photovoltaics require copper to be evaporated onto the surface at high temperatures in a vacuum chamber. This fabrication process is more difficult compared to perovskite solar cell kits, which only involve drop-casting on a prefabricated semiconductor film. For the summer research conducted at the University of North Carolina at Chapel Hill, we used monolithic perovskite solar cell kits which could present a cost-effective and simplified alternative to conventional perovskite solar cells. Fabricating twenty-four solar cells, a series of steps were followed but changed slightly for each "batch" -- approximately two to five composing each. Various steps within the fabrication process were tested and optimized, and each batch was evaluated for its efficiency through illumination using a 405 nm diode laser. By normalizing the electrons extracted from the device to the number of photons absorbed, the measured efficiency ranged from 0.06% to 0.17%. Our findings suggest that monolithic perovskite solar cell kits can be effectively produced as an alternative to conventional methods of typical perovskite photovoltaic cells.

Parallel C24

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Title: **Optimization of post-curing for SLA 3D printed PDMS molds**

Abstract: Polydimethylsiloxane (PDMS) is a hydrophobic, silicon-based organic polymer that is a popular substrate for rapid manufacturing of experimental platforms in bioengineering and for experimental soft-lithography to study microfluidics. In many cases, microfabrication techniques are used to create negative molds of channels. Geometry is created on silicon wafers, and PDMS is poured over these geometric features allowed to cure. When peeled off the substrate, fine details remain in the PDMS. To further increase the speed of iterative design, and to push the limits of creating 3D microfluidics, an additive manufacturing technique called stereolithography is used in “SLA” printers is being adopted for creating the casting molds for PDMS. Modern 8K resolution images on these SLA printers can push the line resolution into the tens of microns. Unfortunately, the chemical resins use to create SLA parts chemically interact with PDMS which often can delay or even prevent complete curing, rendering the molds useless. Therefore, post-processing steps (washing, extended UV curing, etc.) are often necessary to prevent this interaction. This project explores the optimization of the use of SLA molds for curing PDMS microchannels.

Parallel C25

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Title: **Investigating PEG-lipid alternatives for Lipid Nanoparticles to address the PEG dilemma**

Abstract: Lipid nanoparticles (LNPs) are the most clinically advanced platform for gene delivery, with notable FDA-approved examples including the Onpattro siRNA liver formulation and COVID-19 mRNA vaccines. LNPs consist of an ionizable cationic lipid, a helper lipid, cholesterol, and a poly (ethylene glycol) (PEG) lipid. Ionizable lipids protect the

RNA cargo and assist in cytosolic transport, while cholesterol and PEG prevent aggregation and extend the circulation half-life. Helper lipids, typically phospholipids, enhance stability and RNA encapsulation. Currently, FDA-approved lipid nanoparticles (LNPs) administered systemically are primarily used for liver-targeted therapies. This is because LNPs naturally adsorb apolipoprotein (ApoE). Increasing PEG-lipid length and concentration can improve accumulation in non-liver organs. However, this creates a “PEG dilemma”; as the steric barrier also hinders membrane fusion between LNPs and the endosomal membrane, affecting cargo release. The goal of this study is to evaluate PEG-lipid alternatives including poly(sarcosines), poly(sorbates), and poloxamers to maintain stability and enhance mRNA delivery efficiency. The project involves synthesizing LNPs with these alternatives and screening formulations for size, zeta potential, mRNA encapsulation, serum stability, and protein corona formation. Top-performing formulations will be tested for cellular activity to assess endosomal escape efficiency.

Parallel C26

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Title: **Solid State Nanopores for Protein Detection**

Abstract: Nanopore technology has shown potential in single molecule analysis and sequencing techniques; nanopores have the capability to sense and characterize DNA, nucleic acids, and recently even proteins. In this work, we use solid state nanopores to effectively detect protein translocations, as they can operate at high applied voltage with relatively low noise. Analyzing the ionic current changes of our system can provide an idea of a protein’s event signal. As proteins travel across the pore, there may be various chemical and physical interactions that occur and alter the event signal, causing slight inconsistencies within a protein’s signal. Protein adsorption, proper wetting of the pore, and conformational changes all pose a barrier to discriminating signals between distinct proteins and their different conformations; we aim to investigate these factors and resolve individual protein differentiation, or “fingerprints,” through repeated trials of varying proteins paired with efficient methods of data analysis. Additionally, we aim to investigate the fabrication process on a small-scale, hoping to gain additional knowledge about the integrity of the synthesized nanopores and the process. In the future, we plan to try 2D materials, like graphene, as a membrane for our nanopore. 2D membranes may aid in lowering noise even further, as well as increasing protein signal fidelity. Advancements in nanopore protein delineation can lead to novel applications in biopharmaceutical development and diagnostics, such as early detection of cancers or neurodegenerative diseases.

Parallel C27

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Title: **Anodically bonding a silicon wafer with aluminum traces to a glass wafer**

Abstract: This research investigates the parameters necessary for successful anodic bonding of silicon wafers with aluminum traces to glass wafers, which will play a crucial role in the fabrication of MEMS (Micro-Electro-Mechanical Systems) devices. The primary goal is to optimize the bonding conditions, focusing on aluminum layer thickness while maintaining constant temperature, pressure, and voltage after initial successful bonding trials. Initial experiments established a baseline for bonding success under set conditions, leading to subsequent experiments that varied aluminum thickness to assess its impact on bond quality. The bond quality was evaluated using optical microscopy and attempts were made to physically separate the bonded wafers. Additionally, resistance of the aluminum traces was measured before and after the bonding process to assess any changes. Preliminary results suggest that varying the aluminum thickness influences bond integrity, guiding future experiments towards refining other parameters for achieving optimal bonding in MEMS applications. This research provides insights into the role of aluminum thickness in anodic bonding, which could prove essential for developing robust and reliable MEMS devices.

Parallel D28

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Title: **Plasmon Field Effect Transistor (FET) for a Sensing Platform**

Abstract: There is a growing demand for precise detection and measurement across fields such as medical diagnostics, environmental monitoring, and industrial processes. Traditional methods often lack the sensitivity to detect low concentrations and involve bulky, expensive equipment that delays real-time monitoring. To address these challenges, this study builds on previous research involving the Plasmon Field Effect Transistor (PFET), a hybrid device that leverages Localized Surface Plasmon Resonance (LSPR), an oscillation of electrons generated by light absorption in metallic nanoparticles. By incorporating gold nanoparticles onto the channel of a Field Effect Transistor (FET), the PFET efficiently converts plasmon energy into an electrical signal. When exposed to light, the energized electrons in the gold nanoparticles enhance the drain current, enabling the detection of minute changes in the sensor’s surrounding environment. To further advance the development of the PFET, we report results on how varying the diameters of gold nanoparticles affects the device's sensing range. Gold films of 3nm, 5nm, and 7nm were deposited to form nanoparticles of different diameters, and their respective spectral responses were measured to uncover the relationship between nanoparticle size and sensor performance. Understanding this relationship is crucial for customizing PFETs for specific applications and the development of compact, highly sensitive sensors for a wide range of uses.

Parallel D29

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Title: **Optical MZI Correction Based on Normalization of Parasitic Oscillations**

Abstract: In optical telecommunication systems, modulators are crucial in encoding information onto light waves to be transmitted. One such modulator is the Mach-Zehnder Interferometer (MZI), which uses the interference phenomena of light waves to modulate light. However, in experiments, MZI modulation often shows spurious transmission artifacts due to reflections in the system. These parasitic oscillations prevent precise modulation by introducing unwanted measurement. To correct these artifacts, specifically those concerning the transmission amplitude, we propose an algorithm based on a pre-computed normalization factor. With this correction algorithm, we aim to enhance the reliability and accuracy of MZI modulators, to be used in communication systems requiring precise optical signal manipulation.

Parallel D30

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Title: **Vapor and Solution Compatible Perovskite Solar Cell Fabrication**

Abstract: Hybrid halide perovskites (HP’s) are a class of semiconductors that have revolutionized solar cell fabrication over the past decades due to their affordability, high efficiency, and simple design structure. Although the apparent defect-tolerant characteristics of these cells offer revolutionary advances in optoelectronic technologies through various fabrication techniques, developing HP thin films into high-performance devices is often quite complex. This complexity arises from the careful selection and fabrication techniques of their transport layers and HP absorber layer. In this project, we aimed to develop a perovskite solar cell (PSC) design suitable for both solution deposition and a novel chemical vapor deposition (CVD) method for the HP layer using MAPbI3. Using an n-i-p structure, we determined that the nature of the electron transport layer heavily affected the surface coverage of the solution-deposited HP films. We tested both ALD-deposited TiO2 and spin-coated SnO2 compact layers and found that the SnO2 films offered better surface coverage with the HP layer. We expect this design to be compatible with our CVD-grown HP films as well, allowing us to compare device performance.

Parallel D31

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Title: **Effects of the Presence of Oxygen on the Morphology and Ultrastructure of Mitochondria in Yeast Cells**

Abstract: The ultrastructure of yeast mitochondria provides valuable insight for exploring various aspects of mitochondrial biology, contributing to our understanding of cellular function, health, and evolution. Regardless of the presence of oxygen, certain cells can take anaerobic pathways of growth where most glucose is converted to lactate; this is referred to as the Warburg Effect. Cancer cells will often rely on such anaerobic pathways for growth. The anaerobic pathway results in a lower return of ATP/mol Glucose than aerobic pathways, and due to the need for energy for cancer cells to thrive, this phenomenon seems impractical. There remains a need to evaluate the pathways taken by cancer cells in growth through models mimicking such environments. Thus, we have investigated yeast cells as a model system for cancer research to study the Warburg Effect.This work focuses on the investigation of yeast mitochondria to gain insight in eukaryotic cell morphology and ultrastructure when grown in either aerobic or anaerobic conditions. Through *ex-situ* transmission electron microscopy (TEM) imaging of the yeast cells’ mitochondria, we hope to reveal insight into their morphology and potential changes caused by the different growth conditions. In addition to analyzing mitochondria and their cristae (structures formed by the inner mitochondrial membrane), we may investigate the interactions and spatial relationships between mitochondria and other yeast cell organelles such as the endoplasmic reticulum.

Parallel D32

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Title: **Controlled Conversion of As-Cast Perovskite Thin Film Using Antisolvent Bath**

Abstract: Hybrid perovskite semiconductors (SCs) have received significant attention for their potential in photovoltaic applications. While synthesizing standalone SCs is straightforward, the technological significance lies in the ability to directly grow SCs on foreign substrates. However, this poses significant challenges due to the prevalence of heterogeneous nucleation. This study delved into antisolvent techniques to gain insights into the factors influencing the quality of thin films in ambient temperatures. FA0.9Cs0.1Pb(I0.85Br0.15) was chosen as the precursor, and we used three distinct antisolvent methods—drip, bath, and combined drip-bath—with chlorobenzene, diethyl ether, and toluene as antisolvents. The films are spin-coated in a glass substrate under a UV-Vis spectrophotometer to observe the conversion process of the films throughout time. This study contributes to the fundamental understanding of antisolvent techniques in perovskite semiconductor processing, offering insights into optimizing film morphology. Hybrid perovskite semiconductors (SCs) have received significant attention for their potential in photovoltaic applications. While synthesizing standalone SCs is straightforward, their technological significance lies in the ability to directly grow SCs on foreign substrates. However, this poses significant challenges due to the prevalence of heterogeneous nucleation. Previous studies suggest that the antisolvent drip method may not reach complete crystallization prior to annealing. Conversely, the antisolvent bath method has demonstrated more uniform and complete crystallization before annealing. Incomplete crystallization has been shown to increase stress in the substrate, which is correlated with lower quality films. Top of FormBottom of FormThis study delves into different antisolvent techniques to gain insight into the factors influencing the quality of thin films in ambient temperatures. FA0.9Cs0.1Pb(I0.85Br0.15) was the chosen precursor which we used with three distinct antisolvent methods—drip, bath, and combined drip-bath—with chlorobenzene, diethyl ether, and toluene. The films are spin-coated in a glass substrate under a UV-Vis spectrophotometer to observe the conversion process and crystal growth of the films throughout time. This study contributes to the fundamental understanding of antisolvent techniques in perovskite semiconductor processing, offering insights into optimizing film morphology and crystallography.

Parallel D33

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Title: **Effects of Background Pressure During Resonant Infrared Matrix-Assisted Pulsed Laser Evaporation (RIR-MAPLE) Deposition of Thin Film Hybrid Perovskites**

Abstract: Hybrid organic-inorganic perovskites (HOIPs) are a class of materials with highly tunable electrical properties that are excellent candidates for novel optoelectronic technologies such as photovoltaics and light emitting diodes. Resonant Infrared Matrix-Assisted Pulsed Laser Evaporation (RIR-MAPLE) is a physical vapor deposition technique that reduces the limitations of traditional solution processing methods. During RIR-MAPLE deposition, the frozen precursor solution is placed in the vacuum chamber, where the hydroxyl bonds of the matrix solvent resonantly absorb energy from the laser, producing a vapor plume that propels the desired precursor materials up to the substrate. However, previous studies of RIR-MAPLE deposition for HOIPs have been conducted under active vacuum conditions, which are a substantial obstacle to the use of RIR-MAPLE for HOIP manufacturing on an industrial scale. Samples of 2D [phenylethylene lead iodide, (PEA)2PbI4] and 3D [methyl ammonium lead iodide, MAPbI3] HOIPs were grown at pressures from 10-5 mTorr to 500 mTorr and were analyzed using atomic force microscopy and optical spectroscopy methods. Photoluminescence (PL) spectroscopy indicated a correlation between background pressure (BGP) during deposition and photoluminescence peaks, where films grown at higher pressures had narrower, blue-shifted peaks. This suggests that films grown at higher BGP have fewer defects that cause PL peak widening. In addition, atomic force microscopy showed that while an increase of BGP from 10-5 mTorr to 100 mTorr was associated with an increase in film roughness of approximately 60%, further increase of BGP up to 500 mTorr did not significantly affect film roughness. These results show that HOIP films of comparable quality can be produced under higher BGP, demonstrating the continuing potential of RIR-MAPLE as a large-scale HOIP deposition technique.

Parallel D34

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Title: **Characterization of CaCl2 in Mesoporous Silica as a Thermochemical Material for Energy Storage Applications**

Abstract: The building sector accounts for a third of the total energy consumption in the United States, of which 60% is utilized in space and water heating. Thermal energy storage (TES) is one of the “five thermal energy grand challenges for decarbonization” as it has the potential to be low cost, can be implemented at large scales (kW – GW), and can store energy across different time scales (hourly to seasonal) to match the supply and demand. Thermochemical materials (TCMs) in the form of salt hydrates that undergo an endothermic dehydration reaction (charging) and an exothermic hydration reaction (discharging) are promising materials for a reversible solid-gas thermal battery. This project focuses on characterizing the microstructure and properties of pure calcium chloride (CaCl2) salt and pure EV 26 (silica), specifically their porous composite with varying weight percentages of CaCl2 in EV 26, to evaluate their performance as thermal battery materials. CaCl2 is of particular interest due to its high sorption abilities and high energy density which make it an efficient medium for storing and releasing thermal energy. However, due to some of its limitations, porous silica is being added as a support matrix to improve its hygroscopic stability. Through this research, we aim to enhance the understanding and application of these materials in TES systems, contributing to more efficient and sustainable energy usage in the building sector and in other ecological engineering applications.

Parallel D35

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Title: **Atomic scale characterization of the planar defects in calcite**

Abstract: Studying calcite (CaCO3) is important because it plays a crucial role in environmental processes, industrial applications, and biological systems, impacting everything from climate change to material science and marine ecosystems. At high pressures and temperatures, calcite undergoes a phase transformation to the polymorph aragonite. The lack of atomic scale investigations and elemental analysis around planar defects within calcite prohibit from understanding the mechanism. In this work, we use scanning electron microscopy (SEM) to characterize general morphologies, transmission electron microscopy (TEM) for atomic scale analysis, X-ray photoelectron spectroscopy (XPS), secondary ion mass spectroscopy (SIMS), and SEM-electron dispersive X-ray spectroscopy (SEM-EDS) for elemental analysis. Those results will improve our understanding of transition mechanism about calcite to aragonite which helps countless studies. Using these advanced techniques will improve our understanding of calcite transformation mechanisms, and it will enhance scientific research by providing deeper insights into fundamental geological processes, improving the development of advanced materials, and informing environmental strategies for carbon sequestration and climate change mitigation.

Parallel D36

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Title: **Atomic scale characterization of the planar defects in calcite**

Abstract: Friction defines how humans interact with their environment. It applies to a wide variety of engineered systems, yet its application is limited with robotic haptics. In recent years, methods of applying dynamically tunable friction to robotic systems via the use of thermally-modulated stiffness has been widely studied. There is now evidence that this may be accomplished by applying micro-scale heating systems to a thin layer of shape memory polymer (SMP).

An array of microheaters have the ability to provide a low power-consumption method of thermally stimulating a small area in a quick and controlled manner. SMPs soften and easily deform when exposed to thermal stimuli above a specific temperature. To this effect, an array of microheaters were previously designed and fabricated using a newly-developed nanofabrication method.

This research explores the characteristics of those microheaters, their ability to alter the mechanical properties of SMPs, and investigates adjustments that may further optimize this system.

Parallel E37

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Title: **Particulate Reduction in Pulsed Laser Deposition of Complex Metal Oxides**

Abstract: Thin films made by pulsed laser deposition (PLD) have a wide variety of applications. However, during the deposition process, particulates can be produced and incorporated into the film. These particulates generally have a negative effect on the film properties and can lower the uniformity of the films. This work aims to determine the optimized PLD process to reduce target damage and particulate contamination using a model system, lithium manganese nickel cobalt oxide (LiNi0.8Mn0.1Co0.1O2, NMC811). This system is of special interest because it has applications in batteries and would benefit from films with less particulates. Although many means of reducing particulates exist in the literature, this study focuses on three methods that do not require considerable equipment modification or capital outlay: Target usage/polishing; Laser fluence; Variation of pulse orientation, relative to target, during film deposition by target rastering. We hope that these results will allow for further research in the applications of the films grown by pulsed laser deposition.

Parallel E38

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Title: **Electrospun Non-Woven Mats as Substrates for Flexible Electronics**

Abstract: Electrospinning is a manufacturing technique that can produce non-woven mats from polymeric solutions (e.g., polyacrylonitrile (PAN) 10%). It has shown potential to produce fine resolution fibers on the order of 40-50 micrometers and can be used for various applications such as electronics and filtering. Due to high areal surface, these non-woven mats could potentially benefit the sensitivity and performance of flexible electronics (e.g., strain gauge sensors, wearable sensors, etc.) Thus, the purpose of this study is to analyze the feasibility of printing conductive lines on top of the electrospun flexible substrate. Extensive screening of the electrospinning process parameters was done and it was determined that optimal conditions for the strongest substrates were: a distance of 13 cm, a flowrate of 0.40 mL/hr, and a voltage of 6.7 kV. The flexible substrate is manufactured using these parameters for 5 hours. A conductive design can be printed on the top of the substrate using additive manufacturing processes. Aerosol Jet Printing (AJP) with silver conductive ink was used in this case. The substrates were then baked on a hot plate at 200°C for five minutes. To improve the properties of the printed conductive lines, the substrates were cured the print patterns via Intense Pulsed Light (IPL) treatment. The entirety of the printing process was repeated in order to have one, two, and three layers of conductive ink. The results showed that the printed lines were conductive after curing. Further research to investigate and quatify the conductivity for different electrospinning solutions and AJP inks will be performed.

Parallel E39

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**Title: Oxidizing Silicon Membranes for MEMS Applications**

Microelectromechanical Systems (MEMS) are crucial components to modern everyday devices, such as microphones, pressure sensors, and actuators. A variety of MEMS devices contain mechanical components like silicon membranes, which have characteristics that allow for MEMS functionality. In this experiment, membranes of varying dimensions were fabricated using tetramethylammonium hydroxide (TMAH) and subjected to thermal oxidation to assess their structural integrity. Contributing factors that would affect membrane integrity, such as uniform oxide growth and membrane thickness, width, and shape, were thoroughly tested. Subsequent results will be used to guide the creation of a generalized fabrication process which supports the creation of various MEMS devices. This process will be incorporated into a design and fabrication course at Montana State University.

Parallel E40

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Title: **Effects of Bismuth Incorporation on the Electronic Properties of 2D Hybrid Perovskites**

Abstract: 2D hybrid perovskites are a class of semiconducting materials that combine layers of inorganic metal-halides and organic cations to access a wide range of electronic properties. While lead-based perovskites have become notable for their potential within photovoltaic applications, the toxicity of their composition creates a push for lead-free perovskites. As an alternative, this project investigates the structural stability of bismuth-containing and bismuth-based perovskites, using first principles methodology and density functional theory to predict the geometry of the structures and to assess ordering preferences associated with compensating vacancies. From this, the electronic band structure of these materials can be calculated and analyzed to better understand the electronic properties. The project first explores different vacancy arrangements of layered (AE2T)Bi2VacI4 compounds, consisting of metal-halide layers with ratios of Bi2 to one site vacancy (Vac). Structure optimization of five different vacancy patterns (each leading to large structure models including 928 atoms) reveals that an arrangement of single next-nearest neighbor vacancy rows on B sites, alternating with two Bi rows, shows the lowest energy among the arrangements probed (FHI-aims code, “light” settings) and also displays an energy band gap consistent with experimental observations. In contrast, nearest-neighbor vacancy rows and zig-zag arrangements of second nearest neighbor vacancies are higher in energy and, during relaxation calculations, remain metallic in character and present slow, computationally expensive convergence during structure optimization. We next studied a set of (AE2T)PbI4 structures with partial Pb substitution by Bi and vacancies, in which the metal-halide layer was modified to contain Pb5Bi2 and one site vacancy. Band structure calculations for these vacancy arrangements are in progress at the time of writing and are expected to reveal the character of Bi derived energy levels alloyed into a traditional lead halide based layered perovskite.

Parallel E41

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Title: **The AmoeBot: A Bioinspired Soft Robot with Nitinol Wire Actuation and Gecko-like Adhesion**

Abstract: The AmoeBot is an innovative soft robot designed for dynamic movement and surface adaptability. Constructed primarily from silicone, the AmoeBot features a four-legged amoeba-like shape with an elevated body and movement driven by soft actuation mechanisms utilizing nitinol wire. Nitinol, also known as muscle wire, is a shape-memory alloy (SMA) composed of nickel and titanium. It is controlled by pulsed electrical currents that contract the wire when heated and expand once cooled. The design allows for flexible movement while maintaining low power consumption. A distinguishing feature of the AmoeBot is its ability to climb various surfaces, facilitated by gecko-inspired foot pads. These foot pads are fabricated using hydrogels as templates, which induce the silicone to develop a mesoporous structure. This structure enhances the van der Waals forces responsible for the adhesion mechanisms of gecko setae, enabling the robot to adhere to surfaces in a similar manner. Additionally, the AmoeBot is equipped with a neural processing unit (NPU) inspired by the adaptability of animal groups governed by collective behavior, such as flocks of birds. This NPU allows the AmoeBot to make decisions and coordinate actions similarly to biological systems. By integrating and testing a variety of bioinspired traits, the AmoeBot aims to advance future research and development of multifaceted soft robots, with potential applications in search and rescue, medical devices, pipe inspections, and much more.

Parallel E42

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Title: **Unlocking the Characteristics of Roman Concrete through a Multi-Technique Approach**

Abstract: Ancient Roman concrete is renowned for its exceptional durability and longevity. This research analyzed concrete samples extracted from Emperor Tiberius’ villa located in Sperlonga, Italy. This structure, resilient against over 2000 years of aggressive exposure due to its proximity to the Tyrrhenian Sea, presents a unique opportunity for study.A novel minimally-destructive multi-technique approach was used to analyze the concrete. This analysis involved micro-XRF (micro-X-ray-Fluorescence) to identify and map the elemental composition found within the sample, in-situ XRD (X-ray-Diffraction) to determine the chemical phases that these elements have taken, and nanoindentation to assess the mechanical properties of the concrete. The analysis revealed the utilization of volcanic material and lime, along with strong indications of seawater incorporation in the production process. The ions present in seawater, when reacted with the volcanic material, fostered the development of additional compounds to further enhance the resilience and durability of the concrete.This research holds significant importance in establishing a connection between the durability of Roman concrete and its microstructure. The findings from this study strives to shape the future of concrete by gaining insight into developing environmentally friendly concrete through elucidating the secrets behind Roman concrete's longevity and resilience.

Parallel E43

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Title: **Assessing tilt angle range for rotating propeller frequency analysis**

Abstract: While extensive research has been conducted on detecting various propeller-bearing objects using different modalities, there is limited work on detecting the frequency and angle of rotating propellers. This study aims to answer the question: "Within what range of tilt angles can the frequencies of a rotating propeller be identified in the spectral analysis of LiDAR pulses on a stationary propeller?" We propose a LiDAR-based solution to detect both frequency and angle via spectral analysis. Using CNN bounding box detection to identify the propeller signal in a spectrogram, we anticipate that frequencies can be detected within a range of 70-90 degrees. We expect our results to indicate that the system's performance is primarily dependent on the angle between the propeller and the LiDAR beam, as well as the position of the beam on the propeller. While we find that frequency detection appears straightforward, identifying the angle of the propeller will likely remain inconclusive.

Parallel E44

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Title: **Cryogenic Thermal Conductivity and Thermopower of Cubic-BAs Crystals**

Abstract: Semiconducting materials with ultrahigh thermal conductivities and thermopower have the potential to enhance the performance of microelectronic and thermoelectric power devices. One material of interest is cubic BAs (c-BAs), which is a III-V semiconductor with an ultrahigh thermal conductivity, high Seebeck coefficient, high hole mobility, and advantageous mechanical properties for microelectronic applications. First principles calculations show that c-BAs has a room temperature thermal conductivity of 2000 $\frac{W}{m\*K}$ , but empirical measurements haven’t been able to verify this due to high thermal contact resistance. There is also a lack of published data on the Seebeck coefficient of c-BAs, which is necessary to understand its physical relationship with phonon phenomena. A novel thin film thermometry and cryostat device was used to obtain cryogenic thermal conductivity measurements of CVT-grown c-BAs crystals with high accuracy. A conventional solid-state thermoelectric measuring device was used to validate the temperature-dependent thermopower in these crystals. We expect that these techniques will achieve the peak thermal conductivity and Seebeck coefficient in c-BAs crystals to provide evidence of its importance in microelectronic applications. Future work in this area will be applying these measurement techniques to other semiconducting crystals with ultrahigh thermal conductivities like TaN.

Parallel E45

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Title: **Using Metal Halide Perovskites to Design Materials Resilient to Radiation**

Abstract: Photovoltaic technology is applied globally, but photovoltaic technology is active only in the sunlight. There is a need to develop power sources that operate continuously. Halide perovskite solar cells are thin, lightweight ionic conductors that convert sunlight into electricity. This study investigates which additives and concentrations create a thick, crystallized lead halide perovskite capable of absorbing ionizing radiation. Cesium lead bromide mixed with different amounts of polyethylene glycol and starch were prepared inside a glove box and then applied to a glass slide using blade coating. The characterization process analyzed the substrates' crystallization, bandgap, and thickness. Cesium lead bromide with a 50% concentration of polyethylene glycol created a bandgap of 2.3 electron volts and a thickness of 2.3 micrometers. Cesium lead bromide with a 30% concentration of starch created a bandgap of 2.3 electron volts and a thickness of 2.3 micrometers. These findings suggest that cesium lead bromide with a 50% concentration of polyethylene glycol has a high tolerance to ionizing radiation.

Parallel F46

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Title: **Quantum Cryptography in Education for a Brighter Future**

Abstract: The education of quantum cryptography is crucial as it equips the next generation with the knowledge and skills needed to address future security challenges. Current encryption protocols safeguarding our digital communications and data will become obsolete as quantum computers develop. Quantum computers have the potential to break widely used cryptographic algorithms. By educating students in quantum cryptography, we prepare them to design and implement new cryptographic methods resistant to quantum attacks, ensuring the future security of information. The BB-84 quantum key distribution protocol is a foundational concept in quantum cryptography, typically demonstrated using expensive and complex equipment. This research aims to reduce the cost of BB-84 Education Resources to make them accessible in primary, secondary, and undergraduate schools. We have significantly reduced expenses by transitioning from traditional metal constructions to 3D-printed components. We have designed and built custom detectors utilizing Arduino Nano Every microcontrollers and solar panels, thus lowering costs and enhancing education by allowing students to engage directly with the system's inner workings. Our preliminary results indicate that our 3D-printed BB-84 system costs ≈$500.00, compared to traditional systems' ≈$3,900.00 price tag. Furthermore, our system offers greater adjustability and configuration options, making it an adaptable tool for various educational scenarios. This innovative approach holds promise for widespread implementation, making advanced quantum cryptography education more accessible and engaging, ultimately contributing to developing a secure digital future.

Parallel F47

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Title: **Reproducible Electron Beam Evaporation of High-Quality 1500 Å Aluminum Films on Silicon Substrates**

Abstract: Wire grid polarizers are an important component of many optical devices. An important fabrication step of wire grid polarizers is using a physical vapor deposition (PVD) method for applying a thin metallic layer over the substrate. Although manufacturing procedures are the crucial step to high-quality components, PVD is an unpredictable process with inherent uncertainties in many research facilities. In this research project, we investigate the effect of different fabrication parameters of electron beam evaporation in an Angstrom Engineering EvoVacof aluminum onto flat and patterned silicon on surface quality and reproducibility. Important fabrication variables such as deposition rate, substrate velocity, and substrate temperature were systematically altered to discover the optimal recipe for smooth aluminum thin films. These samples were characterized through scanning electron microscopy (SEM), atomic force microscopy (AFM), and profilometry. We found that 1500 Å aluminum samples deposited at 30 Å/s with the stationary substrate held at room temperature yield reproducible films with acceptably low surface roughness that can be used in the fabrication of wire grid polarizers.

Parallel F48

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Title: **Microfluidic Platform to Quantify Intra-tumoral Stress**

Abstract: Glioblastoma has a short life expectancy, a potential avenue for new therapeutics is through understanding tumor development and growth within its microenvironment. As a tumor grows in a confined space, it generates intra-tumoral stress. Current research shows compressive stress intratumorally has direct impacts on cancer progression. These forces assist the cancer cells in escaping tumors, highlighting an emergent mechanobiological driver of cancer progression. However, with current *in-vitro* tools this driver is poorly understood. To better understand this phenomenon, we have developed a microfluidic device that generates alginate microbeads that allows us to quantify intra-tumoral stress. The fabrication of the device was done using PDMS molds plasma bonded to glass slides, with inlets for alginate and oil, and a collection outlet. To generate beads, the alginate and oil went through channels ranging from 10-40um into an alginate-in-oil emulsion. Beads were then soaked in a Calcium Chloride solution where they underwent a chemical cross-linked via the outlet channel to then further be collected. Characterization of the beads involves using the ImageJ to calculate average radius range and atomic force microscopy (AFM) to get the elastic moduli, allowing for quantification of the force required for deformation. The beads were embedded into a glioblastoma stem-cell spheroid using the hanging drop method and subsequently embedded into a methacrylate hyaluronic acid gel, a biomimetic matrix. As the spheroid progresses, stress is exerted on the bead, causing it to deform. Deformation of the beads was studied using z-stack images of bead, images were taken using confocal microscopy.

Parallel F49

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Title: **Exploration of Organic Ionic Liquid Electrolytes of Micro Aluminum Air Batteries**

Abstract: Micro Aluminum-Air Batteries (mAABs) operating with aqueous electrolytes have shown promise in extending the flight duration of small-scale quadrotor drones. However, a main constraint of the aqueous electrolyte mAAB is that it cannot be recharged due to the limited stability of the aqueous electrolyte. In this work, we will explore alternate electrolyte solutions, primarily of the organic ionic liquid type, to allow for rechargeability. Combining AlCl3 and EMImCl forms an ionic solution and can be used as an electrolyte, enabling a mAAB to be discharged and charged continuously under 0.1 mA. Altering the ratio of AlCl3 and EMImCl can result in a higher power output due to the increased concentration of the Al2Cl7- ion. In addition, organic ionic liquid electrolytes have decreased corrosion rates of the aluminum anode compared to aqueous solutions, resulting in longer battery shelf life and less degradation in the anodic columbic efficiency. We have also characterized the cathode utilized within mAABs with the help of EDAX. The cathode is fabricated via co-sputtering Ag and Cu, followed by Cu selective etching to increase the surface area of Ag. EDAX is used to quantify the dealloying process, which shows that the cathode has a 9:1 atomic weight percentage ratio between Ag and Cu. Preliminary results suggest the promise of secondary mAABs, and further research is required to determine their application within small-scale quadrotor drones.

Parallel F50

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Title: **Building Generative Machine Learning Models to Analyze Microscope Images of Material Systems**

Abstract: Generative machine learning models offer a promising approach to developing qualitative understanding of microscopic images and the techniques used to obtain them. Current models, such as OpenAI’s CLIP and DALL-E, have successfully learned to classify and generate images from their textual descriptions. In materials science, these models can be trained on microscopic images of materials to gain insights into their properties and suggest synthesis methods for specific applications. This project aims to provide rich, qualitative descriptions of scanning electron microscope (SEM) images and the parameters used to acquire them, as well as to auto-generate images from textual descriptions. The model’s insights into materials systems can guide the specification of synthesis parameters (e.g. temperature, time, etc.) to achieve targeted functionalities. The chosen material class to test this project is Metal-Organic Frameworks (MOFs), known for their porous, tunable structures with applications ranging from carbon capture to catalysis. Given their wide applications, it is worthwhile to determine a system to analyze them. To acquire training data, images of various MOFs (UiO-66, NU-1000, MIL-101 Cr, and MIL-101 Fe) are obtained using Hitachi S-3400 SEM at different operating voltages, magnifications and other SEM settings. To enhance the model quality despite limited data, data augmentation techniques such as blurring and stretching are employed. The model will be trained to predict the material type, size, shape, morphology, the SEM settings used to capture the image, and potential applications of the material given an image input.

Parallel F51

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Title: **Characterization of Voltage Controlled Magnetic Anisotropy for Use in Spintronic Logic Devices**

Abstract: Voltage Controlled Magnetic Anisotropy (VCMA) is an interfacial effect that occurs between an iron-based ferromagnet and an oxide that allows for modification of the magnetization at the interface. VCMA is important for reducing the energy required to de-pin domain walls and increasing the reliability of switching in domain wall Magnetic Tunnel Junction (MTJ) logic devices. Traditionally, the domain wall in MTJ logic devices is pinned using a physical notch that requires a large current pulse to de-pin and subsequently switch. VCMA reduces the energy required to switch devices by eliminating the physical notch in exchange for a pinning method that can be controlled electrically.

Different oxides have different VCMA coefficients corresponding to the strength of the interfacial effect. Characterization of the VCMA coefficient is possible using the Anomalous Hall Effect. By fabricating Hall Bars, we can measure changes in the Hall resistance due to VCMA, allowing us to calculate the VCMA coefficient. During my REU I have fabricated CoFeB-based Hall Bars with SiO2 and Al2O3 oxide layers, helped design the Hall measurement setup, and taken measurements of out-of-plane and in-plane Hall loops.

Parallel F52

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Title **Micro-Additive Manufacturing Processes for Electrochemical CO2 Reduction**

Abstract: This work investigates the application of micro-additive manufacturing in the development of gas diffusion electrodes (GDEs) for electrochemical CO2 reduction reactors. This technology relies on the principles of electrochemistry to convert CO2 into useful chemical products. A key focus of this work is the reactor design and fabrication, as these elements impact the overall efficiency and functionality of the system. The gas diffusion electrode is identified as a common failure point in such reactors. To enhance the performance and durability of the GDE, we utilize the Nanoscribe GT2 Two-Photon Lithography System to print a microporous layer atop a carbon paper electrode. This effort aims to prevent electrolyte flooding in our vapor-fed reactor. A copper catalyst will be deposited onto the microporous layer using the AJA Sputter System. Subsequent analysis of the GDE surface will be conducted using a Scanning Electron Microscope (SEM) to ensure structural integrity and optimal surface characteristics. To evaluate the performance of the CO2 reduction reactor, measurements of open-circuit potential, electrochemical impedance spectroscopy, and cyclic voltammetry will be scrutinized. The results will highlight common failure modes, such as catalyst delamination and electrolyte flooding. Additionally, a long-duration, steady-state test will be performed to measure changes in potential at a fixed current, providing insights into the long-term performance and lifespan of the GDE. Our findings will deliver quantitative insights into the optimization of gas diffusion electrode synthesis, advancing the efficiency of electrochemical CO2 reduction processes. This research underscores the potential of micro-additive manufacturing in addressing critical challenges in renewable energy and carbon capture technologies.

Parallel F53

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Title: **Fast Simulation and Inverse Design of Nanophotonic Lasers**

Abstract:The past decade has seen a push to miniaturize lasers, leveraging nanophotonics to shrink bulky tabletop systems to chip-scale devices, compact enough for a new suite of applications. Harnessing the full power of the nonlinear dynamics, machine learning and fast numerical methods promise increased flexibility in the design and control of ultrafast lasers[1].

The goals of this project are twofold. The first stage is to develop fast GPU-accelerated differential equation solvers for models describing multimode and solid-state gain dynamics in nonlinear nanophotonic waveguides. Inspired by algorithms for similar problems in optical fibers [2], we seek to leverage parallel computing methods so the solvers are efficient for use on large scale design problems.

The second stage is to develop tools for ‘learning' of laser parameters and designs, such as for applications in supercontinuum lasers with uniform output spectrum in the visible regime[3]. Rather than manual sweeping of parameters, test data paired with machine learning and mathematical optimization inform design and characterization of devices in a massive parameter space. This project complements existing work on photonic inverse design by expanding the tools available for design with optical nonlinearity.

Parallel F54

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Title: **Effect of Temperature on Poly(Glycidyl Methacrylate) Nanoparticle Morphology Polymerized via Liquid Crystal-Templated Initiated Chemical Vapor Deposition**

Abstract: Nanoparticle morphology highly influences particle properties and is a crucial parameter to manipulate. The ability to create designed polymer particle shapes would greatly benefit many applications, including timed drug delivery. Using liquid crystal (LC)- templated initiated chemical vapor deposition (iCVD), we have successfully polymerized a range of glycidyl methacrylate (GMA) nanoparticle morphologies in a one-step, one-pot process. Multiple temperatures can be achieved in one polymerization by leveraging a temperature gradient placed directly on the reactor stage, and different GMA particle morphologies have been observed for the various temperatures achieved. The E7 LCs are sensitive to temperature, and their phase will transition from the nematic phase to the isotropic if the temperature is too high; at this point, the templating effect no longer exists. We have investigated the effect of temperature on the rate of evaporation and phase change of the LCs using a long-distance focal microscope. The microscope also allows for *in situ* monitoring of the polymerization. Using a set of controls and experiments, we have mapped a set of reactor conditions where temperature solely influences the progression of GMA particle morphology, allowing us to study how the morphology emerges with higher temperatures. The particle morphologies have been characterized using the Cornell NanoScale Facility Zeiss scanning electron microscopes. We have seen the emergence of larger, rod-like particles as temperature increases with orientations influenced by the templating effect of the LC.

Parallel G55

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Title: **Friction Mediation via Synthetic Mucin Polymer Formation into Tribofilms**

Abstract: Mucus is a natural product of biological systems, playing many vital roles as an organ coating, germ barrier, lubricant, and even as an externally secreted adhesive. In particular, mucus consists of numerous proteins, cell debris, bacteria, as well as mucin polymers, which are thought to be primarily responsible for its physical properties. Investigating the mechanisms by which mucin polymers modulate frictional forces between surfaces may lead to a better understanding of diseases such as cystic fibrosis and irritable bowel syndrome, or advancements in medical implants, drug delivery, and joint and tissue adhesives. Synthetic mucin polymers offer many advantages over biological mucin, including homogeneity and monodispersity, allowing greater confidence in attributing the physical properties responsible for friction modulation. Using lateral force microscopy (LFM), the contact between a SiO2 colloidal probe and polydimethylsiloxane (PDMS) substrate can be approximated to a single asperity system with analytically tractable contact mechanics. As I will demonstrate, there are two primary interactions of mucin on these substrates – firstly, the adsorption as a thin layer over the surface of the probe, and secondly, the transformation of the adsorbed mucin under higher stresses into a tribofilm – both of which play a role in lubrication and adhesion. The growth of the tribofilm under applied loads can lead to dramatic decreases in friction under differing loads and speed. However, the degree of friction decrease relative to PDMS-SiO2 direct contact is observed to vary between nominally identical experiments. Context about what factors may control the formation, durability, and lubrication capacity of mucin tribofilms will be discussed.

Parallel G56

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Title: **Composition- and Temperature-Dependent Anharmonic Phonon Dynamics in Formamidinium Lead Halide Perovskites**

Abstract: Phonons, sound quanta in the form of collective vibrations in a periodic crystal lattice, significantly affect the thermal and electrical transport properties of materials. The halide perovskite (HP) family of materials with the formula ABX3, where A is a monovalent cation, B is a divalent metal, and X is a halogen anion, boast long charge carrier lifetimes and high photovoltaic efficiency. Previous studies have shown significant electron-phonon coupling, which suggests that investigating the phonon dynamics of these materials is key to understanding their optoelectronic properties. At high temperatures, HPs adopt a cubic structure, but diffuse scattering experiments have shown that there are localized regions of correlated tilts of the BX6 octahedra, corresponding to strongly anharmonic phonon modes. We hypothesized that changing the chemical environment of the octahedral lattice, via substitutional disorder on the halide site, should affect the phonon dynamics. We studied FAPbBr3-xClx (FA = formamidinium) with Raman spectroscopy to elucidate the compositional and temperature-dependence of phonon modes. Doping the halide sites causes increased energy and broadening of certain phonons, while leaving other modes relatively unchanged. We found two vibrational modes of interest, one of which varied with temperature, and the other which coupled strongly to composition, but neither coupled to both variables. We found these phonons to be strongly anharmonic as evidenced by peak broadening with increasing temperature. Based on literature findings, we determined that these are molecular modes, vibrations of covalent bonds in organic compounds. The changes in one mode’s energy due to modification of the inorganic lattice suggests a coupling to formamidinium. These results can be used for rational design of photovoltaic materials, by helping us better understand the mechanism by which hybrid organic-inorganic materials derive their favorable optoelectronic properties.

Parallel G57

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Title: **Ultrasound mediated cell transfection in microchamber systems**

Abstract: In the realm of emerging cancer therapies, chimeric antigen receptor (CAR)-T cell therapy stands out for its potential to revolutionize cancer treatment. By harnessing and reprogramming a patient's white blood cells to target cancer cells, this therapy promises precision and efficacy against even the most resistant cancers. However, a current barrier with CAR-T cell therapy is the time spent genetically modifying T-cells in the lab. The Kopechek lab aims to address this by optimizing cell transfection, or the artificial insertion of cancer-fighting genes into T-cells. Our approach utilizes ultrasound-driven microbubble oscillation to deliver genetic material into cells. Furthermore, we employ polydimethylsiloxane (PDMS) microchamber wells fabricated from an SU8 mold for detailed single-cell analysis of the transfection process. In our study, we used bright field, phase contrast, and fluorescence microscopy to analyze Jurkat T-cells seeded on microchamber wells coated with fibronectin. We identified an optimal well size of 50 microns, a seeding cell concentration of 50,000 cells/ml, and an ultrasound treatment time of one day after cell seeding. We also identified methods to reduce air bubbles in cell media due to PDMS aeration. Finally, we imaged samples over time to track cell migration and proliferation, and we created a MATLAB-based computational analysis method to analyze fluorescence-stitched microscopy images. These results hold the potential to enhance the precision and efficiency of cell seeding in microchamber wells and set the stage for in-depth observation and machine-learning analyses of the transfection process.

Parallel G58

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Title: **Analysis of Thin Films through Various Collimation Methods on an X-ray Diffraction 2D Detector** Abstract: Thin films are used in various fields, including catalysis, sensors, and semiconductor electronics. To identify their potential applications, scientists seek to understand their structural properties. Several techniques for thin film characterization involve the use of x-ray diffraction off of crystalline planes. The X-ray beams yield specific intensity patterns due to how they scatter from these plane interactions. This work focuses on the properties of single crystal thin films grown via pulsed laser deposition. High-resolution X-ray diffraction (XRD), X-ray reflectivity (XRR), and in-plane Grazing Incidence Wide-angle X-ray diffraction (GIXRD) scans were done to evaluate film characteristics such as thickness, roughness, electron density, etc. In addition, we are now exploring how to expedite this data collection using the full 2D capabilities of the area detectors. This will enable the capture of multiple diffraction peaks in one shot from polycrystalline samples or collect fast XRR and reciprocal space maps in principle. However, this requires the beam to be small and collimated in both directions normal to beam propagation. Currently, the X-ray source is a line source. To resolve this, we are applying collimation slits to convert the linear x-ray source to a point. This results in decreased incident intensity. We are trying to determine whether data collection using the 2D detector is more efficient than the 0D detector and compare the 2D detector’s relative effectiveness given its loss in intensity. We are also using 2D reciprocal space mapping to determine the relative position of Bragg peaks, which will inform a film’s strain and mosaicity. Our findings will provide valuable insights into optimizing X-ray characterization techniques for thin films, enhancing the understanding of their structural properties for various applications.

Parallel G59

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Title: **Slowing Oxygen Release Kinetics via Microencapsulation**

Abstract: Capsules that can slowly release oxygen over the course of hours or days could lead to the development of new technologies for promoting wound healing and scar prevention. Perflourodecalin (PFD) has excellent oxygen-dissolving capabilities due to its low density, providing the oxygen reservoir needed for prolonged oxygen release. However, the chemical properties of PFD make it immiscible in both water and oil, creating a challenge to encapsulate via standard double emulsions. Additionally, even if PFD is successfully encapsulated, the capsule shell must provide a sufficient barrier to oxygen diffusion to achieve the goal of slowing oxygen release kinetics. In this study, we show a way to encapsulate PFD and modulate the shell properties to tune oxygen release. We use a microfluidic approach to generate monodisperse capsules with precise control over the thickness-to-diameter ratio.

Parallel G60

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Title: **Development and Processes for High-Temperature Lithium Niobate Acoustic Devices**

Abstract: Ultrasound is widely utilized for non-destructive evaluation, yet conventional piezoelectric transducers are limited by penetration depth, energy transmission, and reduced bandwidth. These issues can be addressed through piezoelectric micromachined ultrasound transducers (PMUTs). Nonetheless, functionality is also influenced by harsh thermal conditions. Ultrasonic transducers capable of withstanding extreme heat are essential for in-situ monitoring of systems such as nuclear power plants, where temperatures can exceed 800°C. The selection of piezoelectric material is critical for high-temperature applications. Lithium niobate is a suitable candidate due to its strong piezoelectric properties, high crystal quality, and a melting point exceeding 1200°C. For the development of high-temperature PMUTs, the longitudinal vibrational mode of lithium niobate must be excited. To this end, we have fabricated acoustic resonators to assess the high-temperature and electrical performance of platinum electrodes on lithium niobate. Despite challenges such as poor adhesion and photoresist reflow during platinum deposition, the resonator—comprising lithium niobate on amorphous silicon on a high-resistivity silicon stack—demonstrates potential. The fabrication process involves Argon gas etching, platinum thin film deposition, and xenon difluoride etching to suspend the lithium niobate, thereby reducing acoustic radiation loss and enhancing device performance. These devices will undergo high-temperature treatments for performance evaluation.

Parallel G61

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Title: **Investigating the Lateral Spreading of Vanadium Based Ohmic Contacts**

Abstract:Aluminum Gallium Nitride (AlGaN)-based electronics have emerged as strong candidates for next-generation power devices in recent years, due to their high breakdown voltage and superior thermal conductivity. Despite these intrinsic material advantages, a key challenge for high-performance AlGaN power devices is forming effective ohmic contacts, especially at high Aluminum compositions. Several studies have indicated that poor contact morphology can significantly degrade the performance of vanadium-based ohmic contacts to high AlGaN. However, the impact of annealing conditions and the choice of diffusion barrier metals on the lateral spreading of the alloy after annealing remains unexplored. Our research focuses on determining the annealing conditions that minimize the lateral spreading of vanadium-based ohmic contacts on Silicon for applications on aluminum gallium nitride (AlGaN) substrates. As reported in literature, aluminum nitride (AlN) PN diodes have often been shorted due to the spreading of the ohmic metals. The lateral spreading causes the metals to come in contact with each other or the n and p-layers to be shorted, allowing the electrons to take the path of least resistance and move in between the metals rather than through the designed semiconductor heterostructure. Our experiments were carried out on 8x8 mm silicon pieces with varying metal stacks while testing different annealing temperatures and the amount of time annealed in order to find the optimal condition that would cause the least amount of spreading. We characterized the amount of spreading and identified the metal causing the spreading using the CNF’s Zeiss Supra Scanning Electron Microscope (SEM) and the Bruker Quantax 200 Energy Dispersive Microscopy (EDS). The measurements were taken from circular transmission line model (C-TLM) and linear transmission line model (L-TLM) structures.

Parallel G62

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Title: **Simulation of Magnetic Skyrmions Under Strain**

Abstract: Magnetic skyrmions are a magnetic spin texture that are stabilized by the Dzyaloshinskii-Moriya interaction (DMI). These have various potential applications within spintronics, such as magnetic memory devices. However, the conditions for the formation and control of skyrmions require further investigation. In this project, I simulate how strain can affect the eccentricity and overall shape of magnetic skyrmions. Using Mumax3, an open source micromagnetics software package, and UNL’s Holland Computing Center, I simulated the formation of elliptical skyrmions through the application of strain. Finally, I compared the radii and domain wall widths of the skyrmions to a mathematical model of a skyrmion.

Parallel G63

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Title: **Growth of** $Ce\_{2}Ge\_{2}Mg$ **to study quantum magnetic states**

Abstract: $Ce\_{2}Ge\_{2}Mg$ is a metal that contains magnetic $Ce^{3+}$ ions on the Shastry-Sutherland Lattice (SSL). Materials with magnetic moments arranged on the SSL are candidates to study quantum spin liquid states, which are of interest for quantum information. We have successfully grown $Ce\_{2}Ge\_{2}Mg$ single crystals via the molten flux method. Using powder X-ray diffraction, we determined the crystal structure. Additionally, we confirmed the atomic proportions of Ce, Ge, and Mg to be 2:2:1 using energy dispersive spectroscopy. We are refining the synthesis process to increase the yield of $Ce\_{2}Ge\_{2}Mg$ crystals. Our goal is to accumulate enough sample mass to study the quantum magnetic states using inelastic neutron scattering.

Parallel G64

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Title: **Atomic Layer Deposition of High K Dielectrics**

Abstract: Conventional HfO2-based high K dielectrics gate stacks cannot produce such a small effective oxide thickness and the consequent high capacitance without removing the interfacial SiO2, which negatively impacts electron transport and gate leakage current. The superlattice gate stacks offer much-reduced leakage current and zero mobility deterioration as they lack the need for this kind of scavenging. The gate stacks are used in GaN transistors for power and communication, the existing dielectric in these transistors causes significant leakage and damages the underlying material. Ultrathin ferroic HfO2-ZrO2 multilayers, stabilized with competing ferroelectric–antiferroelectric order, offer a new method for advanced gate oxide stacks in electronic devices beyond traditional HfO2-based high-dielectric-constant materials. The project is looking to develop a process to deposit the high-k HfO2/ZrO2 superlattices. Atomic Layer Deposition (ALD) is used to build up the superlattice, we use ALD because it provides uniform and precisely tuned thickness, then through various depositing methods such as sputtering and e-beam evaporation aluminum was deposited through a capacitor shadow mask and then annealed through rapid thermal processing. The fabricated devices were characterized on a DC probe station and graphed for current versus voltage, voltage over time, and Capacitance - Voltage (C-V), the latter of which solves for the dielectric constant and also examines other material parameters such as defect density. The project is working towards the smallest leakage at the smallest equivalent oxide thickness.

Parallel G65

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Title: **Fabrication of Twisted Bilayer Photonic Crystals**

Abstract: In this study, we investigate the fabrication and optimization of a twisted bilayer photonic crystal (TBPhC). Utilizing a detailed fabrication process, we create TBPhC structures by twisting two photonic crystal slabs relative to each other at precise angles. The resulting moiré patterns significantly alter the photonic band structure, enabling tunable optical properties. Characterization techniques, including momentum space–resolved optical response measurements and band structure analysis, are employed to assess the impact of various twist angles on the photonic behavior. Our findings reveal a high degree of tunability in the optical band structure due to interlayer coupling and moiré scattering. This research not only provides insights into the complex optical phenomena in TBPhC systems but also offers a pathway for developing advanced photonic devices with customizable optical properties. Future work will focus on optimizing the fabrication process to enhance the reproducibility and performance of these structures, aiming to integrate them into practical applications such as tunable filters, sensors, and optical communication systems.

Parallel G66

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Title: **Ultrafast THz Studies in Spintronic Devices**

Abstract: Terahertz (THz) radiation is located between visible light and radio waves on the IR spectrum. Because these frequencies are hard to access by both electronic oscillators and optical transitions, this region is also known as the "THz gap”. As the demand to achieve large bandwidths in wireless communications increases, developing THz sources has become a hot research topic. One emerging technique for generating and detecting THz is based on ultrafast lasers. In this project, we employ this technique to explore the use of spintronic THz generation. In spintronic THz emission, we optically excite a hetero-structural material (ex: NiFe/Pt) with a femtosecond ultrashort pulse to generate a THz field utilizing the inverse spin Hall effect in the presence of an externally applied magnetic field. We use this method as a means to create and manipulate THz fields. One approach we use in manipulating these fields is to process the multilayered structure in the form of photonic resonators, enabling the amplification of certain THz fields and filtering others. Moreover, we investigate the potential of using chiral effects in spintronic THz generation. The obtained data aids in understanding the characteristics of THz signals emitted by spintronic processes, which can be eventually exploited in the emerging application of 5G and 6G communications.

Parallel H67

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Title: **Advanced Photonics for On-Chip Sensing: Design, Optimization, and Implementation in Integrated Sensor Devices**

Abstract: In pursuing better-performing devices, the scientific community creates innovative device ideas around The Figure of Merit (FOM). Traditional water quality testing methods perform less efficiently among the FOM values because they require larger sample sizes, greater laboratory analysis, less mobile equipment, and higher energy consumption. Pursuits for water quality testing have emerged to address practicality. Therefore, photonic crystal sensors’ sensitivity and specificity capabilities provide greater long-term experimental potential in water quality testing than traditional laboratory methods. In this study, we fabricated a Si3N4 photonic crystal slab utilizing a rectangular air-hole array on a fused SiO2 substrate. Crystal dimensions such as the radius and lattice constant were optimized using the commercially available computational tool “Lumerical FDTD.” The fabrication process involves advanced electron beam lithography followed by plasma etching techniques to create a periodic nanostructure that boosts light-matter interactions and should thus enhance Raman scattering for the molecular identification of metals such as lead (Pb²⁺) and mercury (Hg²⁺). The future extension of this project will include the assembly of nanocapsules with silver nanoparticles onto the photonic crystal to provide a constant enhancement of its SERS effect, making the sensors more sensitive beyond hotspot proximities.

Parallel H68

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Title: **Optimizing Protein Imaging Techniques**

Abstract: Biological imaging is a process used to examine how different biological samples function and react under stressors. It is important to image biological samples on a widespread level to accurately assess their behavior and phenotype. Through electron microscopy techniques such as SEM and TEM, we can obtain high-resolution images at a higher magnification than light microscopy. However, current EM techniques require the dehydration of compounds, which does not mimic real hydrous biological conditions. To accurately assess the folding of Apoferritin, we hypothesize that integrating Cryo-EM into our regular imaging will improve the scope of biological imaging altogether. Our approach includes comparing SEM and TEM images to Cryo-EM to identify their differences. SEM and TEM require samples to be chemically fixed and then dehydrated. However, through Cryo-EM, we found that the plunge-freezing process more accurately depicts how Apoferritin behaves in our bodies. The future of biological imaging lies in Cryo-EM techniques because they accurately depict biological compounds in vivo, rather than relying on EM methods that dehydrate samples.

Parallel H69

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Title: **Exploring the Immunostimulatory Effects of Gold-SNA Through Variable DNA Lengths**

Abstract: The spherical nucleic acid (SNA) form factor in which a nanoparticle core is radially functionalized with adjuvant DNA has become a promising delivery platform in cancer vaccinology due to its high rate of cellular uptake and immune activation. The proper selection of an adjuvant is critical to elicit a specific immune response. SNAs adorned with DNA containing cytosine – guanine dinucleotide motifs, or CpG DNA, have been extensively utilized for their immunostimulatory activity through interaction with the pattern recognition receptor toll-like receptor 9 (TLR-9). We investigated how varying the length of CpG DNA attached to gold nanoparticle (AuNP) SNAs affects both cellular uptake of the SNA into RAW-Lucia cells and activation of TLR-9. The CpG sequences were modeled after the CpG1826 sequence and synthesized with decreasing length down to five nucleotides (nt). Cellular uptake will be assessed with inductively coupled plasma mass spectrometry (ICP-MS). Activation and uptake will be further assessed with a UV-vis immunostimulation assay. It is hypothesized that decreasing the length of CpG DNA will decrease AuNP SNA uptake and TLR9 activation. Determining how length and sequence of CpG DNA impacts SNA uptake and immune activation can better inform strategic SNA structure design.

Parallel H70

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Title: **Fabrication of 2D-Material-Based Ionic Transistors**

Abstract: We used CNF's Heidelberg Mask Writer DWL-2000, ABM Contact Aligner, Oxford 81 RIE, AJA Ion Mill, and SC4500 Even-Hour Evaporator to fabricate the 2D-material-based ionic transistors. Traditional electronic field-effect transistors (FETs), which utilize electrons and holes as charge carriers, are indispensable in modern electronic devices such as integrated circuits and microprocessors. They form the backbone of today's digital technology by enabling efficient information processing, storage, and transmission. Despite ongoing challenges in the miniaturization of electronic transistors, ionic FETs offer distinct advantages, particularly biocompatibility and tunable conductance. Our project aims to fabricate ionic transistors using advanced 2D materials and address the limitation of low on-off current ratios in these devices. The human brain, with its highly selective ionic transmission system, processes vast amounts of information and facilitates neural communication daily. To mimic the ultra-functional capabilities of the brain, nano-channeled ionic field-effect transistors that use ions like Na+ and Ca2+ as carriers, similar to those in neural processes, show great potential for future applications. Such transistors are promising for artificial brain systems and memory devices like neuromorphic memristors due to their unique ability to maintain discrete conductivity states, which serve as memory storage units. To replicate the ultra-selectivity of brain ionic channels, we aim to fabricate ionic transistors with nanochannels approaching the Debye length. Conventional microchannels, with their short Debye length and discontinuous electric field effect, result in the undesirable coexistence of both negative and positive ions. In contrast, the nanochannel design enables the electric field to penetrate the entire channel, predominantly permitting the passage of only a single ion type, mirroring brain function. After completing the entire fabrication process—depositing the nanoscale organic cage molecules akin to Cu-TCPP with pyridine treatment, forming a heterostructure with a monolayer of MoS₂, coating SiO₂ as the insulating layer, and setting up the drain, source, and gate electrodes—the transistor is expected to show a current of less than 10-11A when the drain and source are not connected. This would indicate a successful fabrication with no leakage, making it ready for future integrations.

Parallel H71

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Title: **Mobile Fiber Structures Seeded With Living Cells**

Abstract: Creativity in art revolves around well-known techniques, rather than developing at the cutting edge alongside new knowledge. Since the 1500s professionals have been attempting to integrate the fields of art and science. Leonardo Da Vinci and Ernst Haeckel are early and pivotal examples - their infatuation with unveiling the systems of humans and animals led to illustrations which changed both the science and art worlds [1]. Da Vinci and Haeckel made art inspired by science, but not art produced by science. I would like to switch this narrative to investigate how artists can work with scientists and use lab techniques to create art, while examining what causes viewers to see an object as alive. This summer I had the privilege of being a research student in Kit Parkers Disease and Biophysics Group. Specifically, their work with biomimicry - a tissue engineered ray [2] and a biohybrid fish [3] each made of cardiomyocytes seeded on unique substrates to mimic the original creatures motion - interests me. I will use these examples as foundations to build my project from. I aim to utilize laboratory tools to craft a living sculpture that examines qualities observed as alive, and to further capture the construction of my creation using Scanning Electron Microscopy (SEM) imaging techniques. I will use Focused Rotary Jet Spinning technology to generate nanofibers and create the sculptural aspect of my project. I will seed my sculptures with cardiomyocytes, and mature these cells enough that they beat. I will also image my creation with SEM to capture a detailed picture that brings the viewer down to the cell level, and shows how cells align on unique nanofiber scaffolds. Overall, this project opens the door to understanding the complex relationship between artistic expression and scientific tools, offering a unique chance to utilize each unconventionally.

Parallel H72

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Title: **Stoichiometric Dependence of Physical and Electrical Properties of Silicon Nitride**

Abstract: In recent years, nitride transistors have received much attention in the semiconductor device research community due to their wide bandgap, high thermal conductivity, and polarization properties. Two important performance metrics of these devices are the suppression of leakage current through the gate dielectric and its resilience under repeated use. Previous studies [1] have shown that these properties can be improved in SiNx (a common gate dielectric for nitride transistors) by changing the stoichiometry of the dielectric deposition. This investigation entails the physical and electrical characterization of silicon nitride (SiNx) thin films deposited on silicon substrates by low-pressure chemical vapor deposition (LPCVD). Films were deposited at temperatures of 775oC, 750oC, and 725oC, and dichlorosilene to ammonia gas flow ratios of 5:1, 5:2, and 1:4, yielding a total of nine samples. Physical characterization measurements, including stress and index of refraction, were conducted on each film. The films with the lowest Si content showed the most stress and lowest index of refraction. Aluminum contacts were deposited on the silicon nitride using CNF’s CVC SC4500 Thermal Evaporation System and patterned by contact lithography in a metal-first process to form MOS capacitors. Capacitance-voltage behavior of the fabricated capacitors was measured at a DC probe station to determine the dielectric properties of the SiNx . The leakage current through the capacitors under applied bias was also measured as a function of time to determine the time-dependent dielectric breakdown of each film.

Parallel H73

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Title: **A Novel, Opto-fluidic Window Design Capable of Independently Controlling the Amount of Light and Thermal Radiation Entering a Building**

Abstract: Buildings are responsible for approximately a third of all energy usage worldwide, with a significant amount of this energy usage dedicated entirely to simply maintaining a desired temperature and brightness level indoors [1]. Building infrastructure, from HVACs to blinds and indoor lighting, has been developed and implemented in buildings to maintain the comfort levels of those inside. Windows, as the least insulating part of most buildings, are often viewed as the most active region of energy exchange between a building and its surroundings. However, much of this exchange results in wasted energy, with recent estimates suggesting that windows account for 40% of total building energy costs [2]. Thus, recent research efforts have investigated the fabrication of different materials that exhibit control over light and heat independently. However, while these optical and thermal systems operate well separately, most are incapable of operating synergistically within the same building design. In order to develop a single platform that will allow for the achievement of optical and thermal control over energy exchange between buildings and their external environment, we propose looking at a new class of materials: fluids. Other studies conducted in this field have investigated approaches such as electrochromic windows, liquid crystal window designs, and even more complex optical filters. However, all of these methods require the use of unconventional window materials or complex fabrication processes that prevent them from being easily scalable. Our proposed solution is simple: by pumping fluids, with precisely tuned optical properties, through two layers of a larger window, certain bands of electromagnetic radiation can be tunably transmitted, reflected, or absorbed in a desirable fashion. Fluids of varying particle size and visible color were fabricated and shown to selectively transmit or reflect visible and near-infrared radiation. To aid the optical efforts of these fluids, additional ITO-based thin films and titanium dioxide and silver dielectric/metal/dielectric (D/M/D) stacks were fabricated on the interior glass window pane and were proven to selectively reflect mid-infrared light, representative of the black body radiation most commonly transmitted between nearby buildings. Together the use of these specially designed microparticle solutions and optical thin films was proven to save energy compared to the typical energy levels required to maintain a comfortable room temperature and brightness level by selectively and independently controlling when mid-infrared light is absorbed or reflected, when near-infrared light is reflected or transmitted, and when visible light is reflected or transmitted into a building.

Parallel H74

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Title: **Environmental Stimuli of Amphiphilic Block Copolymer Assemblies**

Abstract: Poly(butadiene)-block-poly(acrylic acid) (pAA) and Poly(butadiene)-block-poly(ethylene oxide) (pEo) are block copolymers that are dynamic, robust, and can form membranes similar to those seen in nature. Like lipids, they possess an amphiphilic structure- meaning they both have a hydrophobic and a hydrophilic side. This study focuses on how micelles made from these two polymers react to pH and ionic strength during their formation to be able to better understand cell membrane structure. Methods used include Atomic Force Microscopy (AFM), Dynamic Light Scattering (DLS), Ultraviolet Visualization (UV-Vis), and Fluorescence Recovery After Photobleaching (FRAP)- which in order, measured 2D membrane thickness, micelle size, wavelength excitation, and membrane fluidity. We are anticipating trends between high pH and larger size, more concentrated ions and larger size, as well as stronger fluidity in pAA compared to pEo. By studying the environmental stimuli that impact synthetic membrane structures, we hope to better understand how cell membranes can sense, respond, and adapt to changing environments. In the future, we hope this research on how these polymers react to these stimuli can allow us to use them in various industries such as using them in precise drug delivery, as a form of biosensors, and other biocompatible applications.

Parallel H75

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Title: **Si Substrate Integrated Waveguides for Millimeter-Wave Integrated Circuits**

Abstract: Substrate Integrated Waveguide (SIW) technology is a leading candidate for the realization of millimeter-wave integrated circuits. The structure of a SIW is similar to that of a conventional metal waveguide with an air cavity, utilizing two parallel rows of through-substrate vias (TSVs) embedded in a dielectric substrate to confine an electromagnetic wave. SIWs merge the benefits of traditional waveguides—such as low loss, high power capacity, and minimal cross-talk—with a cost-effective and highly scalable manufacturing process. This project has focused on the fabrication and characterization of SIWs on Si substrates, specifically targeting a TSV resistance below 2 ohms and a SIW insertion loss of 0.2 dB/mm in the D Band (110-170 GHz). The fabricated SIWs have also been used to extract fundamental material properties at millimeter-wave frequencies, such as electrical permittivity and loss tangent.

Parallel H76

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Title: **Metal Assisted Chemical Etching for Quantum Cascade Lasers**

Abstract: Quantum Cascade Lasers (QCLs) are semiconductor lasers operating in the mid to long infrared and terahertz regimes. These lasers are composed of multiple quantum wells that create a superlattice structure. As electrons pass through these wells, they transition between energy levels and emit photons at each step. This cascade effect allows a single electron to generate multiple photons, enhancing efficiency. Compared to other lasers, it has broad tunability, robustness, and compactness. QCLs provide a faster and more precise alternative to FTIR, mass spectrometry, and photothermal microspectroscopy, particularly in high-resolution spectroscopy and real-time gas analysis. However, most QCLs fabrication techniques rely on wet or dry etching, such as ICP-RIE (Inductively Coupled Plasma Reactive Ion Etching), both of which introduced artifacts that degrade performance. Metal-Assisted Chemical Etching (MacEtch) is a technique that uses the catalytic properties of metals to enhance the wet etching process, producing anisotropic high aspect ratio structures, damage-free sidewalls, and efficient patterning of semiconductors at the micro and nanoscale. In this project, we will demonstrate a high-performance GaAs/AlGaAs-based QCLs by using the MacEtch process. We will also explore different etching and patterning recipes to optimize the GaAs/AlGaAs MacEtch technique. This research aims to offer an alternate fabrication process for QCLs, ultimately improving their performance and application range.

Parallel H77

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Title: **Computational Optimization of Collinear Printed Pneumatic Soft Actuators**

Abstract: Pneumatically actuated soft robots are often used for their flexible range of applications and similarity to natural biological forms of motion. On the centimeter scale, fluidic soft robots act at a high strength-to-weight ratio and compatibility with natural structures, but require high pressure inputs to operate. However, micron-scale applications can achieve similar morphing motifs at lower pressures and while demonstrating less plastic strain, thus enabling the fabrication of complex microarchitectures and precise actuations. The ability to pattern and process such microactuators is simplified by the coaxial 3D printing of elastomeric tubes on a flexible substrate. This fabrication approach can produce actuators that closely mimic natural structures, such as the furling and unfurling of leaves or vascular networks in the human body. To first explore this computationally, we utilize Finite Element Modeling (ABAQUS) python scripting compatibility and multi-physical analysis. We propose a method to create and run a full static analysis of the pneumatic expansion using an empirically derived hyperelastic model. This method is optimized by implementing the use of a Newton Raphson root-finding algorithm, catering to the highest actuation curvature while minimizing overall strain for improved repeatability and robustness. Thus, the optimization expands the range of applications, enabling the actuators to be used for precise and repeated use environments due to their enhanced durability and fabrication success rate.

Parallel H78

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Title: **Additive manufacturing of yttria-stabilized zirconia ceramics**

Abstract: Yttria-stabilized zirconia (YSZ) is a fine ceramic material featuring Yttria additives to achieve a desired crystal structure in Zirconia. YSZ is a high strength, high melting point material. These properties allow materials such as porous YSZ to make gas filters that can be used in high-temperature regions; however, often high-density ceramics are needed. The high strength and high melting point of YSZ and other fine ceramic materials make them difficult to manufacture. This research aims to use modern additive manufacturing techniques to additively manufacture both low and high-density YSZ for extreme applications such as filters, orthodontics, and refractory coatings.

Parallel I79

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Title: **Assessing Calcium Propagation and Twitch Stress in hiPSCs-Cardiomyocytes (CMs) for Comparison to Fabry Disease Derived hiPSCs**

Abstract: Fabry disease (FD), an X-linked lysosomal storage disorder, affects between 1 in 40,000 and 1 in 117,000 individuals (Pieroni et al., 2021).This condition results from a mutation or absence of the *GLA* gene, leading to decreased activity of α-galactosidase A, an enzyme that breaks down globotriaosylceramide (lyso-Gb3) in the lysosome. (Choi et al., 2015). The buildup of lyso-Gb3 impairs the function of cardiomyocytes and stimulates secondary pathways that can lead to left ventricular hypertrophy (Pieroni et al., 2021), and in some patients, heart failure (Weissman et. al, 2024). We hypothesize that human induced pluripotent stem cell derived cardiomyocytes (hiPSC-CMs) expressing Fabry disease phenotypes exhibit decreased twitch stress and abnormal calcium propagation (Bray et al., 2007). Using patient derived hiPSC-CMs, we will model Fabry disease conductive and contractile phenotypes using the heart-on-a-chip platform. Wild-type (*wt*) hiPSC-CMs were seeded onto MTFs and G-Nodes and analyzed to establish baseline measurements for twitch stress and longitudinal conduction velocity. The recordings of twitch stress and calcium propagation in cardiomyocytes derived from healthy human-induced pluripotent stem cells will be analyzed and compared to those from FD patients. Additionally, confocal microscopy was used to assess the structural integrity of the *wt* cells. Structural data of *wt* and hiPSC-CMs will also be compared to establish an accurate disease model to better understand the molecular basis of FD.

Parallel I80

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Title: **Atomic Layer Etching of III-Nitride Semiconductor Films**

Abstract: III-nitride semiconductors offer unique advantages in the manufacturing of high-voltage field effect transistors (FETS). However, production of nanoscale III-nitride FETs requires precise etching of III-nitride semiconductor films. We identified atomic layer etching (ALE) as an ideal technique for this application. ALE weakens the bond between a film and its surface layer via a chemical reaction with a reagent gas or plasma. The reagent is then purged, and the surface is bombarded with non-reactive ions. These ions impart enough energy to sputter away the reacted surface layer, but not enough to remove unreacted material underneath. These self-limiting characteristics make it possible to remove just a few atomic layers at a time. To adapt and characterize ALE for the processing of III-nitride films, samples with gallium nitride (GaN), aluminum nitride (AlN), and aluminum-gallium nitride (AlGaN) films were etched in the Cornell Nanoscale Facility’s (CNF) Plasma-Therm Takachi ALE tool. Critical etch metrics such as surface roughness, film thickness, etch rate, and etch selectivity were monitored with various metrological tools. These included CNF’s Veeco Icon Atomic Force Microscope (AFM), Zeiss Ultra Scanning Electron Microscope (SEM), KLA P-7 Profilometer, and Woollam RC2 Ellipsometer. Initially, samples were processed via traditional reactive ion etching (RIE) due to the lack of a functional ALE recipe. Data from these trials matched expected RIE etch rates of 30-40 nm/min, and an expected etched surface roughness of approximately 2 nm root-mean-squared (RMS). When an ALE recipe became available, samples were processed and analyzed. The results of these trials are not available at the time of writing. To give context, typical ALE processing can be expected to remove single-digit nanometer layers of material per etch cycle while producing a surface roughness below 1 nm RMS. With the results of these experiments, researchers will be able to more successfully and consistently produce III-nitride based FETs.

Parallel I81

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Title: **Mechanical Stability Assessment of Silicon Microcapsules**

Abstract**:** This project, a collaboration between the Filler and Vogel Labs at Georgia Tech, aims to revolutionize microelectronics manufacturing by developing a scalable, bottom-up approach to create high-performance nanoelectronic elements. The method utilizes silicon microcapsules produced through a double emulsification process, which serve as growth substrates for nanowires via a volumetric vapor-liquid-solid (VLS) mechanism. Central to this innovative approach is the use of a Powder Coat 300 system for tumbling the microcapsules and introducing precursor gasses to initiate nanowire growth. The success of this method hinges on the mechanical stability of the silicon microcapsules during the tumbling process. By assessing the microcapsules' ability to withstand these mechanical stresses, this research aims to validate and optimize the scalability and efficiency of this novel nanoelectronics manufacturing approach. The findings will contribute to the broader goal of making high-performance microelectronics production more accessible and cost-effective.

Parallel I82

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Title: **Heat-selective Mirrors: Methods for Construction**

Abstract: With a myriad of factors contributing to heat flux to buildings (solar heating, ground temperature, occupancy, etc.), buildings are consistently exposed to a wide variety of thermal scenarios, throughout both the day and year [[1]](https://www.zotero.org/google-docs/?EcY5Ol). However, these scenarios are not always the ideal condition for building inhabitants. In these non-ideal scenarios, buildings need to control how heat is flowing into or out of the building. Currently this is done with insulating layers to isolate the interior spaces, and heaters and coolers to control indoor temperature. However, these heaters and coolers require exorbitant amounts of energy to maintain temperature differences between the building interior and its external environment. In addition to the heating and cooling, building occupants also have energy drawn from lighting the space that they inhabit. To limit the required energy consumption of such buildings working to maintain a comfortable temperature and lighting level, this project presents a novel way of fine-tuning energy flux of light and thermal radiation. By incorporating multiple fluidic layers, where injected fluids in spaces within glass window panes can control different wavelength ranges, this device can control visible, near-infrared, and mid-infrared light independently. This work also focuses on the fabrication of a reflective surface for mid-infrared light which can be blocked by an absorbing fluid to create a switchable control for mid-infrared radiation. This surface was made by creating rugate filters using electrochemical etching techniques and chemical vapor deposition to create both effective and real changes in index of refraction, forcing a strong reflection of a chosen wavelength.

Parallel I83

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Title: **Investigating the effects of competing contaminants and pH on the performance of sponge-based nanocomposites for environmental remediation**

Abstract: Nutrient pollution in natural water systems, such as nitrogen and phosphorus introduced into bodies of water primarily from agricultural runoff, can lead to harmful algal blooms, oxygen depletion, and severe impacts on aquatic ecosystems and water quality. Eutrophication, excessive nutrients, contribute to disruptions of the nitrogen and phosphorus cycles and the growth of algal bloom creating dead zones in aquatic environments. Current water treatment technologies are timely and lack versatility to remove different contaminants. Conversely, interest in the use of nanomaterials is increasing due to their availability and ability to be tailored to containments. Here we aim to investigate the remediation of phosphates and metals typically found in storm and wastewater using a nanocomposite that consists of iron oxide nanoparticles coated cellulose sponge. Previous studies have shown success, with high-performing adsorption rates of phosphorus in lower pH systems and subsequent recovery of the phosphorus occurs at a pH near 11. In exploring the impact of pH levels, we also investigate how much water is required for successful recovery of phosphorus off the nanocomposite, testing recovery in volumes of 15 mL, 100 mL, and 500 mL of pH 11 water. Kinetics trials were run to examine how the system's contents affect the capture and recovery rates by comparing phosphorus and multi-ion kinetics. Finally, a flow-through system was used to mimic real water systems and study how flow rate influences performance. Scanning electron microscopy (SEM) is also used to observe how the nanoparticle coating is affected by these variables. This study will give more insight into how nanoparticle coatings can selectively remove pollution from flowing and stagnant water; creating a solution for large-scale pollution that is cost-effective and sustainable for the environment allowing us to recover and reuse these nutrients.

Parallel I84

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Title: **Fabrication of Superconducting Resonators on hBN Thin Films**

Abstract: 2D materials have attracted much attention due to their unique physical and chemical properties. Here we investigate the integration of a thin film grown of one of these 2D materials, hexagonal Boron Nitride (hBN), into a superconducting device. We believe that hBN will be compatible with the device because of its low dielectric loss tangent. The device, a coplanar waveguide resonator, was designed for high sensitivity to loss at the metal-substrate interface, allowing us to compare loss between a device with hBN and without. We fabricate a Nb on hBN on sapphire resonator and compare it to a standard Nb on sapphire resonator. The fabrication process was performed at the Cornell Nanoscale Facility at Cornell University, using the AJA sputter deposition tool, ABM Contact Mask Aligner, and Plasmatherm 770 Etcher. In this work, we explore the various adjustments made in order to accommodate and prevent damage to the hBN substrate. Additionally, certain adjustments to the device design were made in order to accommodate the testing platform at Fermilab.

Parallel I85

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Title: **Developing Biodegradable Acoustic Triboelectric Sensors (BATS)**

Abstract: The triboelectric effect occurs when two surfaces come into contact and generate a charge at their interface through rubbing or sliding, commonly known as static electricity. This natural phenomenon can be harnessed for applications, including wearable electronics, self-powered sensors, and energy generation using triboelectric nanogenerators (TENGs). TENGs leverage the combined effect of contact electrification and electrostatic induction to convert mechanical energy into electrical energy without the need for an external power source. However, fluorine-containing polymers, which do not readily break down in the environment, are the most popular choice for the dielectric layers in such devices. Hence, this project focuses on the development of biodegradable acoustic triboelectric sensors (BATS), which are thin film-based biodegradable triboelectric nanogenerators designed for harvesting acoustic energy. This research focuses on creating fully biobased TENGs using silk fibroin, PLLA, and paper to enable battery-free operation. Physical vapor deposition was used for the metallization of polymer films. The incorporation of a small amount of non-biodegradable polyvinylidene difluoride (PVDF) was explored to evaluate the effects of halogenated content over time, providing guidelines for the feasibility of replacing fluoropolymers with biodegradable polymers in TENGs, contributing to the advancement of eco-friendly energy harvesting devices. Device performance was assessed by measuring the voltage output using drop tests.

Parallel I86

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Title: **MMP-Responsive Biodegradable Hydrogel-Based Bioprinted Multilayer Liver Models with Enhanced Hepatic Metabolic Function**

Abstract: 3D bioprinting has emerged as an intriguing approach for producing complex in vitro models. The goal of this project is to continue refining the digital light processing (DLP) printing method and enable the development of a 3D biomimetic liver model that recapitulates the native liver architecture. Specifically, we aim to incorporate stiffness tuning, degradability, and multi-layer printing into our liver model. We will assess the effects of non-degradable and degradable peptides in our hydrogel to control its degradability, which is crucial as cell spreading relies on matrix degradation via hydrolysis or proteolysis through cell-secreted matrix metalloproteinases (MMPs). Additionally, the hydrogel stiffness, ranging from 3-7 KPa, can be achieved by varying UV light intensity and exposure time, ensuring that the compressive moduli of the hydrogel matrices mimic those of reported liver tissue. We will present a 3D hydrogel-based co-culture model that embeds hiPSC-derived hepatocytes (hiPSC-HPCs), a major liver cell type, with human umbilical vein endothelial cells (HUVECs) as supporting cells. The endothelial extracellular matrix assists hepatocyte maturation, improving hepatic metabolic functions. This bioprinted, biodegradable, multi-layer liver model holds promise as a tool for early personalized drug screening and liver pathophysiology studies in vitro.

Parallel I87

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Title: **Identifying Microparticle Clusters in High Resolution: Computer Vision Applied to Polymer Particles in Liquid Crystal (LC) to Enable On-the-Fly Characterization of Their Morphology and Size**

Abstract: In-situ monitoring of polymer particle formation by iCVD-in-LC is limited by relatively low-resolution (LR) capabilities compared to its ex-situ microscopy approaches. In this paper, we address this challenge by fine-tuning and developing an object-oriented super resolution model to improve the image resolution obtained from the in-situ monitoring and enable identification and characterization (e.g. size estimation) of individual polymer particles both singly dispersed and aggregated as clusters. This framework will transform low-resolution images into high-resolution object-level high-resolved (HR) images by learning from LR–HR image pairs obtained from samples observed both in the iCVD reactor (LR) and in the laboratory using a high-resolution microscope (HR). Current methods are constrained by the use of object detection, which is limited by the time needed to manually label the clusters during both train and test time for input into the super-resolution neural network. By contrast, our method uses classical computer vision techniques to isolate the slides where the particle clusters lie, keeping spatial awareness and allowing for scalability and little to no preprocessing for inputting LR images into the super resolution network. In this project, we used 5µm polystyrene particles dispersed in 5CB liquid crystal as a surrogate for polymerization via iCVD as samples for the LR and HR dataset. To align the image pairs to maximize the surface area of the slide and clusters shown, we converted images to grayscale, applied a Gaussian blur (σ = 20), identified and filtered the image contours with maximum area via the marching squares algorithm, and added a Hough Transform on the LR images to correct for any rotational vibrations added by the iCVD reactor during imaging. These slides were split into a 80/10/10 train/test/validation split and fine-tuned on the Real-ESRGAN super resolution model with pretrained weights. Resolution upgrade was quantified using the peak signal-to-noise ratio metric during validation and testing. In the end, we show that super resolution neural nets may present an alternative to predicting the characteristics of iCVD polymer formation compared to post ex-situ microscopy approaches with only use of the LR iCVD reactor image set.

Parallel I88

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Title: **Ferromagnetic Nanoparticles for Treatment of Traumatic Brain Injuries**

Abstract: Traumatic brain injuries (TBIs) are damages to the brain tissue that arise from external damage to the skull, and are a leading cause of death and disability in the United States. The severity of TBIs is largely correlated to incident injury severity, which results in localized damage that disrupts normal brain function. Primary injuries are observed in patients immediately after TBI incidence, and require immediate diagnosis and care. However, secondary injury can also arise weeks, months, or even years after, making TBI extremely dangerous. The urgent nature of this injury requires therapeutics that are fast-acting, localized, and have minimal side effects for best patient outcomes and prevention of future complications. This research carefully considers the cascading physiological effects of TBI to design a ferromagnetic nanoparticle for expedited treatment of TBIs. Targeted and localized delivery of nitric oxide is achieved with these ferromagnetic nanoparticles to restore blood flow to the injury site, which provides an innovative and non-invasive solution to treatment and reduction of TBI damage. This treatment was explored in rodents to carefully observe nanoparticle treatment efficacy, symptoms and side-effects after treatment, and performance in central nervous system function after administration post-TBI.

Parallel I89

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Title: **Optimizing Compact Density for Enhanced Electrochemical Stability in SPAN Cathodes of Li-S Batteries**

Abstract: The electrochemical stability of sulfurized polyacrylonitrile (SPAN) cathodes significantly influences the performance and longevity of lithium-sulfur (Li-S) batteries. This study investigates the impact of compacted density variations in SPAN cathodes on their electrochemical behavior and structural evolution during cycling. Using scanning electron microscopy (SEM) to analyze cathode morphology, we systematically vary cathode density and measure parameters including cell cycle life, capacity retention, resistance changes, and degradation indicators. Our findings aim to identify the optimal compact density that may enhance specific electrochemical properties and longevity of SPAN cathodes, thereby contributing valuable insights to the development of Li-S battery technology.

Parallel I90

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Title: **Fabrication of a Sensing Structure on the sAFAM Microrobot**

Abstract: One of the main challenges in microrobotics is control of the miniature robots at the microscale. For this reason, awareness of the robot’s behavior is critical. Robot’s are usually monitored and directed with the help of optical or electron microscopy systems. However this approach has disadvantages due to the extended response times and complexity of the custom control system. The solution is a sensor integrated with the body of the microrobot where nano-microscopic size of features requires application of the cleanroom techniques. In this paper we propose the fabrication method of the sensor structure for the microscale robot utilizing additive manufacturing method Aerosol Jet Printing (AJP). As a testing device we chose solid Articulated Four Axis Microrobot (sAFAM) designed for the nano/microscale manipulation. Sensor’s structure consists of the insulating (bottom) and piezoresistive sensing (top) layer. Insulating layer is fabricated in the cleanroom using Atomic Layer Deposition (ALD) and the piezoresistive part is printed using AJP and PEDOT:PSS ink. Since some of the microrobot’s components experience mechanical deformation during the operation, we can utilize the piezoresistivity effect to detect and assess motion of the robot’s part. Precise printing and inspection is conducted with the help of the Nexus system, a large robotic system integrating various additive manufacturing tools and enabling automated multiscale manufacturing of custom devices. Fabricated sensing structures were tested and evaluated. Proposed manufacturing method offers a simpler and low-cost solution compared to MEMS techniques. Collected experience and further development could lead to the establishing novel advanced manufacturing methods enabling integration of the multiscale devices.