2022 NNCI REU Convocation

National Nanotechnology Coordinated Infrastructure

NNCI is supported by 16 individual cooperative agreements from the NSF. Award # ECCS 2100059

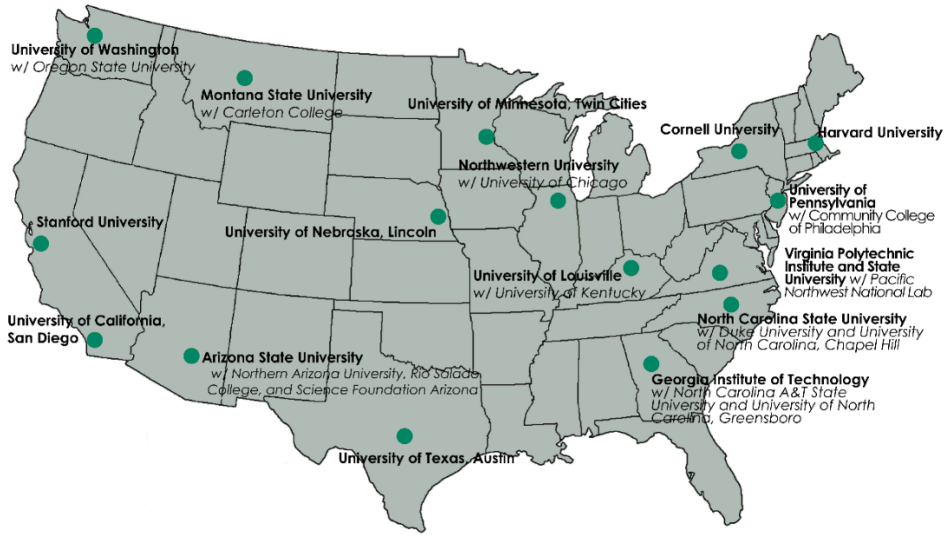
August 8-10, 2022
University of Louisville
Louisville, KY

Hosted by

KY MULTISCALE
The NSF NNCI Multi-Scale Manufacturing & Nano Integration Node

2022 NNCI REU Convocation Participating Sites

CNF	The Cornell NanoScale Science & Technology Facility	Cornell University
CNS	Center for Nanoscale Systems	Harvard University
MANTH	Mid-Atlantic Nanotechnology Hub	University of Pennsylvania & Community College of Philadelphia
KY Multiscale	Kentucky Multi-Scale Manufacturing and Nano Integration Node	University of Louisville & University of Kentucky
NCI-SW	Nanotechnology Collaborative Infrastructure Southwest	Arizona State University, Northern Arizona U., Rio Salado College, & Science Foundation Arizona
RTNN	Research Triangle Nanotechnology Network	North Carolina State University, Duke University, and University of North Carolina at Chapel Hill
SENIC	Southeastern Nanotechnology Infrastructure Corridor	Georgia Institute of Technology & Joint School of Nanoscience and Nanoengineering
NNF	Nebraska Nanoscale Facility	University of Nebraska - Lincoln
MONT	Montana Nanotechnology Facility	Montana State University & Carleton College
SDNI	San Diego Nanotechnology Infrastructure	University of California – San Diego
SHyNE	Soft and Hybrid Nanotechnology Experimental Resource	Northwestern University & University of Chicago



2022 NNCI REU Convocation with be jointly celebrated with the

www.nanoamsummit.com

Courtesy of

KY MULTISCALE

2022 NNCI REU Convocations Students will participate in the 2022 NNCI NANO + Additive Manufacturing Summit Networking and Research Poster Reception and attend keynote presentations by

Professor John A. Rogers
Northwestern University
Fellow - National Academies of Engineering, Science, & Medicine

Khershed P. Cooper, Ph.D.
National Science Foundation
Program Director - CMMI Advanced Manufacturing

Gilroy Vandentop, Ph.D.
Intel Labs
VP & Director of Corporate University Research

Kurt Petersen, Ph.D.
Silicon Valley Band of Angels
Top 10 Inventor & Fellow of National Academy of Engineering

Program Schedule
2022 NNCI REU Convocation
KY Multiscale – Louisville, KY

Monday, August 8, 2022

2:00-5:30 PM *Check-in to hotel (Hilton Garden Inn Airport Hotel)*

Hotel Address: 2735 Crittenden Dr., Louisville, KY 40209

Hotel Phone: (502) 637-2424

6:00 PM *Group 1* - Ride shuttle from hotel entrance to evening reception @ Churchill Downs, Kentucky Derby Museum*

Kentucky Derby Museum Address: 704 Central Ave, Louisville, KY 40208

6:15 PM *Group 2* - Ride shuttle from hotel entrance to evening reception @ Churchill Downs, Kentucky Derby Museum*

6:30 PM *Registration at Derby Museum*

6:30 PM *Group 1 depart on walking tour*

6:45 PM *Group 2 depart on walking tour*

7:00 PM *"Hatitute" Activity*

7:50 PM *Invitation to Great Hall*

8:00 PM *The Greatest Race film*

8:20 PM *Race Activity*

9:00 PM *Group 1 – Ride shuttle from museum entrance to hotel*

9:15 PM *Group 2 – Ride shuttle from museum entrance to hotel*

(*) Shuttles Group 1 & 2 will be arranged in the hotel lobby (< 40 participants per shuttle)

Tuesday, August 9, 2022

7:45AM	Hotel	*Group 1 - Ride shuttle from hotel entrance to event venue* *Venue Address: University of Louisville, Swain Student Activities Center - Herman and Heddy Kurz Pavilion, 2100 S. Floyd St. Conference rooms W215,116A & 118A, Louisville, KY 40208*
8:00AM	Hotel	*Group 2 - Ride shuttle from hotel entrance to event venue*
8:00AM	W215C&D	***Registration and Breakfast***
8:30AM	W215C&D	***Introduction & Kickoff*** *Remarks by Dr. Kevin Walsh - NNCI/KY Multiscale, Dr. Shamus McNamara – NNCI/KY Multiscale, Dr. Lynn Rathbun – NNCI/CNF, & Dr. Kevin Gardner – EVPRI UofL*
9:00AM	W215C&D	***Keynote Presentation*** *"Three Dimensional Mesostructures - from Neural Interfaces to Electronic Microfliers" by Prof. John Rogers, Northwestern U.*
10:00AM	116 & 118	***NNCI REU Convocation Parallel Presentations Sessions A and B***

Parallel Session A: Room 116 *Moderator: Leslie O'Neill, SENIC*	*Parallel Session B: Room 118* *Moderator: Melanie-Claire Mallison, CNF*
1. "Fabrication Of Bilayer Suspended Photonic Crystal (Phc)", **Rebekah Jin, CNS (Harvard)**	*2. "Development and Characterization of 3D-Printable Conductive Polymer Composites for Application in Tactile Sensors",* **Chelsea Latham, KY Multiscale (U. of Louisville)**
3. "Fabricating Porous, Ceramic Based Spacers for Thermionic Energy Applications", **Orevaoghene Omodior, MANTH (UPenn)**	*4. "Superfluorescence of Hybrid Halide Perovskites In Optical Cavity",* **Aaliyah Beckford, RTNN (NC State U.)**
5. "Characterizing the Conductivity and Gauge Factor of PEDOT:PSS", **Daniel Woodruff, KY Multiscale (U. of Louisville)**	*6. "Detection and Modeling of Water Contaminants Using Microcantileverbased Biosensing Platforms",* **Ryan Talusan, SHyNE (Northwestern U.)**
7. "Understanding the Origin of Absorption and Emission Spectra of Organic Materials", **Nicholas Edwards, RTNN (NC State U.)**	*8. "Structural and Band Level Alignment Investigation of Cspbbr3 / Graphene / Cspbi3 Heterostructures Via First Principles Calculations",* **Daniel Duke, RTNN (Duke University)**

9. "High Efficiency Flexible Perovskite Solar Modules", ***John Mark Page, RTNN (U. of NC – Chapel Hill)***

10. "An Investigation into Lead Absorption from Drinking Water by Tea", ***Stephanie Wang, SHyNE (Northwestern U.)***

11:00AM		*Break*
11:15AM	W215C&D	***Keynote Presentation*** *"Semiconductor Research @ Intel Labs" by Dr. Vandentop, Intel Labs*
12:10PM	W215C&D	***Lunch***
1:10PM	CARDINAL LOUNGE	***Set Up Posters on Poster Boards***
1:20PM	W215C&D	***Keynote Presentation*** *"Micro/Nano/MEMS Entrepreneurship" by Dr. Kurt Petersen, Silicon Valley Band of Angels*
2:20PM		*Break*
2:30PM	W215C&D	***Keynote Presentation*** *"NSF Fellowship & Introduction to Program in Japan" by Dr. Lynn Rathbun, NNCI-CNF Cornell U.*
3:30PM		*Break*
3:40PM	116A &118A	***NNCI REU Convocation Parallel Presentations Sessions C and D***

Parallel Session C: Room 116	*Parallel Session D: Room 118*
Moderator: Tirzah Abbott, SHyNE	*Moderator: Kathryn Hollar, CNS*
11. "Pyrolysis of Two-Photon Polymerized Foam Structures", ***Hibiki Mitsuboshi, NNF (Nebraska)***	*12. "Crystallinity and Morphological Changes in Layered Hybrid Perovskites Post Amino-Efflorescence",* ***Katherine (Katie) G. Broun, RTNN (U. of NC –Chapel Hill)***
13. "High Throughput Production of Nature-Derived Biodegradable Polymer Micron/Nanofibers", ***Catherine Pfaltzgraff, CNS (Harvard)***	*14. "Coplanar Microwave Waveguide Resonators",* ***Sean Anderson, CNF (Cornell)***
15. "Effect of Sliding Speed on the Formation of Zro2 Antiwear Tribofilms In Boundary Conditions", ***Julia Griffin, MANTH (UPenn)***	*16. "A Python-Based Jupyter Notebook Guide for X-ray Diffraction Techniques",* ***Hasan Al Saeedi, SHyNE (Northwestern U.)***

17. "Optimizing Nanomagnetic Force Modulation Through Geometric Shaping", ***Hannah Kempfert, MONT (Montana State U.)***

18. "Soft Nanomaterial Carriers: Eliminating Burst Release of their Cargo", ***Ashley M. Martinez, NCI-SW (Arizona)***

19. "New Findings in the Fabrication of Silicon Micropillar Arrays Using the Bosch Process", ***David Li, CNS (Harvard)***

20. "Characterization of a Silica-Packed Microreactor over Flowrate and Temperature", ***Ryan C. Chow, KY Multiscale (U. of Louisville)***

4:40PM	STAIRS CARDINAL LOUNGE	***Gather for Group Photo***
4:40PM	CARDINAL LOUNGE	***Networking and Poster Reception***
5:45PM	CARDINAL LOUNGE	***Gather in Groups for Tours to Manufacturing Core Facilities*** *-Check with registration table for details*
6:45PM	CAMPUS	*Group 1 - Ride shuttle from event venue to hotel*
7:00PM	CAMPUS	*Group 2 - Ride shuttle from event venue to hotel*

Wednesday, August 10, 2022

7:45AM	Hotel	*Group 1 - Ride shuttle from hotel entrance to event venue* *Venue Address: University of Louisville, Swain Student Activities Center - Herman and Heddy Kurz Pavilion, 2100 S. Floyd St. Conference rooms W215,116A & 118A, Louisville, KY 40208*
8:00AM	Hotel	*Group 2 - Ride shuttle from hotel entrance to event venue*
8:00AM	W215C&D	***Registration and Breakfast***
8:30AM	W215C&D	***Introductions*** *Remarks by Dr. Kevin Walsh - NNCI/KY Multiscale, Dr. Shamus McNamara – NNCI/KY Multiscale , Dr. Lisa Cassis – U. of Kentucky EVPRI, & Dr. Oliver Brand – NNCI Director*
9:00AM	116A &118A	***NNCI REU Convocation Parallel Presentations Sessions E and F***

Parallel Session E: Room 116 *Moderator: Jessica Hauer, ASU*	*Parallel Session F: Room 118* *Moderator: Heather Rauser, MONT*
21*. "Printing Functional Gas Diffusion Layers via 3D printers for Carbon Dioxide Reduction Reactors",* **Zeinab Ismail, CNF (Cornell)**	***22****. "Electrical Characterization of MEMs Microgrippers in Circuits",* **Nathan Song, KY Multiscale (U. of Louisville)**
23*. "Computer Vision Aided Automatic Waveguide Alignment and Optimization System",* **Schuyler Diaz, SDNI (U. of California at San Diego**	***24****. "Biodegradable Phosphate Sensor for Agricultural Use",* **Ariel Struzyk, MANTH (UPenn)**
25*. "Assessing the Chondrogenic Influence of Nanofabricated 3D Scaffolds on Human Mesenchymal Stem",* **Haley Thompson, MANTH (UPenn)**	***26****. "Microvalve Array for a Reconfigurable Tactile Tablet for Vision Impaired Individuals",* **Parisa Zalmai, KY Multiscale (U. of Louisville)**
27*. "Development of Sputtered Aluminum Nitride Thin Films on Silicon",* **Jada Bonds, CNS (Harvard)**	***28****. "Microfluidic Handling of DNA for Efficient Spatial Genomics Research",* **Eryka Kairo, CNF (Cornell)**

9:45AM		*Break*
10:00AM	116A &118A	***NNCI REU Convocation Parallel Presentations Sessions G and H***

Parallel Session G: Room 116	*Parallel Session H: Room 118*
Moderator: Kathryn Hollar, CNS	*Moderator: Jessica Hauer, ASU*
29. "Imaging of Hyperbolic Plasmon-Phonon Polaritons in Twisted Double Bilayer Graphene", **Anna Li, CNS (Harvard)**	*30. "Development and Characterization of Fusogenic Porous Silicon Nanoparticles for siRNA Delivery for the Treatment of Retinal Neovascularization",* **James Gow, SDNI (U. of California at San Diego ")**
31. "Formulating Lipid Nanoparticles with Targeting Peptides", **Errysteinn Frondarina, SDNI (U. of California at San Diego)**	*32. "SARS-CoV-2 Enzyme (Mpro) Detection with a Matrix-Insensitive Nanoplasmonic Platform",* **Christina Vialva, SDNI (U. of California at San Diego)**
33. "Simulation of Glancing Angle Deposition", **Ojas Kulkarni, KY Multiscale (U. of Louisville)**	*34. "Development and Fabrication of Silicon Nanostructures for Mechano-Bactericidal Studies",* **Wesley Chiu, SHyNE (Northwestern U.)**
35. "Hybrid Porous Silicon Nanoparticle and Polycaprolactone Drug Delivery System for Revascularization of the Anterior Cruciate Ligament Post Surgically", **Laura Charria, SDNI (U. of California at San Diego)**	*36. "Alternative Development Methods for NR9-1500PY Photoresist",* **Giancarlos Solano, MONT (Montana State U.)**
37. "Film Synthesis and Crystal Growth of Perovskites by Melt Processing", **Bethany Claes, RTNN (Duke U.)**	*38. "Characterization of Hybrid Organic-Inorganic Halide Perovskites and 2D/3D Perovskite Heterostructures Deposited by Resonant Infrared Matrix Assisted Pulsed Laser Evaporation (RIR MAPLE)",* **Massyl Mallem, RTNN (Duke U.)**

10:55AM *Break*

11:10AM 116A &118A ***NNCI REU Convocation Parallel Presentations Sessions I and J***

Parallel Session I: Room 116	*Parallel Session J: Room 118*
Moderator: Tirzah Abbott, SHyNE	*Moderator: Heather Rauser, MONT*
39."Characterization of Pleurobema Rubrum Shells", **Angela Wang, KY Multiscale (U. of Kentucky)**	*40. "Cathode Nanofabrication for Increased Power and Extended Drone Flight",* **Jackson Vyletel, MANTH (U. of Pennsylvania)**
41."Solid-State Synthesis of Iron Fluoride Nanocomposites as Cathode Materials for Lithium-Ion Batteries", **Steven Meikle, SDNI (U. of California at San Diego)**	*42. "Charge transfer doping of MAPb0.5Sn0.5I3 Perovskite Films",* **Maria Bambrick-Santoyo, RTNN (Duke U.)**

43. "Using Surface-Enhanced Raman Spectroscopy (SERS) to Detect Breast Cancer", **Marian Yadira Jimenez Quijada, NCI_SW (U. of Arizona, Pima Community College)**

44. "Investigating the Electrokinetic Behavior of Cement-Based and Alternative Cementitious Materials", **Rachel Qian, CNF (Cornell)**

45. "You Will Ru(e) the Day: Developing Area-Selective Processes to Enable Ru-Based Interconnect at the 2 nm Node and Beyond", **Elisa Simoni, CNF (Cornell)**

46. "Compositional Analysis of Historic & Pre-Historic Pigments", **Benjamin Sampson, KY Multiscale (U. of Kentucky)**

47. "Design of a New Broadband Output Coupler for Optimal THz Laser Performance", **Michael Bregar, CNS (Harvard)**

48. "Bio-trapping Bacteria and Impact on Bio-corrosion of Carbon Steel", **Dane Mansfield, MONT (Montana State U.)**

12:10PM	W215C&D	***Lunch***
1:20PM	W215C&D	***Keynote Presentation*** *"Nanomanufacturing Research and Advanced Manufacturing at NSF" by Dr. Khershed P. Cooper*
2:30PM	116A &118A	***NNCI REU Convocation Parallel Presentations Sessions K and L***

Parallel Session K: Room 116	*Parallel Session L: Room 118*
Moderator: Leslie O'Neill, SENIC	*Moderator: Melanie-Claire Mallison, CNF*
***49.** "Characterization and Optimization of Inkjet Printing Process of the Conducting Silver Structures",* **Natalie Ogden, KY Multiscale (U. of Louisville)**	***50.** "Study of Surface Functionalization for Direct Printing of Perovskite Single Crystals on Chips",* **Jordana Mazer, RTNN (North Carolina State U.)**
***51.** "Study of Monolayer Collapse of Droplets in Virtual Wells and on Microfabricated Pedestals",* **Kristopher Luck, KY Multiscale (U. of Louisville)**	***52.** "Fabrication of Flexible Braille Display with Integrated Magnetic Controls",* **Rodolfo Cantu, CNF (Cornell)**
***53.** "Stability of Titanium Oxide Hydrates in Cellulose-Based Films for Green Photonics",* **Yusaku Abe, SENIC (GATech)**	***54.** "Exciton Energy Transfer in Photosynthetic Systems",* **Alexander Hardin, NCI-SW (Northern Arizona University)**
***55.** "Exploring the Centrifugal Force as a Control Mechanism for Metal-Assisted Chemical Etching",* **Frank Lynch, MANTH (U. of Pennsylvania)**	***56.** "Simulating Open Quantum Dynamics Through Quantum Algorithms",* **Isaiah Raspet, NCI-SW (Northern Arizona University)**

57. "Optimization of Ultrasound Fields in Acoustofluidic Channels for Microbubble-enhanced Molecular Delivery to Cells", ***Gavin Fowler, KY Multiscale (U. of Louisville)***

58. "Optimization of Wire-Grid Polarizer Characterization", ***Ganesh Petterson, MONT (Montana State University)***

59. "Manipulating Breast Cancer Cell Alignment by Micro-contact Printing Fibronectin Protein Patterns ", ***Robert Lamarche, CNS (Harvard) – Pre-recorded talk.***

3:40PM	W215C&D	*Break*
4:00PM	W215C&D	***Career Panel*** *"Nanotechnology and Additive Manufacturing Opportunities in Industry (Dr. Gil Vandentop -INTEL), Entrepreneurship (Dr. Kurt Petersen - Band of Angels), Academia (Dr. Oliver Brand- GA Institute of Technology), and National Labs (Dr. Steven Randolph, ORNL). Moderators: NNCI KY Multiscale Director and Co-Director – Drs. Kevin Walsh & Todd Hastings.*
5:00 PM		***NNCI REU Convocation Adjourns***
5:15PM	CAMPUS	*Group 1 - Ride shuttle from event venue to hotel, then airport*
5:30PM	CAMPUS	*Group 2 - Ride shuttle from event venue to hotel, then airport*

For Online Access to 2022 NNCI REU Convocation Proceedings Scan Below

For Online Agenda and Proceedings of the 2022 NNCI NANO + Additive Manufacturing Summit

Presentations Live Feed Links:

https://youtu.be/BrX2651YKWs Room 116 – August 9 Sessions

https://youtu.be/Ah38i5LcOlU Room 118 – August 9 Sessions

https://youtu.be/-4XvL7-OKqQ Room 116 – August 10 Sessions

https://youtu.be/87c2BWTXnaE Room 118 - August 10 Sessions

PRESENTERS

Dr. Oliver Brand *received his diploma degree in Physics from Technical University Karlsruhe, Germany in 1990, and his Ph.D. degree (Doctor of Natural Sciences) from ETH Zurich, Switzerland in 1994. From 1995 to 1997, he worked as a postdoctoral fellow at Georgia Tech. From 1997 to 2002, he was a lecturer at ETH Zurich in Zurich, Switzerland and deputy director of the Physical Electronics Laboratory (PEL). In January 2003, Dr. Brand joined the Electrical & Computer Engineering faculty at Georgia Institute of Technology. Dr. Brand has co-authored more than 120 publications in scientific journals and conference proceedings. His research interests are in the areas of CMOS-based microsystems, microsensors, MEMS fabrication technologies, and microsystem packaging. Research interests: MEMS/NEMS Microsensors for Physical, Chemical and Biological Applications Microsensor Fabrication based on IC Technologies Microsystem Packaging Dr. Lynn Rathbun received his B.S. in Physics from The Ohio State University in 1971. He attended graduate school at the University of Illinois where he obtained his M.S. (1973) and Ph.D. (1979) degrees in Physics, working with Prof. Gert Ehrlich on surface chemistry. He joined the "submicron facility" at Cornell University in 1979 (yes, 40 years ago !) where he has been ever since. From 2004-2015 as Program Manager/Assistant Director of the National Nanotechnology Infrastructure Network (NNIN). He is currently the Laboratory Manager for the Cornell Nanoscale Facility (since 1994) and Associate Director for the User Facility of PARADIM, a materials by design center, since 2016. He has been active in developing a variety of education and outreach programs for CNF, NNIN, and NNCI for more than 30 years. The "radical" idea of a network REU convocation where we fly students around the country 9 to conference of their peers was in fact his, about 25 years ago!! Likewise, the idea of an international REU program for NNIN was a joint effort by him and Dr. Nancy Healy. He is proud to have shepherded these ideas into successful programs.*

Dr. Lynn Rathbun *received his B.S. in Physics from The Ohio State University in 1971. He attended graduate school at the University of Illinois where he obtained his M.S. (1973) and Ph.D. (1979) degrees in Physics, working with Prof. Gert Ehrlich on surface chemistry. He joined the "submicron facility" at Cornell University in 1979 (yes, 40 years ago!) where he has been ever since. From 2004-2015 as Program Manager/Assistant Director of the National Nanotechnology Infrastructure Network (NNIN). He is currently the Laboratory Manager for the Cornell Nanoscale Facility (since 1994) and Associate Director for the User Facility of PARADIM, a materials by design center, since 2016. He has been active in developing a variety of education and outreach programs for CNF, NNIN, and NNCI for more than 30 years. The "radical" idea of a network REU convocation where we fly students around the country 9 to conference of their peers was in fact his, about 25 years ago!! Likewise, the idea of an international REU program for NNIN was a joint effort by him and Dr. Nancy Healy. He is proud to have shepherded these ideas into successful programs.*

Dr. John A. Rogers *obtained BA and BS degrees in chemistry and in physics from the University of Texas, Austin, in 1989. From MIT, he received SM degrees in physics and in chemistry in 1992 and the PhD degree in physical chemistry in 1995. From 1995 to 1997, Rogers was a Junior Fellow in the Harvard University Society of Fellows. He joined Bell Laboratories as a Member of Technical Staff in the Condensed Matter Physics Research Department in 1997, and served as Director of this department from the end of 2000 to 2002. He then spent thirteen years on the faculty at University of Illinois, most recently as the Swanlund Chair Professor and Director of the Seitz Materials Research Laboratory. In the Fall of 2016, he joined Northwestern University as the Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering and Medicine, with affiliate appointments in Mechanical Engineering, Electrical and Computer Engineering and Chemistry, where he is also Director of the recently endowed Querrey-Simpson Institute for Bioelectronics. His research has been recognized by many awards, including a MacArthur Fellowship (2009), the Lemelson-MIT Prize (2011), the Smithsonian Award for American Ingenuity in the Physical Sciences (2013), the Benjamin Franklin Medal from the Franklin Institute (2019) and a Guggenheim Fellowship (2021). He is a member of the National Academy of Engineering, the National Academy of Sciences, the National Academy of Medicine, the National Academy of Inventors and the American Academy of Arts and Sciences.*

Dr. Khershed P. Cooper *is a Program Director for Advanced Manufacturing in the CMMI Division of the Engineering Directorate at NSF. He directs basic research activities in advanced manufacturing, specifically, nanomanufacturing-related projects. He is a disciplinary program officer for the ERC program, where he directs research in systems-based nanomanufacturing. He is a NSF representative for NSTC's Nano Science Engineering & Technology (NSET) Sub-committee. He contributes to the development of the Manufacturing USA Institutes. Prior to joining NSF, he was a Program Officer for the Manufacturing Science program at ONR. Concurrently, he was a Senior Research Metallurgist at NRL.*

Dr. Gilroy Vandentop *is a VP of Intel Labs and the Director of Corporate University Research. His team manages Intel's university research investments for key internal technology and business customers. Dr. Vandentop is also on the board of the Semiconductor Research Corporation (SRC), an industry-wide technology consortium that operates multiple research programs in the US as well as globally to provide competitive advantage to its members as the world's premier university research management consortium. Dr. Vandentop managed the SRC STARnet program and is currently chair for the Governing Council of the JUMP/nCORE program. Dr. Vandentop moved to Intel Labs from TMG's Components Research group in 2015. While in Components Research, he formed the Novel Materials group and managed Intel's EUV program through transfer into*

technology development. From 2000 to 2006, he was responsible for the Packaging Research group in Chandler, AZ. During his first 10 years at Intel, Dr. Vandentop worked in Logic Technology Development on silicon process development in the etch and photolithography areas. Dr. Vandentop completed his Ph.D. in physical chemistry at U.C. Berkeley and his B.Sc. in honors chemistry at the University of Alberta.

Dr. Kurt Petersen *is an American inventor and entrepreneur, known primarily for his revolutionary work on microelectromechanical systems (MEMS). Dr. Petersen received his BS degree cum laude in Electrical Engineering from the University of California at Berkeley in 1970. In 1975, he received the PhD degree in EE from the Massachusetts Institute of Technology. He established a micromachining research group at IBM from 1975 to 1982, during which he wrote the review paper "Silicon as a Mechanical Material," published in 1982 in the IEEE Proceedings. This paper is a highly referenced work in the field of micromachining and MEMS), and it is widely considered to have helped establish MEMS as its own branch of technology. As of 2022, Google Scholar reported an amazing 4,669 citations. Since 1982, Dr. Petersen has co-founded six successful companies in MEMS technology, including Transensory Devices in 1982 and NovaSensor, a company which develops low-cost micromachined blood pressure sensors using bulk silicon micromachining technology, in 1985. In 1996, he co-founded Cepheid, a company which uses microfluidic technology for rapid PCR detection. Dr. Petersen also co-founded SiTime in 2004 and Profusa in 2008. In 2009, he co-founded Verreon and joined as Chief Technology Officer, helping to coordinate the company's sale to Qualcomm in 2010. In 2011, Dr. Petersen joined the Band of Angels in Silicon Valley, an angel investment group which mentors and invests in early stage, high-tech, start-up companies. He joined the Board of Directors for Innovative Micro Technology (IMT) in 2013. Dr. Petersen has published over 100 papers and has been granted over 35 patents over the course of his career. He is a member of the prestigious National Academy of Engineering and is a Fellow of the IEEE. In 2002, Red Herring ranked him as a Top Ten Innovator. In 2019, Dr. Petersen received the IEEE Medal of Honor*

NNCI REU ABSTRACTS BY PRESENTATION NUMBER

1 (Session A)

Student's name: Rebekah Jin
Name of home institution: University of California, Los Angeles
NNCI Site: CNS (Harvard)
REU Principal Investigator: Eric Mazur, Engineering and Applied Science, Physics, Harvard University
REU Mentor: Haoning Tang, Engineering and Applied Science, Harvard University
Contact: rebjinm@g.ucla.edu, mazur@seas.harvard.edu, hat431@harvard.edu
Title: ***Fabrication of Bilayer Suspended Photonic Crystals (PhC)***
Abstract:
Two-dimensional materials in custom-designed stacks have been shown to possess unique and unexpected electronic properties, stimulating recent research into analogous light behaviors within corresponding nanoscale photonic structures. While theoretical investigations into moiré-patterned, suspended two-layer photonic crystals (PhC) such as twisted bilayer PhC, the photonic counterpart to twisted bilayer graphene, have revealed extreme optical properties such as ultra-flat bands, zero group velocity, and ultra-low loss, no such bilayer sample has yet been experimentally fabricated or characterized. Here, we outline the first-ever method of suspended bilayer PhC nanofabrication, primarily involving photolithography, electron beam lithography, and reactive ion etching. This process is practical and generalizable to a wide range of bilayer photonic structures with differing lattice geometries, interlayer distances, and relative twist angles, offering critical degrees of freedom when designing bilayer optical devices. Via a 4f measurement system, we also demonstrate photonic band structure measurements on fabricated twisted bilayer and AA bilayer PhC. While our work is ongoing, we plan to continue collecting band structures of fabricated samples, and aim to analytically identify high quality factor modes foundational to designing low-loss optical devices for use in nonlinear optics and quantum electrodynamics studies.

2 (Session B)

Student's name: Chelsea Latham
Name of home institution: Florida A&M University
NNCI Site: KY Multiscale
REU Principal Investigator: Dr. Kevin Walsh, Associate Dean of Research, University of Louisville
REU Mentor: Dr. Kunal Kate, Mechanical Engineering, University of Louisville. Kavish Sudan, Mechanical Engineering, University of Louisville
Contact: chelsea1.latham@famu.edu , kunal.kate@louisville.edu , kavish.sudan@louisville.edu
Title: ***Development and Characterization of 3D-printable Conductive Polymer Composites for Application in Tactile Sensors***

Abstract:
Tactile sensors have gained much attention in recent years due to their extensive applications, ranging from health monitoring sensors to robotics. These sensors offer strength and flexibility, along with the ability to undergo high strain with little to no deformation. Unfortunately, these sensors come with challenges; utilizing expensive fabrication technologies, lengthy production times, and complexity. An alternative is 3D-printed tactile sensors using conductive Polymer composites that can be printed in any desired pattern, use fewer processing steps, and are fairly inexpensive to fabricate. For this study, graphene, a material with many promising properties, such as high strength, conductivity, and functional stability was added in varying concentrations to a flexible polymer matrix. In weight percent, these concentrations correspond to 2, 4, and 6 wt.%. We studied the effect of graphene loading on the physical, thermal and electrical properties of polymer composites. These filaments were then utilized for 3D printing strain gauge patterns on Kapton substrate, and the effect of process parameters on the printability was also studied. The data collected supports a significant change in properties as Graphene concentration is increased within a polymer composite. Our findings indicate changes in its characteristics, specifically physical and electrical properties. This will allow us a better understanding of which concentration is ideal for tactile sensor application, as well as a process map to develop and demonstrate a fully 3D-printed sensor.

3 (Session A)

Student's name: Orevaoghene Omodior
Name of home institution: Indiana University
NNCI Site: University of Pennsylvania
REU Principal Investigator: Dr. Igor Bargatin, Mechanical Engineering and Applied Mechanics, University of Pennsylvania
REU Mentor: Dr. Matthew Campbell, Mechanical Engineering and Applied Mechanics, University of Pennsylvania
Contact: orevaomodior@gmail.com, bargatin@gmail.com, cammat@seas.upenn.edu
Title: ***Fabricating Porous, Ceramic Based Spacers for Thermionic Energy Applications***
Abstract:
Thermionic energy converters (TEC) are a form of solid-state energy conversion that allow heat to be converted directly into useful energy such as electricity. While there are several devices that possess the ability to convert heat into energy, TECs are the most sought after of the bunch as they boast high levels of energy density. This discrepancy in efficiency is largely due to the structure of thermionic energy converters which consists of two electrodes, a cathode emitter and an anode collector, and a micron sized vacuum gap. The method by which this spacing in the vacuum gap is maintained becomes very important as it determines how much useful energy is efficiently generated. Here we utilize a novel process composed of cleanroom microfabrication techniques to produce a porous, ceramic-based spacer device. Various structural measurements

are collected in order to document the effects of different fabrication process parameters. SEM characterization is also performed to ensure the spacer is produced properly and as intended.

4 (Session B)

Student's name: Aaliyah Beckford
Name of home institution: NC State University
NNCI Site: Research Triangle Nanotechnology Network (RTNN)
REU Principal Investigator: Dr. Franky So, Materials Science and Engineering, NC State University
REU Mentor: Yash Mehta, Materials Science and Engineering, NC State University
Contact: ab11@wellesley.edu , ymehta@ncsu.edu , fso@ncsu.edu
Title: ***Superfluorescence of Hybrid Halide Perovskites in Optical Cavity***
Abstract:
Hybrid halide perovskites are a class of semiconductors known for their application in optoelectronic devices: photovoltaics, light emitting diodes (LEDs), and lasers. This research project is centered around the study of quasi-2D perovskites to understand their structural properties and how they can be applied in lasing operations. Certain perovskites (eg. Cesium Lead Bromide) have been proven to exhibit this phenomenon called superfluorescence. Superfluorescence happens when all of the dipoles in the system spontaneously synchronize (become polarized), and emit a high-intensity burst of light. The objective of this project is to optimize the lasing optical cavity to observe superfluorescence in perovskite Cesium Lead Bromide, its ability to generate coherent lasing emissions, and compare the threshold power required to achieve polarization in superfluorescent and non-superfluorescent light emitting materials. By understanding superfluorescence, this opens up opportunities to produce high-intensity coherent light emissions for lasers.

5 (Session A)

Student's name: Daniel Woodruff
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Title: ***Characterizing the Conductivity and Gauge Factor of PEDOT:PSS***
Abstract:
Aerosol Jet Printing is an emerging technology that shows tremendous promise for the future of printable electronics, flexible devices, and smart additive manufactured structures. Aerosol Jet Printers are capable of printing conformally on nearly any type of substrate due to its 3-5 mm standoff distance from the substrate and its compatibility with a wide range of materials. These qualities allow the technology to be extremely versatile and capable of directly printing complex

elements such as antennas and sensors on a wide variety of substrates, including flex circuits. One material of particular interest for aerosol jet printing is PEDOT:PSS, a flexible and relatively-inexpensive conductive polymer with the potential to replace ITO in applications such as solar cells and compliant sensors. In this study, we develop a process recipe for the Aerosol Jet printing of PEDOT:PSS and characterize its electrical conductivity and gauge factor. Sheath and atomizer flow rates are optimized to print 100 µm wide uniform lines on glass and Kapton substrates. Ethylene glycol is added at a 10:1 ratio (PEDOT to ethylene glycol) to improve its electrical conductivity. After pretreatment of ethylene glycol, conductivity of the printed lines is characterized for curing temperatures varying from 80℃ to 150℃ using an oven. These results show that thermal curing is an effective strategy for maximizing conductivity. The results also show that overcuring can result in a gradual degradation of conductivity and cooling after curing increases conductivity, presumably due to an increase in carrier mobility due to a reduction in thermally-related lattice vibrations. Our experimental conductivity is found to be high as 500 $\Omega^{-1}cm^{-1}$*, while maintaining a gauge factor of 0.2. These values show that with proper thermal curing, PEDOT can be made conductive while still maintaining its flexibility and transparency, allowing it to be used in applications as both a conductor and strain sensor.*

6 (Session B)

Student's name: Ryan Talusan
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REU Mentor: Dr. Dilip Agarwal, Biotechnology, Northwestern University
Contact: rtalus2@illinois.edu, dilip.agarwal@northwestern.edu, v-dravid@northwestern.edu
Title: ***Detection and Modeling of Water Contaminants Using Microcantilever-Based Biosensing Platforms***
Abstract:
The pervasive nature of water contamination must be properly addressed for the benefit of public health. Despite improvements in overall water quality occurring within recent decades, deterioration of outdated plumbing pipes, manufacturing waste contamination, improper use of pharmaceuticals, and many other industrial related pollutants has led to dangerous amounts of chemical exposure from drinking water systems that may cause a large range of chronic diseases. In order to increase public awareness and oppose the lack of government involvement on bettering our water systems, there is an urgent need for an accurate, scalable, cost-effective, and scalable at-home test dedicated to water contamination to be developed. This study explores the use of MOSFET-embedded microcantilevers biofunctionalized with small DNA oligomeric sequences as a platform for contaminant detection. By taking advantage of nanomechanical phenomena that generates deflection of the microcantilever, impurity levels were determined using both optical and electrical techniques. Through our experiments, the presence of pollutants was detected at concentrations from 0.001 µM and greater after the reaction has reached

saturation. To aid in future commercialization attempts, a prediction model has been developed to ensure user-friendliness by providing a simple binary of whether the target analyte is present and by giving a range of concentrations for the tested solution.

7 (Session A)

Student's name: Nicholas Edwards
Name of home institution: NC State University
NNCI Site: Research Triangle Nanotechnology Network
REU Principal Investigator: Dr. Harald Ade, Materials Science and Engineering, NC State University
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Title: ***Understanding the Origin of Absorption and Emission Spectra of Organic Materials***
Abstract:
UV-Vis absorption and emission spectroscopy of organic semiconductors grant us an in-depth picture about their optoelectronic properties (OEPs). The optoelectronic properties including absorption and emission intensity, absorption range and Stokes shift can be of great importance to improve Organic Solar Cells (OSCs) a photovoltaic device with a bulk heterojunction (BHJ) of an organic donor polymer and electron acceptor layer responsible for light absorption. It is known that these properties can be tuned through molecular designing, however, the relationship between the AES and the molecular structure is not given much attention; so, discovering the correlation between them will allow us to provide insight to new chemical engineering guidelines to produce OSCs with more desirable OEPs. With the Franck-Condon Model, we can accurately describe the absorption and emission spectra for a single organic molecule. Therefore, we ventured to understanding the origin of AES of Lumogen Red and Orange, two commonly used organic molecules, and find the relationship between the molecular structure and AES. In the experiment, we found that the simple Franck-Condon Model excellently fit the Lumogen Orange spectra and concluded that a multiparameter Franck-Condon Model would be necessary for the Lumogen Red spectra. Future research will focus on implementing multi-parameter Franck-Condon Models to analyze Lumogen Red and related the observed difference to their molecular structure.

8 (Session B)

Student's name: Daniel Duke
Name of home institution: University of Alabama - Huntsville
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Title: ***Structural and Band Level Alignment Investigation of $CsPbBr_3$ / Graphene / $CsPbI_3$ Heterostructures Via First Principles Calculations***
Abstract:
Heterostructures involving lead halide perovskites have shown impressive potential in recent years for many applications, primarily for high efficiency photovoltaics. However, different types of perovskites in contact tend to interdiffuse, which alters the band gaps of the two materials and reduces the overall efficiency. This arises the need for a separation layer with charge transport properties that prevents diffusion. This work considers graphene for such a role, particularly with $CsPbI_3$ and $CsPbBr_3$ as the two perovskites. First principles calculations (DFT) are used to model the electronic structure and band level alignment of a $CsPbI_3$ / graphene / $CsPbBr_3$ heterostructure. Since this analysis involves the creation of large supercells containing all three materials, the effect of the structural mismatch and induced strain during supercell construction is examined. Additionally, different perovskite crystal planes of interface are modeled, revealing that both perovskites interact stronger with the graphene in the PbX_2 (X=Br, I) plane. The band level alignment of two $CsPbI_3$ / graphene supercells demonstrates that the Dirac point of the graphene lies between the perovskite VBM and CBM, validating its use as an intermediate state for charge transportation. The lattice and electronic structure calculations of the $CsPbI_3$ / graphene / $CsPbBr_3$ heterostructures are ongoing, with the ultimate goal of evaluating their charge transportation properties based on their electronic structures. This work serves as a case study of using 2D structures as a buffer layer to prevent ion interdiffusion without interfering with the charge transfer properties as in applications, such as photovoltaics, LEDs, etc.

9 (Session A)

Student's name: John Mark Page
Name of home institution: Georgia Institute of Technology
NNCI Site: RTNN
REU Principal Investigator: Dr. Jinsong Huang, Applied Physical Sciences; Chemistry, University of North Carolina-Chapel Hill
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Title: ***High Efficiency Flexible Perovskite Solar Modules***
Abstract:
According to the Solar Energy Industries Association (SEIA), solar power's contribution to the total U.S. electrical generation in 2021 was around 4%, compared to 0.1% in 2010. The SEIA has also noted that in 2021 solar power accounted for 46% of all new electric capacity added to the grid. Through the growing national incorporation of solar power, it is apparent that it has come to be considered by many as a reputable clean energy power source. However, creating a 100% clean energy system in the U.S. would require a much higher contribution of solar power to the total U.S. electrical generation. Therefore, solar power production must drastically increase in the

coming years in order to reach this clean energy production goal. These conditions encourage creative solutions to solar power production, including solar (PV) glass and flexible solar modules, but also innovation concerning the materials of the solar cells. Materials that have greater power conversion efficiencies (PCE's), create more efficient and power dense solar cells. One such emerging photovoltaic material is the perovskite solar cell, which has produced a promising PCE of up to 25.7%, according to the National Renewable Energy Laboratory (NREL). Nonetheless in most solar modules, with perovskite solar modules being no exception, there is a power loss that can be attributed to PV coating uniformity/quality, as well as the resistive losses that occur within the module (NREL champion perovskite module is 17.9%). This project aims to record the various resistive losses in flexible perovskite solar modules to predict the optimal sub cell width, to maximize power conversion efficiency (PCE).

10 (Session B)

Student's name: Stephanie Wang
Name of home Institution: Case Western Reserve University
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REU Principal Investigator: Dr. Vinayak Dravid, Materials Science and Engineering, Northwestern University
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Title: ***An Investigation into Lead Adsorption from Drinking Water by Tea***
Abstract:
Heavy metal contamination in drinking water presents a serious problem throughout the world today. Lead poisoning is a major risk factor for intellectual disabilities, heart disease, and stroke, amounting to roughly 1% of the total global health burden. Tea's worldwide popularity as the most consumed beverage makes it an interesting candidate for adsorption applications. We examined remediation of lead by testing multiple tea varieties and tea bag materials. Measurements at thermodynamic equilibrium were coupled with kinetics experiments to determine how varying tea preparation methods at different timescales affected remediation of heavy metals. Inductively-coupled plasma mass spectroscopy (ICP-MS) and optical emission spectroscopy (ICP-OES) quantified the magnitude of tea's purification effect on drinking water. In many cases, highly contaminated levels of heavy metals were reduced below the detection level of the instruments. We hope that these results will improve our understanding of tea's benefits on public health and inspire further research into other economical ways of remediating lead from our environment.

11 (Session C)

Student's name: Hibiki Mitsuboshi

Name of home Institution: Graduate School of Engineering, Toyota Technological Institute, Nagoya, Aichi, Japan
NNCI Site: NNF (University of Nebraska)
Principal Investigator: Dr. Christian Binek
Mentors: Dr. Aofei Mao, & Dr. Yongfeng Lu
Title: ***Pyrolysis of two-photon polymerized foam structures***
Abstract:
Foam-like structures with low density have wide applications in mechanical metamaterials, electrodes, catalysis, biological scaffolds and so on. However, fabrication of such kind of structures is very challenging using conventional methods. Here, we present the fabrication of nanoscale foam structures via two-photon polymerization of a commercially available resin (IP-Q. Nanoscribe GmbH, Germany) and further reduction of densities via pyrolysis. First, by varying printing parameters, including laser power, scan speed,hatching distance, and slicing distance, foam structures with different densities were successfully fabricated. We systematically investigated the pyrolysis processes of twophoton polymerized foam structures. Combined with thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and Raman spectroscopy, the effect of maximum temperature, ramp rate, and pyrolysis time on the shrinkage and composition evolution of as-printed foam structures was revealed. Our results suggest that the reactive groups of photoresists (acrylate) start to decompose at about 300°C and carbonized at around 400°C. Based on our results, we concluded that with maximum temperatures ranging between 450°C~500°C, a pyrolysis time of 5 min, and a ramp rate of 15°C/min, the asprinted foam structures could be carbonized as well as be maintained with a good morphology. Our research extends the capability of nanofabrication using two-photon polymerization and further reduces the low density limits of foam structures.

12 (Session D)

Student's name: Katherine (Katie) G. Broun
Name of home institution: University of Rochester
NNCI Site: RTNN REU on Hybrid Perovskites: University of North Carolina at Chapel Hill
REU Principal Investigator: Dr. James F. Cahoon, Chemistry, University of North Carolina at Chapel Hill
REU Mentor(s): Alicia C. Bryan, Chemistry, University of North Carolina at Chapel Hill, Lorenzo Y. Serafin, Chemistry, University of North Carolina at Chapel Hill
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Title: ***Crystallinity and Morphological Changes in Layered Hybrid Perovskites Post Amino-Efflorescence***
Abstract:
Hybrid perovskites (HPs) are a crystalline organic-inorganic material that display many exciting optoelectronic properties. Additionally, by altering the optoelectronic composition, one can tune these properties (i.e., absorption, emission, bandgap). Precise control over the composition is

therefore highly desirable, although not always straightforward. In particular, controlling the crystallinity and morphology of thin films of the so-called Ruddlesden-Popper or "layered" perovskites (RPHPs) remains a significant challenge. Towards this goal, this study uses vapor-phase techniques in order to induce changes in the film crystallinity that are not readily achieved through traditional synthetic methods (i.e., spin casting, blade coating), through a process called amino-deliquescence/efflorescence. Conventional deliquescence describes the reversible phase transition where a hygroscopic solid uptakes water vapor and liquifies above a critical relative humidity point and becomes a supersaturated solution. The reverse process of efflorescence occurs when the environment drops below this critical humidity point and the solution re-crystallizes. With HPs, using a n-butylamine atmosphere, this study explores the phenomenon of amino-deliquescence/efflorescence of the RPHP BA_2PbI_4 and explores differing conditions for film formation. We elucidate trends in how process conditions alter crystallinity and morphology of RPHP thin films post amino-efflorescence which provides a way to control crystalline orientation.

13 (Session C)

Student's name: Catherine Pfaltzgraff
Name of home institution: Texas A&M University
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REU Principal Investigator: Dr. Kevin Kit Parker, Bioengineering and Applied Physics, Harvard University
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Title: ***High Throughput Production of Nature-Derived Biodegradable Polymer Micron/Nanofibers***
Abstract:
Polymer fibers have wide applications in our daily life. Currently, industries are dependent on the use of petroleum-derived fibers, which are not biodegradable and leads to environmental pollutions. Therefore, there is growing need for polymer fibers that are made from sustainable resources. In addition, fiber with smaller diameters exhibit increase the strength and surface area. However, manufacturing micro/nanosized fibrous structure with a high-throughput production rate has been difficult with existing technologies such as electrospinning. This study explores the production of pullulan as a base for biodegrable micro/nanofibers, using the sustainable manufacturing technique Focused Rotary Jet Spinning (FRJS); and the affects additives have, in respects to its composition, surface morphology, and mechanical properties. Pullulan, dissolved in water, was used to produce sustainable fibers with FRJS. To make functional pullulan-based fibers, different concentrations of thyme oil were added to a pullulan solution. The fibers' composition was then analyzed using Fourier-transformed infrared spectroscopy (FTIR), which revealed incorporations of the additive into the pullulan fibers. The morphology was examined by scanning electron microcopy (SEM), showing minimal effects of on the fiber's formation, with a range of fiber diameters roughly being 1.5 μm. The mechanical properties of the pullulan fibers were also evaluated by tensile testing. The results revealed higher tensile strength in fibers of the

composite fibers with thyme oil as compared to pure pullulan fibers. The application of bridgeable pullulan fibers is useful in the pharmaceutical, food packaging, and tissue engineering fields.

14 (Session D)

Student's name: Sean Anderson Jr.
Name of home institution: Morgan State University
NNCI Site: Cornell NanoScale Science & Technology Facility (CNF)
REU Principal Investigator: Farhan Rana , Electrical & Computer Engineering , Cornell University
REU Mentor: Arjan Singh, Electrical & Computer Engineering, Cornell University
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Project Title: ***Coplanar Microwave Waveguide Resonators***
Abstract:
We are trying to make on-chip superconducting microwave resonators which are capable of driving spins in semiconductors by using the superconducting metal niobium(Nb). These microwave resonators will work mainly in two ways; Sensing magnetic defects and magnetic order in thin films of new materials; Manipulating and measuring the quantum state of a collection of spin defects for use in quantum technologies.

15 (Session C)

Student's name: Julia Griffin
Name of home institution: Mount Holyoke College
NNCI Site: University of Pennsylvania
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Title: ***Effect of Sliding Speed on the Formation of Zro_2 Antiwear Tribofilms in Boundary Conditions***
Abstract:
We studied the ability of lubricants containing ZrO_2 nanocrystals (NCs) to prevent wear of gear steel under mixed rolling-sliding conditions. The mechanism of antiwear action is tribofilm formation, through which ZrO_2 NCs sinter into a surface-bound, solid protective coating in the contact region between the moving steel surfaces. The tribofilm forms in three stages – nucleation, growth, and saturation – and we hypothesize that the morphology and microstructure during the nucleation and growth phases affect the thickness, morphology, and traction at saturation. Preliminary evidence suggests that the tribofilm permits some early-stage wear of the steel, but once saturated, the steel undergoes significant plastic deformation while covered by the tribofilm. We also show that varying the sliding speed affects initial stages of tribofilm formation by causing tribofilm nucleation and saturation to occur at different sliding lengths. This

tribofilm formation process is distinct from those experienced by alternative antiwear additive molecules like ZDDPs, and suggests that the study of tribofilm microstructure can provide mechanistic understanding of metal oxide NC antiwear additives.

16 (Session D)

Student's name: Hasan Al Saeedi
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NNCI Site: Northwestern University
REU Principal Investigator: Professor Michael J. Bedzyk, Materials Science and Engineering, Northwestern University
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Title: ***A Python-Based Jupyter Notebook Guide for X-ray Diffraction Techniques.***
Abstract:
While static, paper manuals have long been employed to guide inexperienced users of experimental equipment, they are lacking interactivity and functionality. This disconnect between users and guides can result in a lack of understanding in the experiment or cause the user to miss a critical step during the experiment. Dynamic instruction guides have the potential to bridge this educational gap and dramatically increase user understanding. We have developed Python-based Jupyter Notebooks containing a variety of interactive modules to be used in the Jerome B. Cohen X-ray Diffraction Facility at Northwestern University. A case study investigating the efficiency of such a guide is performed for the experimental technique X-ray Reflectivity (XRR) on a Rigaku SmartLab Gen 2 diffractometer. The XRR guide contains checklists to guide users through the XRR experimental technique while incorporating text, images, videos, and simulations to give the user a deeper understanding of the methods involved in the experiment. In addition, users have the option to perform reduction and analysis of their data concurrently with acquisition. By using software like Jupyter Notebooks that may be easily re-purposed to any type of instruction guide, we can implement interactive, creative, and easily modifiable guides for a variety of experiments. This combination of flexibility and interactivity allows the application to any scientific field.

17 (Session C)

Student's name: Hannah Kempfert
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Title: ***Optimizing Nanomagnetic Force Modulation through Geometric Shaping***

Abstract:

Magnetically actuated mechanical forces can be exerted on a biological unit by applying an external magnetic field to internalized or adherent magnetic nanoparticles, ultimately modulating cellular growth and signaling. Because of the nanometer-sized objects, these forces are called nanomagnetic. The amplitude and direction of nanomagnetic forces can be locally controlled more precisely using micro-scaled alloys called magnetic elements. In previous research, rectangular shapes of magnetic elements have been used to displace proteins within brain cells. A fuller understanding of how more complex shape geometries could attenuate the force amplitude have yet to be explored and could aid in reducing alloy materials. The current work explores the impacts of different geometric shapes and sizes of magnetic elements on the resulting nanomagnetic force amplitude and effective force area. To accomplish the goal of nanomagnetic force optimization generated by the magnetic elements, magnetic fields were simulated using COMSOL Multiphysics software. An element's impact on local nanomagnetic force modulation was primarily quantified by finding the effective force area, defined in this work as the spatial area surrounding the element with nanomagnetic force amplitudes above a biophysically relevant threshold (e.g., thermal fluctuation, stalling motors). Generally, effective force area and maximum force magnitude increased with an increase in extreme points along the perimeter of the element. This effect was maximized when these points corresponded to sharper vertices in the element and were oriented normally to the external magnetic field. Additionally, the angular orientation of the element significantly contributed to effective force area and magnitude; forces exerted by high aspect ratio and high perimeter elements were observed to follow a sinusoidal trend, with maximum force area achieved when the element's major axis aligned with the external magnetic field. These findings can have a significant impact on designing more precise next-generation nanomagnetic force toolboxes in the field of biomechanics.

18 (Session D)

Student's name: Ashley M. Martinez

Name of home institution: Northern Arizona University

NNCI Site: NCI-SW

REU Principal Investigator: Professor Jennifer Martinez, Applied Physics and Material Science, Northern Arizona University

REU Mentor: Professor Jennifer Martinez, Applied Physics and Material Science, Northern Arizona University

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Title: ***Soft Nanomaterial Carriers: Eliminating Burst Release of Their Cargo***

Abstract:

Nanomedicine has proven effective for major diseases such as cancer and diabetes, and pathological processes including inflammation, vaccination, and microbial infection. However, in order to provide treatment and enhance therapeutic efficacy, drug and vaccine delivery systems must transport an active agent in a stable, safe, and biocompatible manner to the target site at

concentrations high enough to produce a therapeutic response. Delivery systems must be highly tailorable, yet overcome hurdles such as toxicity, clearance, and off-target effects. Here, we developed a tunable, stabilizer-free PLGA (poly(lactic-co-glycolic acid)) nanoparticle formulation capable of encapsulating plasmid DNA and demonstrated the formation of an elastin-like polymer PLGA hybrid nanoparticle with exceptional stability and biocompatibility. We will discuss the synthesis and characterization of PLGA and PLGA-hybrid carriers that span the nanosize regime and vary in their degradation time point. Further we will discuss a series of particle formulations that eliminate burst release of their cargo.

19 (Session C)

Student's name: David Li
Name of home institution: Lehigh University
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REU Principal Investigator: Dr. William Wilson, Center for Nanoscale Systems, Harvard University
REU Mentor: Dr. Ling Xie, Center for Nanoscale Systems, Harvard University
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Title: ***New Findings in the Fabrication of Silicon Micropillar Arrays Using the Bosch Process***
Abstract:
Silicon micropillar arrays, which have applications in microfluidics, optoelectronics, and biosensing, are usually fabricated using the Bosch process of deep reactive ion etching. We investigated how photolithography and etching conditions affect the final shapes of the pillars in order to optimize them. Here, we used a maskless aligner to directly write the micropillar arrays onto positive photoresist, and after development of the photoresist, we etched the substrate with varying conditions. We then characterized the arrays using scanning electron microscopy to measure critical dimensions and the etch rates of both the silicon and photoresist. Through this process, we established that there is an optimal exposure per micron of photoresist independent of array dimensions. In the etching process, we used low platen power that ramps down with time to avoid undercut, and in this way, we were able to fabricate pillars with diameters as small as one micron. We also found that with some of the etching conditions we studied, the etching process has an extremely high selectivity of well over 120:1 to Microposit S1800 series photoresist and that the etch rate of silicon accelerates with depth; the two effects are inexplicable yet well-observed.

20 (Session D)

Student's name: Ryan C. Chow
Name of home institution: University of Utah
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Title: ***Characterization of a Silica-Packed Microreactor over Flowrate and Temperature***
Abstract:
Endogenous carbonyl compounds in exhaled breath are metabolites of biochemical process. Some carbonyl compounds in exhaled breath are related to diseases including diabetes, cystic fibrosis, Tuberculosis, and cancer. Microreactors have been used to preconcentrate ketones and aldehydes using an oximation reaction to detect pulmonary diseases. These microreactors have been previously fabricated with micropillars on silicon wafers to increase surface area where the reaction can occur. Previous studies have shown high pillar density, a triangular pillar shape, and longer reactor length increases capture efficiency. Little has been done outside of microfabricated pillars. Therefore, we are studying the use of a microreactor that packed with silica particles to increase surface area. To optimize the condition for achieving higher capture efficiencies, the microreactor is tested over various flow rates to characterize the reaction kinetics limited and Mass Transfer limited regions. The order from highest to lowest captured compound at a low flow rate was acetone, pentanal, acetoin, then 2-pentanone (39.6, 30.8, 22.1, and 16.7%, respectively). This changed to 2-pentanone, acetone, pentanal, then acetoin at high flow rates due to a change in concentration at the reaction site (59.2, 51.1, 47.8, and 41.2%, respectively). This was repeated for o-(2 3 4 5 6-pentafluorobenzyl)hydroxylamine hydrochloride (PFBHA) and [2-(aminooxy)ethyl]-N,N,N-trimethylammonium triflate (ATM). A flow rate in the reaction limited region (37 mL/min) was then chosen to test multiple temperatures from 0 C to 100 C.

21 (Session E)

Student's name: Zeinab Ismail
Name of home institution: St. John's University
NNCI Site: Cornell NanoScale Science & Technology Facility (CNF)REU Principal Investigator, Department, Institution: Sadaf Sobhani, Sibley School of Mechanical and Aerospace Engineering, Cornell University
REU Mentor, Department, Institution: Giancarlo D'Orazio , Sibley School of Mechanical and Aerospace Engineering, Cornell University
Contact Email for all three: sobhani@cornell.edu , gd373@cornell.edu , zi28@cornell.edu
Presentation Title: ***Printing Functional Gas Diffusion Layers via 3D printers for Carbon Dioxide Reduction Reactors***
Abstract:
Carbon Dioxide Reduction Reactor's (CO2RR) main purpose is to reduce carbon dioxide (CO2) emissions by converting CO2 into more environmentally friendly chemicals, such as ethylene, methane, carbon monoxide, that could be used in energy storage. CO2RR is a necessity in today's world, where renewable energy sources cannot easily translate into bigger industries and require an alternative. The CO2RR we are working with consists of several components: one gas compartment, anode compartment, cathode compartment, ion exchange membrane, counter

electrode, several gaskets, and a gas diffusion layer. The Gas Diffusion Layer (GDL), usually any porous membrane coated in catalyst, serves as the gas-liquid interface in the cell, preventing movement of reduced products from cathode side to be reoxidized by the anode. Our goal was to print GDLs on the Nanoscribe GT2 3D printer and additional adapter pieces on the Objet 30 printer. These adapter pieces are mainly there to support the GDL, which due to its thin and small size is prone to curling, as well as be additional support against the electrolyte being pumped throughout the cell. We created and improved GDL designs using nTopology and Creo software, then we then sliced the sample using DeScribe. Alongside this computer work, we got more accustomed to using the printers by making sample prints. These prints consisted of multiple prints of arrays of microchannels for proximity effect studies as well as smaller, thin arrays resembling a very simplified GDL. We also printed out GDL samples, ready to be coated in copper catalyst and hydrophobic coating and sent over to be tested in our ready-made CO2 cell. How well the cell works is determined by our analysis of IR drop of the cell with our GDL in comparison to the cell using a market acquired GDL.

22 (Session F)

Student's name: Nathan Song
Name of Home institution: UC Berkeley
NNCI Site: University of Louisville
REU Principal Investigator: Dr. Kevin Walsh, Electrical and Computer Eng., University of Louisville
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*Title:**Electrical Characterization of MEMs Microgrippers in Circuits***
Abstract:
Integrating MEMS devices with electronic textiles (E-Textiles) and fabrics requires an understanding of how these devices interact with circuit components in different operating conditions. In this paper, we characterize the electronic properties of MEMS "grippers" in contact with conductive wire. We discuss general guidelines for optimizing the design of said "grippers" and potential MEMS-based circuits. We then demonstrate how these grippers can act as non-rigid circuit components that effectively transfer power to devices such as LEDs. Analysis shows that our "grippers" are suitable conductors (<150 Ω) under standard operating temperatures (25°-100° C) with potential for use as sensors for current overflow or temperature. Methods such as parylene deposition and silver epoxy "glue" to stabilize MEMS performance for robust applications are also discussed and briefly explored.

23 (Session E)

Student's name: Schuyler Diaz
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Contact: skdiaz597@gmail.com; faiman@ece.ucsd.edu; agrieco@ucsd.edu
Title: ***Computer Vision Aided Automatic Waveguide Alignment and Optimization System***
Abstract:
Precise alignment between an optical waveguide chip and an optical fiber array is crucial in the development of optical waveguide devices. Manual alignment of integrated photonic circuits with input fiber arrays is an intricate process that can take several hours. Furthermore, the components are delicate and can be damaged during the procedure. This places severe constraints on the type of devices that can be characterized by this method, which consequently limits their research potential. In order to overcome these limitations it is necessary to develop a system for automated waveguide alignment. To this end we construct an open-source computer vision-based method for current position detection and propose a machine learning model for optimal position detection. The objective of the proposed method is to achieve precision levels better than 0.05° (angle detection), 0.1 µm (line detection), and 2 s (detection time). Finally, the optimization parameter of the method is customizable, and therefore it can be adapted to more general applications such as automated robotic alignment.

24 (Session F)

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Title: ***Biodegradable Phosphate Sensor for Agricultural Use***
Abstract:
Phosphate (P) is prevalent in many fertilizers in agricultural systems. Overuse of fertilizer leads to build up of P in bodies of water, causing eutrophication. Although traditional soil tests for P in labs generate reliable results, they are not viable for quick testing in crop fields. The proposed sensor detects P using a molybdenum(Mo) working electrode and tin(Sn) reference and counter electrodes. Attached to the electrodes, a piece of cellulose sponge soaks up the extract liquid from the soil, creating an aqueous environment for the sensor. The sensor generates a current output for the interface circuit to measure, and then the measurement maps to a P concentration. Tests were completed using phosphate buffered solution(PBS) at 10^{-1} M – 10^{-6} M at multiple pH values, yielding a power function relationship and proving that this sensor does detect different

concentrations of P. Soil that had been pre-analyzed for P content was tested with the sensor and calculations comparing data from the sensor and soil yield an amount of P on the same order of magnitude, proving that the sensor is working. The soil was also fertilized at different doses and the current increased as fertilizer dose increased. This sensor can be used in crop fields in the future by connecting it to a small circuit so a drone can fly over a field and use a RF backscatter communication technique to read the sensor data.

25 (Session E)

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Title: ***Assessing the Chondrogenic Influence of Nanofabricated 3D Scaffolds on Human Mesenchymal Stem Cells***
Abstract
Cartilage tissues inherently have very poor regenerative capabilities, which presents a major issue in cartilage repair for many cartilage-related diseases such as osteoarthritis affecting more than 3 million people in the US and cartilage-dependent surgeries such as laryngotracheal reconstructions. Human mesenchymal stem cells (hMSCs) are multipotent progenitor cells with the ability to differentiate into chondrocytes as a cell source for cartilage repair. Compared to typically used autologous chondrocytes, hMSCs are highly proliferative and are obtainable from many different sources. In light of these promising properties, studies have shown that some MSCs transplantation undergo suboptimal chondrogenic differentiation and cartilage matrix formation opting for more research to be done to further improve MSC chondrogenesis. Preliminary research has shown that the size of the hMSCs microenvironment is a factor that affects chondrogenic differentiation. This research study will utilize 3D nanofabricated scaffolds of different pore sizes to probe the effects of microenvironment confinement on hMSC differentiation towards chondrocytes. First, scaffold designs with 200um and 70um pore sizes were created using SolidWorks, then converted to a .gwl file compatible with the Nanoscribe Photonic Professional two-photon polymerization nano-printer. The 3D scaffold prints were then optimized by increasing the laser power and decreasing the laser speed of the 25x objective. The 3D scaffold material used was an IP-Visio resin and was observed to be non-autofluorescent under fluorescent lighting and biocompatible through Calcein-AM/Ethidium bromide staining. hMSCs were seeded on both 200um and 70um scaffolds at the same density and grown in chondrogenic media. Immunofluorescence for SOX9 expression and actin organization will be used to assess the effects of the 200um and 70um confinement on hMSC chondrogenesis. Future studies include fabrication of different pore shapes to investigate further environmental effects.

26 (Session F)

Student's name: Parisa Zalmai
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Title: ***Microvalve Array for a Reconfigurable Tactile Tablet for Vision Impaired Individuals***
Abstract:
Approximately 14 million people in the United States suffer from some form of visual impairment. The first Braille was invented in 1824, and it has been the main educational tool for vision impaired individuals. Despite many technological advancements to assist vision impaired individuals, there has not been major improvements to display mathematical equations and graphs for the blind beyond the basics. This has led to a lack of access to higher education, especially in STEM fields, for individuals with vision impairment. The ultimate goal of this project is to have a 100x100 array of pneumatically actuated micro-valves on a tablet to replicate Braille. Our current prototype, however, only consists of two Braille cells for testing purposes. The prototype has 3 layers: a rigid, PMMA layer, a PDMS layer, and a Steel Layer. The PMMA layer has holes with dimensions of Braille pins. A thin, flexible, PDMS layer is placed on the PMMA to be inflated/deflated. The steel layer is also very thin and has the exact same dimensions as the first layer, and is screwed on the PDMS layer to hold the layers together.The design works such that when air pressure is applied under the valves of the first layer, it flows through the valves, and inflates the PDMS layer; forming dots/bubbles that one can feel. The forming of dots will display letters/lines/graphs of interest. The bubbles then deflate when pressure is removed. The design is promising such that it addresses the aforementioned limitations for the vision impaired individuals.

27 (Session E)

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Title: ***Development of Sputtered Aluminum Nitride Thin Films on Silicon***
Abstract:

Diamond hosts optically active color centers which have quantum memory capabilities and. Of the many color centers that can be found in diamond, the Lončar Group primarily works on silicon vacancy centers (SiV) because of their stability and strong coupling to strain in the diamond crystal. Current research focuses on the spin levels of SiV within diamond that can be coherently driven with surface acoustic waves (SAW), a process which can control and stabilize the quantum information stored in the spin levels. Experimentation requires a high-quality piezo-electric film, aluminum nitride (AlN), with a thickness of a few hundred nanometers on top of a diamond chip. This works aims to better understand how different parameters can affect the properties of film, with an eye towards maximizing the film's piezoelectric efficiency in transferring SAW to diamond, characterizing these films, and measuring the electrical to SAW efficiency. AlN is a very piezo-electric material, meaning that strain is created when electricity is applied, and thus that a film of AlN can be used to transfer SAW onto the surface of other non-piezo-electric materials. I have been experimenting with AlN to develop the most efficient way to use its piezo-electric properties to create SAW with the hopes of reducing energy loss. The processes I have been using are sputtering, reactive sputtering, and multiple characterization techniques to find the rate at which the AlN film coats the surface of a material, the roughness of the film, and the material composition of the film. Such characterization techniques include scanning electron microscopy (SEM), x-ray diffraction (XRD), x-ray photoelectron spectroscopy (XPS), and profilometry. Future work will include creating electronic SAW devices to test the quality of these films.

28 (Session F)

Student's name: Eryka Kairo
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Presentation Title: ***Microfluidic Handling of DNA for Efficient Spatial Genomics Research***
Abstract:
Nuclear envelope invaginations have been linked to clinical cancer and are tumor biomarkers, however, their function is not yet understood. To get one step closer to this understanding, the organization of chromatin in cells where nuclear invaginations are present must be investigated, as this controls cell-type-specific and disease-specific phenotypes through spatial gene regulation. To explore spatial modulation of gene regulation, small sub-nuclear volumes of chromatin are biotinylated in a method called Femto-seq, which enables affinity purification and the sequencing of nuclear invagination-associated chromatin. To improve the throughput and efficacy of Femto-seq, we demonstrate a microfluidic purification device utilizing a single fluidic channel with a functionalized surface and mixing elements that improve upon the sample yield and purification, elevating the experimental capacity of Femto-seq to elucidate spatial gene regulation patterns

associated with nuclear invaginations. The device was fabricated using multilayer SU-8 photolithography. Herringbone structures were added along the fluidic channel to encourage "chaos" in flow patterns of our sample through the channel, increasing our purification yield. We utilized a negative resist and our design was cast into PDMS and later bonded to a glass surface. Our device was characterized through fluorescence microscopy and biochemical assays to: validate a streptavidin-biotin complex is able to be formed using a novel glass functionalization protocol, validate we are able to optimize an elution protocol suitable for our device, and quantify our sample yield of biotinylated DNA, therefore, quantifying our device efficacy.

29 (Session G)

Student's name: Anna Li
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Title: ***Imaging of Hyperbolic Plasmon-Phonon Polaritons in Twisted Double Bilayer Graphene***
Abstract:
Complex van der Waals heterostructures can be assembled, layer-by-layer, via the deterministic transfer of selected two-dimensional layered materials. The transfer method used offers a significant degree of control and precision enabling assembly of new composite materials with engineered optical properties. Here, we have fabricated twisted double bilayer graphene using a new transfer system with far greater spatial resolution (20 nm) than the previous systems at Harvard. We transferred mechanically exfoliated graphene and hexagonal boron nitride (hBN) with this transfer system (which uses a polymer stamp consisting of Polydimethylsiloxane (PDMS) and polycarbonate (PC)) to form hBN encapsulated, twisted double bilayer graphene at very small (~0.03º) twist angles. The top capping layers of hBN was between 5–10nm thick, as verified using atomic force microscopy, and the bottom layers ranged from 10–20nm thick. These stacks were subsequently imaged using scanning near field microscopy in the mid-infrared range to observe the interference fringes from the systems "mixed" hyperbolic plasmon-phonon polaritons. Excited with a tunable QCL laser, we were able to study the dispersion relation and propagation behavior of the hybridized polaritons in twisted double bilayer graphene.

30 (Session H)

Student's name: James Gow
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Title: ***Development and Characterization of Fusogenic Porous Silicon Nanoparticles for siRNA Delivery for the Treatment of Retinal Neovascularization***
Abstract:
In this study, the fusogenic porous silicon nanoparticles (F-pSiNP) are optimized at two different stages - the loading of siRNA and fusogenic lipid coating. Previous work has shown that trapping of payload into the pores of nanoparticles can be achieved through modification of the surface of pSiNP with heterocyclic silane, such as butyl-aza-silane and diaza-silane. While this "loading" mainly results from the electrostatic interactions between the positively charged surface of pSiNP and negatively charged payload—siRNA and calcein—there may also be physical restructuring of the pores that enables this loading process. In the first part of the study, the cyclic silane modification chemistry is applied at two different stages of loading - before and after loading siRNA. Then, the resulting particles are characterized using Dynamic Light Scattering (DLS) and Fourier transform infrared (FTIR) and analyzed to compare the mass loading of each method. Next, to avoid endosomal uptake and degradation of the therapeutics, the siRNA-loaded pSiNP are coated with fusogenic lipids to form F-pSiNP. In the second part of the study, three different lipid-coating methods are experimented: 1) the conventional lipid-extrusion method; 2) spontaneous fusion of liposome and siRNA-loaded pSiNP; and 3) simple mixing of siRNA-loaded pSiNP with fusogenic lipids without extrusion. The coating efficiency of these methods are compared by determining the size and morphology of the resulting particle using DLS and Cryo-EM.

31 (Session G)

Student's name: Errysteinn Frondarina
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Title: ***Formulating Lipid Nanoparticles with Targeting Peptides***
Abstract:
Traumatic brain injury affects approximately 3 million people among all ages with a total cost of about $93 billion annually in the United States. Secondary injuries persist and lead to disease-specific changes to the microenvironment of the blood-brain barrier and cause long-term issues including physical, cognitive, and psychosocial impairments. Lipid nanoparticles carrying nucleic

acids have been approved for use in humans for the treatment of hereditary transthyretin-mediated amyloidosis and the prevention of COVID-19. We propose that lipid nanoparticles carrying nucleic acids are potential therapeutics to address the gene expression changes after brain injury. One major challenge for delivery to the brain is targeted delivery. Therefore, the formulation of lipid nanoparticles conjugated with targeting peptides will be examined in this research. First, formulation procedures and parameters will be varied and assessed for impact on lipid nanoparticle properties such as sizes <100 nm and uniformity of sizes by dynamic light scattering. Second, we will formulate lipid nanoparticles with peptides for targeting specific cell types and measure whether the resulting nanoparticles can maintain their nanometer size and uniformity. Lastly, we will use single particle tracking to quantify the number of peptides per lipid nanoparticle. Ultimately, we believe targeted lipid nanoparticles as a promising innovation in precision medicine that can meet the urgent need for new therapeutics to treat brain injuries.

32 (Session H)

Student's name: Christina Vialva
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Title: ***SARS-CoV-2 Enzyme (Mpro) Detection with a Matrix-Insensitive Nanoplasmonic Platform***
Abstract:
To date, well over one billion covid-19 tests have been performed worldwide. The ongoing Covid-19 pandemic highlights the timely necessity to develop a simple and cost-effective strategy for rapid SARS-CoV-2 biomarkers screening. Polymerase chain reaction (PCR) and the enzyme-linked immunosorbent assays (ELISA) are expensive, time-consuming, and require specialized operators; however, modern advancements in nanotechnologies are combating these limitations through the development of virus detection via plasmonic nanomaterials. Plasmonic nanomaterials, such as gold or silver nanoparticles, are interesting signal-generating elements as they interact with light more efficiently than organic dyes due to a localized surface plasmon resonance (LSPR) band in the visible region that is very sensitive to their size, shape, and dielectric environment. Our strategy for detection of SARS-CoV-2 involves the color change of infected samples induced by the dissociation of gold or silver nanoparticles assemblies after a proteolytic cleavage. The main protease of the SARS-CoV-2 virus, Mpro, cleaves HS-PEG-peptide conjugates that then releases HS-PEG moieties that can dissociate NP assemblies. This dissociation causes the color change of particles, the intensity of which is related to the concentration of Mpro present. This approach to dissociation is unique in that it is a matrix-insensitive method. First, HS-PEG-peptide were designed to be specific to Mpro and capable of nanoparticles dissociation after the proteolytic

cleavage. HPLC and mass spectrometry were used for the purification and characterization of the compounds, respectively. The dissociation capacity of the HS-PEG-peptide was studied by UV-Vis spectroscopy and the detection of Mpro was investigated in buffer, external breath condensate and saliva.

33 (Session G)

Student's name: Ojas Kulkarni
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Title: ***Simulation of Glancing Angle Deposition***
Abstract:
In this work, we develop a 3-dimensional simulation for a nanostructure growth technique called glancing angle deposition (GLAD). GLAD is a physical vapor deposition process capable of creating nanostructures. GLAD can be used to create sub-100 nm nanofeatures like chevrons, ribbons, columns, helices, and combinations. These structures are formed by ballistic shadowing of particle islands where the vapor flux is unable to land in this shadowed region. However, the visualization of the feature formation mechanism during GLAD is lacking. For the simulation, we utilize Python and incorporate its visual graphics module - VPython - to simulate the growth of these nanostructures in a 3D environment to visualize the GLAD process. We first simulate the deposition of natural seeds on the substrate. Then as shadows are cast from these seeds, the subsequent layers of particles being deposited onto the substrate are simulated. The simulated results of percent coverage and seed size with respect to different inputs such as varying incidence angles, rotation rate, and deposition rates are demonstrated. Additional support for different seeding schemes including cube seeds, line seeds, and sphere seeds are also presented. Our collision resolution algorithm has a time complexity of $O(sn^3)$ where s is the total number of simple features (columns) to make a complex feature. The simulation results are qualitatively agreed with our experimental results; a quantitative comparison between our simulated incidence angle and theoretical ones shows good accordance. Overall, this work demonstrates the simulated growth of GLAD thin films in a Monte-Carlo fashion to predict the fabrication result, which can be used to further guide the design of 3D GLAD nanofeature arrays for application fields such as sensing, optics, and mechanics.

34 (Session H)

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Title: ***Development and Fabrication of Silicon Nanostructures for Mechano-Bactericidal Studies***
Abstract:
The development of synthetic bactericidal nanosurfaces has emerged in recent years to combat bacterial biofilm formation and infection, especially in the realm of medical implants and equipment. However, the exact mechanism of mechano-bactericidal activity and the parameters that affect it are not yet clearly identified. This study seeks to explore the use of a HSiQ photoresist mask, electron beam lithography (EBL) and reactive ion etching (RIE) to produce highly ordered silicon nanostructures for future studies in bactericidal nanosurfaces. As EBL provides a high level of control over exact feature dimensions, pattern designs were created and implemented using existing literature on effective bactericidal nanofeature geometries. Optimum dosage quantities were identified for feature diameters of 50, 75 and 100 nm and various RIE recipes tested for appropriate etch depth and pillar morphology. SEM imaging was used to evaluate nanotopography characteristics. Previous studies have identified optimum EBL fabrication parameters, but this work seeks to also tune the etch depth while maintaining a highly anisotropic pillar shape to improve bactericidal activity. Establishment of these parameters will better inform future systematic studies on the effects of nanofeature geometries on bactericidal effectiveness.

35 (Session G)

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Title: ***Hybrid Porous Silicon Nanoparticle and Polycaprolactone Drug Delivery System for Revascularization of the Anterior Cruciate Ligament Post Surgically***
Abstract:
The Anterior Cruciate Ligament (ACL) is a ligament in the knee commonly torn through sports injury that requires a reconstruction surgery with a lengthy recovery time due to slow and improper neovasculature formation. Unlike other ligaments in the knee, the ACL cannot repair itself since it is surrounded by synovial fluids and lacks direct access to any exterior blood supply. Therefore, the experiment's main objective was to improve the post-surgical recovery of ACL by enhancing its revascularization via a drug delivery system loaded with a vascular endothelial

growth factor (VEGF). The drug delivery system is composed of VEGF - a drug to promote revascularization, Silicon nanoparticles that act as the delivery system by encapsulating VEGF, and a Polycaprolactone (PCL) "patch" with trapped, VEGF-loaded Silicon nanoparticles. The patch is intended to be placed in the knee post-surgery, where we hypothesize a slow release of VEGF into the ACL will significantly enhance its recovery time and efficiency. We have demonstrated a drug-releasing profile that matches the need for a slow, continuous release in the ACL recovery application, suggesting it is promising for the treatment of said injuries. Hence, we are currently focused on both replicating release measurements (spanning a 2-week time period) via ELISA assays as well as improving encapsulation efficiency.

36 (Session H)

Student's name: Giancarlos Solano
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Title: ***Alternative Development Methods for NR9-1500PY Photoresist***
Abstract:
Microelectronic fabrication is heavily relied upon in the field of technology. Most familiarly associated with the manufacturing of semiconductor devices and various electronic components, microelectronic fabrication is an essential component of our everyday lives. Within microelectronic fabrication, photolithography is a necessary process step used to create patterns in various materials on the micro or nanoscale. A common photoresist developer, tetramethylammonium hydroxide (TMAH), is widely used in photolithography and is extremely toxic. A small amount of skin exposure to TMAH can result in severe chemical burns that further develop into the loss of respiratory and cardiac function. In this project, the main objective was to replicate the results of a standard TMAH development using isopropyl alcohol, acetone or heptanone as non-aqueous developers while using NR9-1500PY negative resist. These developers were chosen as safer alternatives to TMAH. The quality of these exposure patterns was determined using optical and electron microscopy. Isopropyl alcohol proved to be inadequate because it left undesirable streaks of undeveloped photoresist. Heptanone and acetone provided comparable results that will be acceptable for many applications. These chemicals are significantly safer than TMAH, and thus may simplify the equipment required to do photolithography safely. Additionally, this opens the possibility of using organic solvents as developers when there are substrate compatibility issues with TMAH.

37 (Session G)

Student's name: Bethany Claes
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Title: ***Film Synthesis and Crystal Growth of Perovskites by Melt Processing***
Abstract:
2-D lead (II) halide perovskites are preferred for their electrical and optical properties, as well as their structural stability as semiconductors. Since lead is toxic, it is important to look for lead-free halide perovskite alternatives. Trivalent antimony and bismuth halide perovskites offer a less toxic alternative to divalent lead or tin perovskites and have similar electrical properties. Perovskite films formed via solution processing have uniform coverage, but also have several limitations including the usage of toxic solvents. Melt processing offers a method of film synthesis that is solvent-free. This research focused on systems of racemic and chiral 1-D bismuth (III) and antimony (III) halide perovskites. Films of trivalent antimony halide perovskites (TMPZ $Sb I_5$ and S-Me TMPZ $Sb I_5$) were synthesized against films of a divalent lead halide perovskite ($(1\text{-Me-ha})_2PbI_4$). Antimony was chosen due to its lower melting point than its bismuth counterparts. These films were formed using a hot press with independently heated pressure plates. Perovskite powders were precipitated by solvothermal synthesis. These powders were then placed on a treated substrate, and melted using a hot press. Hot pressed films were characterized by x-ray diffraction, optical microscopy, uv-visible spectroscopy and profilometry (lead system only). Characterization techniques demonstrated that the hot press can be used to form lead films with almost full coverage. Antimony halide perovskites, on the other hand, are less stable upon melting and will decompose rapidly. Therefore, films of these systems have only partial coverage. This work was unsuccessful in forming lead-free halide perovskite films with full coverage by melt processing. However, it is shown that melt processing lead-free halide perovskites can be a method of crystal formation. The XRD patterns demonstrate that recrystallization occurs following melt, which is one of the first observations of full recrystallization in lead-free halide perovskites.

38 (Session H)

Student's name: Massyl Mallem
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Title: ***Characterization of Hybrid Organic-Inorganic Halide Perovskites and 2D/3D Perovskite Heterostructures Deposited by Resonant Infrared Matrix Assisted Pulsed Laser Evaporation (RIR MAPLE)***
Abstract:
Thin film deposition is an integral step that enables the utilization of exciting functional materials, such as perovskites, in electronic and photonic devices. Solution-based deposition methods such as spin-coating (or spin-casting) are by far the most popular techniques used to deposit perovskite thin films. However, there is an increasing interest in utilizing alternative deposition methods such as Physical Vapor Deposition (PVD). In this project, we characterized thin films grown by a type of PVD known as Resonant Infrared Matrix-Assisted Pulsed-Laser Evaporation (or RIR-MAPLE) and compared them to thin films grown by spin-coating. More specifically, we investigated the halide distribution as well as the elemental composition of phenethyl ammonium lead iodide (PEPI) thin films. Moreover, a unique advantage of RIR-MAPLE is that it seamlessly enables the design of perovskite heterostructures. Specifically, RIR-MAPLE was used to fabricate a thin film comprising a 2D Ruddlesden-Popper hybrid organic-inorganic halide perovskite, namely, phenethyl ammonium lead bromide (PEPB), deposited onto a 3D hybrid organic-inorganic halide perovskite, namely, methylammonium lead iodide (MAPI), together, the perovskites form heterostructures. Finally, these heterostructures were characterized based on halide distribution as well as elemental composition.

39 (Session I)

Student's name: Angela Wang
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Title: ***Characterization of Pleurobema Rubrum Shells***
Abstract:
Freshwater bivalves have shown promise as biological indicators for studying climate and water conditions through study of the annual growth bands of their shell growth. Variations in growth band width can inform climactic considerations such as growth season length and temperature changes. Bivalves may also serve as biological indicators for monitoring pollution levels in lakes or rivers as during the production of the calcium carbonate matrix of their shells, trace levels of other compounds present in the water may be incorporated into the shell crystal lattice. In order to study these effects in Pleurobema rubrum, a species of freshwater mussel found near the Green River in Kentucky, four shells were selected from archaeological and historic sites for study. The

shells were collected from various shell mounds near the Green River from different time periods: the Late Archaic, the Mississippian, and the early 19th century. The shells were mounted in epoxy and cross-sectioned from the umbo to the ventral margin in order to observe annual growth bands under an optical microscope and a scanning electron microscope (SEM), and to determine their composition using EDS and XRF, including trace elements.

40 (Session J)

Student's name: Jackson B. Vyletel
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Title: ***Cathode Nanofabrication for Increased Power and Extended Drone Flight***
Abstract:
Drones will be instrumental in optimizing the modern agricultural process. Currently, drone use in crop inspection and sensor communication technologies is limited by short flight durations of approximately 20 minutes. A possible remedy to this problem is electrochemical exploitation of aluminum air batteries (AAB), which have a theoretical energy density several orders of magnitude higher than lithium-ion batteries. Indeed, flight durations models yield an AAB-based drone theoretical flight duration of over one hour, which is approximately triple the current standard of 20 minutes. A constraint to this approach is the relatively low specific power density of air batteries. Herein, we leverage electrodeposition and plasma vapor deposition of copper and silver onto carbon fibers to improve the specific power density of air batteries. We demonstrate that multiple paths of multilayer deposition, as well as alloy deposition, are successful an achieving a desired power 210 mW/cm^2, which is comparable to the commercial Pt-based catalysts. Economic analysis focuses the work to copper and silver deposition, which boast a six-times cost decrease compared to commercial cathodes. These approaches provide cost-effective alternatives to commercial Pt-based AAB cathodes and advocate for the efficacy of AAB use in agricultural drones moving forward.

41 (Session I)

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Title: ***Solid-State Synthesis of Iron Fluoride Nanocomposites as Cathode Materials for Lithium-Ion Batteries***
Abstract:
Iron fluorides are energy-dense cathode materials for lithium-ion batteries (LIBs). Iron fluoride mass production is hindered by fluorine sources or fluorine-containing gasses, which are highly corrosive and dangerous. In this work, a simple and feasible solid-state reaction is reported to synthesize iron (II) fluoride (FeF_2) by using polyvinylidene fluoride (PVDF) as a fluorine source and ferric oxide (Fe_2O_3) as an iron source. This method delivers carbon coated FeF_2 nanocomposites with a particle size of less than 100 nm, characterized by scanning electron microscopy (SEM). As the ratio of PVDF:Fe_2O_3 increased from 1:1 to 3:1 wt. %, all Fe_2O_3 precursors were fully converted to FeF_2, evaluated by X-ray diffraction (XRD). Ongoing work includes using polytetrafluoroethylene (PTFE) as a new fluorine source to synthesize carbon coated FeF_2. The fast-charging performance and cycling stability of carbon-coated FeF_2 electrodes, paired with lithium metal as a counter electrode in LIBs is intended to be investigated in the future.

42 (Session J)

Student's name: Maria Bambrick-Santoyo
Name of home institution: Yale University
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REU Principal Investigator: David Mitzi, Thomas Lord Department of Materials Science and Engineering, Duke University
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Title: ***Charge Transfer Doping of $MAPb_{0.5}Sn_{0.5}I_3$ Perovskite Films***
Abstract:
Halide perovskites are a class of materials with a wide range of device applications, including LEDs, transistors, photodetectors, and solar cells, which have reached over 25% efficiency in around 10 years of development. Yet doping, which has enabled today's semiconductor technologies, remains challenging in halide perovskite films to compensation from intrinsic defects. Motivated by previous results showing successful p-type doping of $MAPb_{0.5}Sn_{0.5}I_3$ by molecular surface charge transfer, we incorporated two different organic dopants, F4TCNQ and F6TCNNQ, into the precursor solution at 0.2% molar ratio. We characterized the films with scanning electron microscopy (SEM) and x-ray diffraction (XRD), and used AC Hall measurements to understand the transport properties of the film. For films doped with F4TCNQ, we observed an increase in average conductivity by 1 order of magnitude and in average carrier density by ½ order of magnitude, though further Hall measurements are necessary to confirm these results. F6TCNNQ does not yet effectively p-dope $MAPb_{0.5}Sn_{0.5}I_3$, and this may be due to the observed

formation of pinholes in the film, the location of the dopant within the film, or differences in solubility. Future research could include AC Hall measurements with varying concentrations of the dopants to better understand their effect on the perovskite's electrical properties, and modifying the deposition conditions of $MAPb_{0.5}Sn_{0.5}I_3$ with F6TCNNQ to achieve a pin-hole free film. Additionally, Carrier-Resolved Photo-Hall (CRPH) measurements could be performed on the doped and undoped films to understand both the majority and minority carriers.

43 (Session I)

Student's name: Marian Yadira Jimenez Quijada
Name of home institution: University of Arizona, Pima Community College
NNCI Site: NCI-SW
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Title: ***Using Surface-Enhanced Raman Spectroscopy (SERS) to Detect Breast Cancer***
Cancer has been a public health focus for many years and continues to be on the rise. Records from 2020 show that Breast Cancer (BC) was the highest cause of cancer deaths in the world amongst the female population. The gold standard technique used to detect BC is called Mammography, sensitivity ranges from 72%-88%. A mammography compresses the breast with two plates exerting radiation and it is only available to patients over the age of forty, meaning that early detection is difficult for those under forty. After undergoing mammography screening, women frequently develop fibrous tissue in their breasts making it difficult to distinguish between the dense tissue and a possible cancerous tumor. Sialic Acid (SA), also known as N-Acetylneuraminic Acid in the human body, is highly expressed when cancerous cells are present. SA is abundantly distributed throughout the human body fluids, however its highest concentration is in saliva. Salivary sialic acid could thus be used as a biomarker and has advantages as obtaining saliva is simple, efficient, non-invasive, and cost-effective. In this work, we are exploring the use of Surface-Enhanced Raman Spectroscopy (SERS) to detect SA. Specifically, I am synthesizing silver nanowires that help to intensify the traditional Raman Spectroscopy signals and looking for signal enhancement as they bind the SA. This new tool proposes an alternative test to increase the sensitivity of detecting BC using nanotechnology.

44 (Session J)

Student's name: Rachel Qian
Name of home institution: Villanova University
NNCI Site: Cornell NanoScale Science & Technology Facility (CNF)
REU Principal Investigator: Dr. Sriramya Nair, Civil and Environmental Engineering, Cornell University

REU Mentor: Lyn Zemberekci, Civil and Environmental Engineering, Cornell University
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Presentation Title: ***Investigating the Electrokinetic Behavior of Cement-Based and Alternative Cementitious Materials***
Abstract:
Portland cement production is a major contributor of carbon dioxide emissions, so the need to incorporate high amounts of Supplementary Cementitious Materials (SCMs) to reduce the carbon footprint arises. This research aimed at studying the electrokinetic behavior of SCMs such as silica flour (SFL), class F fly ash (FAF), class c fly ash (FAC), metakaolin (MK), and ground granulated blast-furnace slag (SLAG). These particles were dispersed in diluted pore solutions that mimics native pore solutions of cement pastes characterized by their high pH and highly ionic nature. Chemical additives such as naphthalene sulfonate based superplasticizers and sodium glucoheptonate (SGH) retarders were employed to track their efficacy with the SCM. Electrokinetic properties such as zeta potential and particle size were tracked. Factors that influenced zeta potential such as electrical conductivity and pH were measured in optimized particle solid concentrations. Stable zeta potentials have an absolute value measurement of 30 mV or above. It was found that majority of the particles were unstable and tended to aggregate in the pore solutions, with zeta potential values ranging from –3.13 mV to 11.5 mV. Silica flour displayed the most stable behavior in a diluted pore solution concentration, with a zeta potential around –22 mV. The use of chemical additives led to increases in the zeta potential values as compared to those of the neat particles (without additives), demonstrating that the additives are compatible with some of the particles and effective in improving the stability of the solution. Furthermore, scanning electron microscope (SEM) imaging was used to view the shape and size of the cementitious particles as these factors affect the rheology of the cementitious paste.

45 (Session I)

Student's name: Elisa Simoni
Name of home institution: Rose-Hulman Institute of Technology
NNCI Site: Cornell NanoScale Science & Technology Facility (CNF)
REU Principal Investigator: Prof. James Engstrom, Chemical and Biomolecular Engineering, Cornell University
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Presentation Title: ***You will Ru(e) the Day: Developing Area-Selective Processes to Enable Ru-Based Interconnect at the 2 nm Node and Beyond***
Abstract:
This summer, my research goals were to [a] determine if we can use area-selective atomic layer deposition (AS-ALD) with a co-adsorbate to deposit a desired material on a substrate patterned with alternating ruthenium (Ru) and dielectric lines, and [b] determine what manufacturing parameters affect the selectivity of the precursor and co-reactant. We wanted to develop robust processes for area-selective ALD for future interconnect materials: Ru, SiO2 and Al2O3. We also examined AS-ALD on these materials using competitive adsorption to induce selectivity. A number

of fundamental questions were posed, and in this presentation, I will answer some! Can selective deposition be achieved by the appropriate selection of a co-adsorbate? How important is substrate preparation (e.g., the state of the Ru surface) concerning achieving selectivity? If selectivity is lost, why is it lost and what can be done to increase the selective thickness?

46 (Session J)

Student's name: Benjamin Sampson
Name of home institution: University of Kentucky
NNCI Site: KY Multiscale
REU Principal Investigator: Dr. John Balk, Chemical & Materials Engineering, University of Kentucky
REU Mentor: Dr. Michael J. Detisch, Chemical & Materials Engineering, University of Kentucky
Contact: benjamin.sampson@uky.edu, john.balk@uky.edu, mjdeti2@uky.edu
Title: ***Compositional Analysis of Historic & Pre-Historic Pigments***
Abstract:
Procedures and methods were developed for compositional analysis of historic and prehistoric pigments in both ceramics and acrylic and oil painting contexts. An Atlas X scanning micro-XRF instrument from iXRF Systems was used for compositional analysis and mapping. 3-D models of ceramic sherds were produced using a Keyence VL-500 optical scanner with quantitative surface imaging and modelling provided digital optical microscopy. These 3-D models allow for measurements of surface features and partial reconstruction using projection of entire ceramic pieces from sherds. Ceramics of Native American origin from both Southwestern US and Southeastern US regions were analyzed in this way. In both the Southeastern and Southwestern red ochre was positively identified as a surface pigment through linking the red areas to high iron concentrations in composition maps. The Southwestern ceramic is also decorated with a black pigment that has not yet been identified, but may be carbon rich. In addition to ceramic analysis, acrylic and oil paintings were analyzed using XRF mapping. A database of heritage science relevant paints and their elemental makeup was developed during the analysis of two modern paintings. In the acrylic painting, three pigments were identified (lithopone, titanium white, and some variety of umber or sienna). In the oil painting, four pigments were identified (titanium white, gypsum, either red or yellow ochre, and either orpiment or realgar). The spatial distributions of the various paints were studied using XRF mapping and matched with high resolution imaging techniques to study paint distribution and painting methods.

47 (Session I)

Student's name: Michael Bregar
Name of home institution: California Institute of Technology
NNCI Site: Harvard Center for Nanoscale Systems

REU Principal Investigator: Dr. Federico Capasso, School of Engineering and Applied Sciences, Harvard University
REU Mentor: Dr. Paul Chevalier, School of Engineering and Applied Sciences, Harvard University
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Title: ***Design of a New Broadband Output Coupler for Optimal THz Laser Performance***
Abstract:
Generating terahertz frequency radiation has been a challenging problem in physics for several decades. In recent work, the Capasso Group at Harvard addressed the problem of frequency tunability by generating terahertz radiation using a quantum cascade laser (QCL)-pumped molecular laser (QPML) concept. A shortcoming of the current QPML cavity design is the output coupler. The goal of the project was to design a broadband output coupler for QPML terahertz lasers that had high efficiency and low losses in a wide frequency range by running simulations for different output coupler designs, materials, sizes, and thicknesses. Simulations were performed with various output coupler designs such as periodic arrays (periodicity g) of metallic strips, squares, and circles. The circular design (radius r) was promising since it had a large region of frequencies with high reflection (≈90%) and low transmission (≈10%), which allows for amplification of the light inside the laser cavity by stimulated emission. For substrate materials with different optical indices (n), it was found that the reflection and transmission functions of the normalized frequency (defined as n g/λ with periodicity g and wavelength λ) over the region 0.017 to 0.95, were similar. The absolute operating frequency region of a given array thus depends on the substrate index of refraction. Different periodicities were simulated to find the frequency regions that maximized efficiency and reflection while minimizing losses. Although a wide range of g values were simulated, the reflection and efficiency were consistently high and the losses consistently low near n g/λ =0.8 and r/g =0.35, meaning that the coupler should be designed with a r/g ratio of approximately 0.35 for normalized terahertz wavelengths of λ=n g/0.8. The new designed output coupler exhibited a higher efficiency (maximum around 60%) than the previous pinhole coupler, making it an attractive alternative coupler for terahertz lasing applications.

48 (Session J)

Student's name: Dane Mansfield
Name of home institution: Amherst College
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Title: ***Bio-trapping Bacteria and Impact on Bio-Corrosion of Carbon Steel***
Abstract:
This study investigated the role of biofilms in the corrosion of 1018 carbon steel surfaces at the

nanoscale. Experiments were conducted in triplicate using two groups of carbon steel coupons that were polished to a high mirror finish. Three coupons were functionalized with a positively charged layer of amines (NH_2/NH^+_3), and three non-functionalized coupons were used as a control. All these coupons were exposed individually to an anaerobic sulfidogenic medium of living bacteria (Desulfovibrio alaskensis G20) for two weeks. It was hypothesized that a layer of positive charge on a coupon surface would trap the typically negatively charged bacterial cells, thereby keeping them near the surface through electrostatic interaction and influencing the initial stages of biofilm formation.The development of nanoscale pits around MnS inclusions and in and around pearlite lamella was expected.The two sets of coupons were analyzed before and after they were subjected to the corrosive medium. Coupons were characterized using high resolution field emission scanning electron microscopy (FE-SEM), energy dispersive X-ray analysis (EDX), and electron backscatter diffraction analysis (EBSD). Particular attention was paid to (1) biofilm formations on the coupons and (2) the localized corrosion in the immediate surroundings of MnS inclusions and within pearlite grains. We observed that functionalized surfaces showed evidence of biofilms piling up on top of each other, helping biofilm/biomineral deposits accumulate on the surface. We also noticed that localized accelerated initial corrosion was more prevalent on functionalized surfaces than on non- functionalized surfaces, perhaps due to greater microbial concentrations present early in the corrosion process. However, it is possible that this localized corrosion is eventually halted by the continued formation of the biofilm in the long term.

49 (Session K)

Student's name: Natalie Ogden
Name of home institution: Rowan University
NNCI Site: KY Multiscale
REU Principal Investigator: Dr. Kevin Walsh, Electrical and Computer Engineering, University of Louisville
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Title: ***Characterization and Optimization of Inkjet Printing Process of the Conducting Silver Structures***
Abstract:
Direct write inkjet printing is a recently advanced additive manufacturing technique that presents several advantages, including low-cost of manufacturing and a quick turn-around. Applying this technology to the micro assembly of microrobots and the fabrication of robotic skin touch sensors, inkjet printing can be a useful option to fabricating in the clean room. Controlled deposition of single droplets can be realized with the help of the Nordson EFD Pico Pulse inkjet printer. A characterization study is presented of conducting inks printing process for a glass substrate. The different conductive inks used are SPI Silver conductive paint and Novacentrix JS-A211 silver

nanoparticle ink. The Taguchi design of experiment (DOE) method was applied determine optimal set of process parameters: air pressure, deposition height, and stroke. The minimum diameter found is 449 microns and the largest is 1068 microns. Deposition quality was evaluated with respect to diameter size, amount of satellites, regularity of droplet's shape. Using this methodology, the best parameters were chosen to print continuous conductive silver lines on a glass substrate. It is hypothesized that the lower levels for each parameter produced the best quality print and smallest diameters.

50 (Session L)

Student's name: Jordana Mazer
Name of home institution: University at Buffalo
NNCI Site: RTNN
REU Principal Investigator: Dr. Aram Amassian, Materials Science and Engineering, North Carolina State University
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*Title**: Study of Surface Functionalization for Direct Printing of Perovskite Single Crystals on Chips***
Abstract:
Previously, direct integration of perovskite single crystals directly into devices has been met with tedious procedures and strict requirements on processing times in addition to low success rates. Specifically, low success rates have been seen when it comes to single crystal growth on pre-patterned chips with metal contact. This is in part due to the differing surface energies affecting the drying behavior on the pre-patterned chip, as well as the heterointerface that can serve as a nucleation spot. This study explores the possible influence surface functionalization may serve single crystal formation. Different self-assembled monolayers (SAMs) that were either thiol-based or silane-based were created and tested to obtain contact angles with solvents such as water and n-cyclohexyl-2-pyrrolidone (CHP), as well as two solutions containing methylammonium lead bromide. Additionally, scans of the surface of each SAM were taken using atomic force microscopy (AFM) to determine height and roughness. Each SAM saw an increase in contact angle measurements and small increases in surface roughness compared to the substrate with no treatment. Additionally, an increase in carbon chain length came with higher contact angles. It is hypothesized that the success rate of single crystal growth on pre-patterned chips can increase with proper surface treatment of each metal to minimize the difference in surface energies and the influence of the heterointerface, which in turn can promote the growth of perovskite single crystals.

51 (Session K)

Student's name: Kristopher Luck
Name of home institution: Murray State University

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Title: ***Study of Monolayer Collapse of Droplets in Virtual Wells and on Microfabricated Pedestals***
Abstract:
Past research focused on patterns that resulted from monolayer collapse on evaporated bourbon whiskey droplets on flat glass slides and coverslips. The methods used in previous research was limited to high contact angle liquids. This research involves two methods of pinning droplets, Teflon wells and pedestals. The Teflon wells are capable of containing the droplet but have rough edges. The pedestals, on the other hand, seem more ideal because they wouldn't have the sides of the wells that could compromise results. To make these pedestals we used SU-8 2100. Following the photolithography process, the pedestals were 120 microns tall and the edges of the top surfaces have much cleaner edges when compared to the Teflon wells. Initial testing of the pedestals included water and 95% ethanol. Compared to glass coverslips, the pedestals gave consistent shaping for the water and the 95% ethanol stayed on the pedestal surface. The pedestals were successfully able to hold 2 µL of water and 95% ethanol. Next, we compared the consistency of patterns from collapsed monolayers using diluted bourbon whiskey (25% ABV, 2 µL droplets). Ten digital images from Teflon slides and SU-8 pedestals each were analyzed using a MATLAB algorithm that compared pixel density and intensity. These results showed that the patterns formed on pedestals are more consistent compared to webs formed on Teflon wells.

52 (Session L)

Student's name: Rodolfo Cantu
Name of home institution: University of Texas at Austin
NNCI Site: Cornell NanoScale Science & Technology Facility (CNF)
PI: Dr. Amal El-Ghazaly, Electrical and Computer Engineering, Cornell University
Mentor: Ludovico Cestarollo, Material Science and Engineering, Cornell University
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Title: ***Fabrication of Flexible Braille Display with Integrated Magnetic Controls***
Abstract:
Technological advancements to date have primarily focused on stimulating only two of the five human senses: sight and hearing. Touch-based interactive technologies can still be considered to be in their infancy. Haptic devices allow tactile interactions between humans and digital interfaces, assisting humans in industries such as healthcare, automotive and entertainment. Magnetorheological elastomers (MREs) based on nanoparticles constitute a promising candidate material for creating tactile interfaces capable of creating high-resolution features on the micron scale. These magneto-responsive elastomers must be integrated with magnetic micro-controls to create the local magnetic fields necessary to actuate deformations.

In order to highlight the potential for these devices, a process was developed to create a system of micromagnetic controls integrated into free-standing microscale cantilevers and beams. First, magnetic microscale circles and ellipses were developed via contact photolithography, sputtering and lift-off process. Circles and ellipses were utilized to create magnets with magnetic moments pointing respectively in the direction perpendicular and parallel to their surface. The magnetic properties of the deposited magnets were studied via vibrating sample magnetometry and the optimal dimensions for both geometries were identified. Based of simulation results, the optimally fabricated circles and ellipses were then deposited in pairs at different distances from each other. These systems of magnets were ultimately designed to be integrated into cantilevers and beams made of a micrometer thin nanoparticle-based MREs to create a magnetic soft actuator.

53 (Session K)

Student's name: Yusaku Abe
Name of home institution: Waseda University Tokyo, Japan
NNCI site: Georgia Institute of Technology, GA
REU PI: Dr. Natalie Stingelin
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Title: ***Stability of Titanium Oxide Hydrates in Cellulose-Based Films for 'Green Photonics'***
Abstract:
Yusaku Abe, Mia Crider, Tanner Hickman, Victoria Quiros Cordero, Natalie Stingelin
Polymers are widely used in optics and photonics as they often are of low optical loss, but their application space is limited by the low refractive index range between 1.3 and 1.6 that can be accessed. One straightforward approach to tune the refractive index of polymers is to incorporate inorganic nanoparticles in the polymer matrix. However, nanoparticles often cause optical losses via light scattering. Recently, transparent hybrid materials with high refractive index between 1.5 and 2.1 have been produced with poly(vinyl alcohol) (PVA) and titanium oxide hydrates. These molecular hybrids are solution-processable and exhibit very low optical losses due to crosslinks between the –OH groups of the PVA and the titanium oxide hydrates, which prevent the formation of TiO_2 particles, thus minimizing optical losses. In this work, we advance 'green' photonics materials using cellulose derivatives in place of PVA. We find that hybrids produced with carboxymethyl cellulose and titanium oxide hydrates are insoluble in water, indicating that physical crosslinks form between the carboxylate groups and the inorganic species. Conversely, when hydroxyethyl cellulose is used as the polymer matrix, the hybrid material remains soluble in water and nanoparticles form over a period of days to weeks. To prevent particle formation, citric acid can be used as a stabilizer of the titanium oxide hydrates, thus achieving stable and homogeneous hybrid films using sustainable resources. This work provides a viable route towards the preparation of sustainable transparent materials of high refractive index and low optical losses for photonics applications.

54 (Session L)

Student's name: Alexander Hardin
Name of home institution: Northern Arizona University
NNCI Site: NCI-SW
REU Principal Investigator: Dr. Ines Montano, Applied Physics and Materials Science, Northern Arizona University
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Title: ***Exciton Energy Transfer in Photosynthetic Systems***
Abstract:
In nature, photosynthetic light harvesting is a highly efficient process (>90%) that can be adapted to a wide range of light conditions, such as different wavelengths and quantities. Artificial photosynthetic technologies have the potential to eclipse the efficiency of current technology by several times. Understanding this process would allow for the development of new light driven chemistry and solar energy, such as new pharmaceutical synthesis techniques. Green bacteria contain sacs of chlorophyll known as chlorosomes that capture this light energy in the first step of photosynthesis. In these organelles, chlorophyll molecules are arranged in helical tubes and sheets, known as aggregates. These aggregates are also known as antennas because a photon interacts with one of these chlorophyll molecules and its energy is transferred through this system of chlorophyll molecules to other systems. Computational models have been used for years to predict the behavior of these systems, but the complicated protein environment of natural systems has made them difficult to compare. Recently advances have been made in making synthetic versions of these organelles, known as polymer chlorosome nanocomposites, which have potential efficiencies greater than those found in nature. These simplified synthetic systems allow for easy comparison to computational models. The challenge at hand is to generate and understand these computational models. These physically based computational models have been constructed using data gathered from Ab Initio computational chemistry software. From this data, Hamiltonians (total energy matrices of the system) were constructed and used in combination with quantum mechanical techniques to predict the time evolution of the system.

55 (Session K)

Student's name: Frank Lynch
Name of home Institution: University of Scranton
NNCI Site: Singh Center for Nanotechnology, University of Pennsylvania
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REU Mentor: Tori Dang, Electrical Engineering, University of Pennsylvania
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Title: ***Exploring the Centrifugal Force as a Control Mechanism for Metal-Assisted Chemical Etching***

Abstract:

Metal-assisted chemical etching (MACE) is a promising wet etching technique that can be used to fabricate Silicon nano/microstructures. In MACE, a thin gold film is selectively deposited on the substrate surface using standard lithography and liftoff techniques. The gold catalyzes an etching reaction on the metal-substrate interface when exposed to the etchant solution consisting of an acid and an oxidant (HF and H_2O_2 in this case). MACE is scalable, low-cost, and flexible; however, due to the random motion of the catalyst during etching, it is inconsistent and difficult to control. This lack of reliable control greatly hinders the potential application of features etched via this method. In this study, the centrifugal force is explored as a potential mechanism to control catalyst motion during MACE procedures. 1 µm diameter hole arrays are etched in a centrifuge across a range of relative centrifugal forces, and the resulting etch profiles are analyzed. Results demonstrate little support for the centrifugal force, as utilized in these experiments, as a practical MACE control mechanism. Etching in a hyper-gravity environment dramatically decreases etch rate, and in some cases, entirely prohibits etching. Tentative explanations for the results are considered, future outlooks are provided, and further questions and experiments are proposed and discussed.

56 (Session L)

Student's name: *Isaiah Raspet*

Name of home institution: *Northern Arizona University*

NNCI Site: *NCI-SW*

REU Principal Investigator: *Dr. Ines Montano, Applied Physics and Materials Science, Northern Arizona University*

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Title: ***Simulating Open Quantum Dynamics Through Quantum Algorithms***

Abstract:

Quantum systems can be simulated through the use of quantum algorithms running on quantum computers. There are currently several possible ways of simulating quantum systems, but it may be helpful to understand quantum systems simulated using the same laws that govern the systems that are being modeled. This method of simulation is relatively less developed, and is what the majority of this project is focused on. The features of quantum computers allow them to act as an analogue of some quantum systems, which may be helpful in models and simulations, but the full extent of its use is unknown yet. In this project, I investigated how to predict the time evolution of an open quantum system, i.e. a quantum system interacting with the environment, using quantum algorithms. Using the Hamiltonian of a given system as input, I studied how to

derive the corresponding quantum circuit which allows to simulate how a given quantum system will change with time.

57 (Session K)

Student's name: Gavin Fowler
Name of home institution: Somerset Community College
NNCI Site: KY Multiscale Site
REU Principal Investigator: Kevin Walsh, Dept. of Electrical & Computer Engineering, University of Louisville
REU Mentor: Jonathan Kopechek, Dept. of Bioengineering, University of Louisville
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Title: ***Optimization of Ultrasound Fields in Acoustofluidic Channels for Microbubble-enhanced Molecular Delivery to Cells***
Abstract:
Recent studies have demonstrated the feasibility of a 3-D printed acoustofluidic system combining ultrasound and flow channels for microbubble-enhanced molecular delivery to cells to potentially treat diseases such as leukemia. However, the ultrasound field generated within the 3-D printed acoustofluidic device has not been well characterized or optimized for this system. The objective of this REU project was to characterize the ultrasound field generated by the transducers in the acoustofluidic system and to manipulate the field for maximum ultrasound pressure within the acoustofluidic channels, which can enhance microbubble destruction and increase drug delivery to cells. During this project, the ultrasound field was measured and mapped out using a 0.2-mm needle hydrophone in a water tank. The distance from the transducer to the region with maximum ultrasound pressure was determined in water alone in comparison to a 1" block of aluminum that was placed in the water tank to increase the speed of sound and move the peak ultrasound pressure closer to the acoustofluidic channels. In addition, experimental studies were conducted to assess the level of microbubble destruction in various ultrasound field conditions. Measurements of the ultrasound field demonstrated that the maximum ultrasound pressure was detected at a distance of 120 mm in water alone, but the maximum pressure was only 40 mm away when the aluminum block was placed in the water tank. Microbubble destruction within acoustofluidic channels increased significantly when the aluminum block was placed in front of the transducer compared to control samples without the aluminum block, as indicated by acoustic attenuation measurements ($p = 0.024$, n=5-6/group). The results of these studies show that optimizing the materials located within the ultrasound field can have a significant impact on the ultrasound pressures within the acoustofluidic channels and can be optimized to enhance microbubble destruction and drug delivery to cells.

58 (Session L)

Student's name: Ganesh Petterson
Name of home institution: St. Lawrence University
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REU Principal Investigator: Dr. Kevin Repasky, Electrical and Computer Engineering, Montana State University
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Title: ***Optimization of Wire-Grid Polarizer Characterization***
Abstract:
The Wire-Grid Polarizer (WGP) is a nanostructure-based device that can function as a polarizing beam splitter effective at multiple incidence angles. A WGP will transmit one polarization state of light, while reflecting the orthogonal polarization, yielding a transmitted and reflected beam. Accurate characterization of these devices is essential, as the transmission and reflection efficiencies vary with incidence angle and input polarization state. Our characterization setup contains elements with parallel reflective surfaces, creating Fabry-Perot cavities which cause power fluctuations dependent on wavelength and incidence angle. To mitigate this issue, power measurements are collected and averaged across a range of wavelengths at each incidence angle to give a mean power at said angle. This lengthy process significantly adds to the duration needed for a full characterization. In this project, we explore methods for reducing the amount of data, and consequently the time, needed to characterize a WGP. Through minor hardware changes, altering the sampling rate to be closer to the Nyquist rate, and reducing the number of samples used, we determine a series of sampling protocols that more than halve the necessary number of samples.

59 (Session K)

Student's name: Robert Lamarche
Name of home institution: Bunker Hill Community College
NNCI Site: CNS (Harvard)
REU Principal Investigator: David Bell
REU Mentor: Jiten Narang, PhD, Bio-Soft Lithography Engineer
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Title: ***Manipulating breast cancer cell alignment by micro-contact printing fibronectin protein patterns***
Abstract:
Previously, the tumor micro-environment (TME) has been studied and tumor cells migration and preferential alignment toward stiffer extracellular matrices (ECM) has been positively correlated. This physical difference is one factor toward tumor metastasis. In this study we aim at improving the understanding of cell alignment by manipulating the arrangement of fibronectin proteins to

subsequently improve mimicked engineering models of the TME. A combination of Photolithography and Soft lithography were used to micro contact print an array of different patterns of fibronectin to create patterned substrates suitable for cell growth. We then studied the resulting arrangement of cells due to the variable fibronectin environment. We produced four patterns: lines, 5 micron in width and spaced 5 microns apart; isosceles triangles, 3 microns by 6 microns; A hexagonal type pattern with a 40 micron diameter; and lastly a solid square used as a control.

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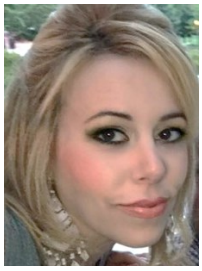

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