KY NANO+AM SYMPOSIUM

July 31 & August 1, 2019

Premier Event Focusing on 3D Printing and Nanotechnology

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Table of Contents

Editor and Document Rights *2*

Table of Contents *3*

Welcome from the 2019 KY Nano+AM Symposium Chair *4*

Organizing Committee *5*

Patrons *6*

Agenda *7*

Keynote Speakers *11*

Panelists *16*

Session 1A: Additive Manufacturing Part I *25*

Session 1B: Technology Opportunities *29*

Session 2A: Cool MEMS Devices & Structures Part I *33*

Session 2B: Manufacturing Core Facilities Part I *37*

Session 3A: Materials for Nanotechnology Part I *41*

Session 3B: Manufacturing Core Facilities Part II *45*

Session 4A: Bioengineering and Life Sciences *49*

Session 4B: Cool MEMS Devices and Structures Part II *54*

Session 5A: Additive Manufacturing Part II *59*

Session 5B: Cool MEMS Devices & Structures Part III *63*

Session 6A: Additive Manufacturing Part III *67*

Session 6B: Materials for Nanotechnology Part II *71*

Poster Abstracts *75*

Abstract *103*

Biography of Presenter *103*

Welcome from the 2019 KY Nano+AM Symposium Chair

On behalf of our Organizing Committee and Technical Chair, it is my pleasure to welcome you to the ***2019 KY Nano+AM Symposium*** being hosted at the University of Louisville. This interdisciplinary 2-day symposium brings together users, researchers, and leaders from industry, government, and academia in the advanced manufacturing fields of additive manufacturing, 3D printing, micro-technology, roll-to-roll printing, nano-technology and inkjet printing to discuss new findings, share results, promote applications, debate the future, and network with one another. We intend this to be ***the premier annual technical conference for advanced manufacturing in the state and immediate region***! Over the course of the next two days you will have the opportunity to a) hear exciting talks from 4 nationally-renown keynote speakers, b) listen to inspirational comments from special guests including the mayor of Louisville and the engineering deans from UofL and UK, c) enjoy over 50 technical talks and poster presentations, d) participate in panel discussions lead by experts in their fields, e) tour state-of-the-art university core facilities open to the public, f) enjoy fantastic food and beverages, and g) reacquaint with old friends and network with new professional contacts.

We thank the financial assistance of our valuable sponsors and patrons listed in the Symposium Proceedings. Without their help, the registration fee would not have been so modest. Finally, I wish to personally thank the hard work of our Organizing Committee, and especially acknowledge the long hours put into this effort by Ana Sanchez, Jacqui Smith and Prof. Shamus McNamara.

Sincerely,

Kevin Walsh
Symposium General Chair

Organizing Committee

General Chair

Kevin Walsh, U. of Louisville

Technical Chair

Shamus McNamara, U. of Louisville

Ana Sanchez Galiano, U. of Louisville

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Tim Gornet, U. of Louisville

Thad Druffel, U. of Louisville

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Erica Gabbard, U. of Louisville

Sanju Gupta, Western K.U.

Glenn Edelen, Funai Lexington Technology Corp.

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Agenda

Day 1 – July 31

8:00 am	**Registration Opens**
8:30 am	**Introduction and Kickoff (W215C-D)** Kevin Walsh, Symposium General Chair Emmanuel Collins, JB Speed School of Engineering John Balk, UK College of Engineering Shamus McNamara, Symposium Technical Chair
9:00 am	**Keynote Speaker (W215C-D)** Philip Rack, University of Tennessee – Knoxville "*Nanoscale Focused Electron and Ion Beam Induced Processing: Extending 3D Printing to the Nanoscale*"
9:45 am (Concurrent Sessions A&B)	**Session 1A (W215A): Additive Manufacturing Part I** **9:45 AM -** "*Powder Packing and Thermal Conductivity in Selective Laser Melting*" by Shanshan Zhang **10:05 AM -** "*Mechanical Properties and Functionalities of 3D Printed Architected Metamaterials*" by Yanyu Chen **10:25 AM -** "*Mechanical Properties and Corrosion Resistance of Laser – Powder Bed Fusion Processed Duplex Stainless Steel*" by Arulselvan Arumugham Akilan
	Session 1B (W215B): Technology Opportunities **9:45 AM –** "*Kentucky Economic Development*" by Brian Mefford **10:05 AM –** "*Louisville Forward*" by Mary Ellen Wiederwohl **10:25 AM –** "*Engineering Capstone Projects for Industry*" by Erica Gabbard
10:45 am	**Break**
11:00 am (Concurrent Sessions A&B)	**Session 2A (W215A):Cool MEMS Devices & Structures Part I** **11:00 AM -** "*Advanced Microelectronics Collaboration: Quilt Packaging® and Bio-MEMS Integration by Indiana Integrated Circuitsat MNTC*" by Jason M. Kulick **11:20 AM -** "*Mass Production Rate Manufacturing of Polymer NanoFilms into Ultraflexible Suspended NEMS/MEMS Structures*" by Robert W. Cohn **11:40 AM -** "*Developing MEMS Bistable Actuators*" by Dilan Ratnayake

	Session 2B (W215B): Manufacturing Core Facilities Part I **11:00 AM –** "*GE First Build*" by Larry Portaro **11:20 AM –** "*The Micro/Nano Technology Center: A Research Core Facility Open for Access*" by Julia Aebersold **11:40 AM –** "*A Look into CeNSE at the University of Kentucky: Cutting Edge Nanoscale Research at the Heart of KY*" by Jillian Cramer
12:00 pm	**Lunch (W215C-D)** Flash Poster Presentations
1:30 pm	**Keynote Speaker (W215C-D)** Harold Sears, Ford Motor Company "*Additive Manufacturing @ Ford - Moving Beyond Prototypes*"
2:15 pm (Concurrent Sessions A&B)	**Session 3A (W215A): Materials for Nanotechnology Part I** **2:15 PM -** "*A Computer Engineering Approach To Design For 3D-Printing Manufacturability*" by Hank Dietz **2:35 PM -** "*Intercalation-Induced Phenomena in Layered and 2D Materials*" by Jacek B. Jasinski **2:55 PM -** "*Solid-Liquid-Vapor Etching of Negative Nanowires and Vapor-Liquid-Solid Metal Oxide Composite Materials*" by Alexandra J. Riddle
	Session 3B (W215B): Manufacturing Core Facilities Part II **2:15 PM –**"*Rapid Prototyping Center and Additive Manufacturing Competency Center*" by Tim Gornet **2:35 PM –** "*Electron Microscopy Center at the University of Kentucky*" by Nicolas Briot **2:55 PM -** *Conn Center* by Thad Druffel
3:15 pm	**Panel Discussion: Open Innovation (W215A)** Panelists: Larry Portaro, GE FirstBuild John Flynn, Fast Radius Nicole Williams, HIVE Adel Elmaghraby, University of Louisville
4:00 pm	**Break**
4:15 pm	**Tours** (MNTC, GE FirstBuild, RPC, Conn Center)
5:30 pm – 7:30 pm	**Evening Reception, Poster Session, and Networking (W215C-D)** **7:00 PM -** Welcome Reception Remarks by Greg Fischer, Mayor of Louisville

Day 2 – August 1

8:00 am	**Registration Opens**
8:30 am	**Introduction (W215C-D)**
8:45 am	**Keynote Speaker (W215C-D)** Edward Kinzel, University of Notre Dame "*Additive Manufacturing of Glass and Scalable Sub-Micron Surface Patterning*"
9:30 am (Concurrent Sessions A&B)	**Session 4A (W215A): Bioengineering and Life Sciences** **9:30 AM -** "*Synergistic Activity of Antiretrovirals co-administered with Q-GRFT Against HIV-1*" by Farnaz Minooei **9:50 AM -** "*Effect of Acoustofluidic Flow on Intracellular Molecular Delivery*" by Connor S. Centner **10:10 AM -** "*DNA-mediated Hierarchical 3D Superstructures of Anisotropic Gold Nanoprisms*" by Emtias Chowdhury **10:30 AM -** "*Development and Optimization of Dual Conjugated Gold Nanoparticles for Glioblastoma Therapies*" by Nicholas Allen
	Session 4B (W215B): Cool MEMS Devices and Structures Part II **9:30 AM –** "*Commercialization Opportunities with the University of Louisville*" by Kayla N. Meisner **9:50 AM -** "*Electronic Glaucoma Drainage Device*" by Saliya Kirigeegagage **10:10 AM -** "*Glancing Angle Deposition for Nanoporous Membranes*" by Chuang Qu **10:30 AM -** "*Analysis of Carbonyls in Exhaled Breath of Smokers and Nonsmokers By A Microreactor Approach*" by Zhenzhen Xie
10:50 am	**Break**
11:00 am (Concurrent Sessions A&B)	**Session 5A (W215A): Additive Manufacturing Part II** **11:00 AM -** "*Low Cost Additive Manufacturing Economic & Environmental Comparison with Conventional Injection Molding*" by Eric Wooldridge **11:20 AM -** "*A 3D Printed Microfluidic Mixing Chamber*" by Alexa M. Melvin **11:40 AM -** "*Optimizing additive manufacturing of NiTi*" by Sayed Ehsan Saghaian
	Session 5B (W215B): Cool MEMS Devices & Structures Part III **11:00 AM -** "*Old Technology New Application: Applying Thermal Inkjet Technology to Emerging Fields*" by Glenn Edelen **11:20 AM -** "*ChevBot: An Innovative Laser Driven Locomotive Microrobot*" by Zhong Yang **11:40 AM -** "*Design and Fabrication of Micro Structures toward Non-volatile Mechanical Memory Devices*" by Ji-Tzuoh Lin
12:00 pm	**Lunch (W215C-D)** Poster Award Presentations

1:30 pm	**Keynote Speaker (W215C-D)** Placid Ferreira, U. of Illinois Urbana-Champaign "*Exploiting Micro & Nanoscale Phenomena for Developing New Manufacturing Capability at Small Dimensional Scale*"
2:15 pm (Concurrent Sessions A&B)	**Session 6A (W215A): Additive Manufacturing Part III** **2:15 PM -** "*A Little Variation Makes a Big Difference: Effect of Composition on Microstructures and Mechanical Properties of 3D Printed 17-4 PH Stainless Steel*" by Thomas Starr **2:35 PM -** "*Tailoring the properties of NiTiHf through selective laser melting process parameters*" by Guher P. Toker **2:55 PM -** "*Metal Fused Filament Fabrication (MF3) of Bronze*" by Mohammad Qasim Shaikh
	Session 6B (W215B): Materials for Nanotechnology Part II **2:15 PM -** "*Determining the Structure and Stability of Thermoelectric La3-xTe4-Ni Composites using High-Resolution and In-Situ TEM*" by M. P. Thomas **2:35 PM -** "*In situ Transmission Electron Microscopy Studies of Metal to Insulator Transition in Tungsten Doped Vanadium Dioxide (V1-xWxO2, x= 0.0, 0.01)*" by Ahamed Ullah **2:55 PM -** "*Adsorption and Opto-electronic Properties of Phosphorene*" by Manthila Rajapakse
3:15 pm	**Panel Discussion: Investors Panel (W215A)** Panelists: Paul Ehlinger, Venture Finance at KSTC Eric Dobson, Angel Capital Group Cy Megnin, Elevate Ventures Claudia Reuter, Techstars
4:00 pm	**Closing Remarks (W215A)**

Keynote Speakers

Nanoscale Focused Electron and Ion Beam Induced Processing: Extending 3D Printing to the Nanoscale
Philip Rack, University of Tennessee – Knoxville

Additive Manufacturing @ Ford - Moving Beyond Prototypes
Harold Sears, Ford Motor Company

Additive Manufacturing of Glass and Scalable Sub-Micron Surface Patterning
Edward Kinzel, University of Notre Dame

Exploiting Micro & Nanoscale Phenomena for Developing New Manufacturing Capability at Small Dimensional Scale
Placid Ferreira, University of Illinois

Nanoscale Focused Electron and Ion Beam Induced Processing: Extending 3d Printing to the Nanoscale

Philip D. Rack[1,2]
[1]University of Tennessee, Department of Materials Science and Engineering, Knoxville, Tennessee 37996, USA
[2]Oak Ridge National Laboratory, Center for Nanophase Materials Science, Oak Ridge, Tennessee 37830, USA

Focused electron and ion beam induced processing have been used for decades as a means to direct nanoscale deposition and etching. While particularly suited for nanoscale prototyping due to the relatively slow process, commercial applications such as lithographic mask repair and circuit editing have emerged. In this talk we will overview the critical electron/ion-solid-gas interactions that are critical to nanoscale directed synthesis via focused electron and ion beams. We will then illustrate a synchronized pulsed laser assist can facilitate both enhanced purity deposition and faster etching, where we leverage short photothermal pulses to mimic an atomic layer deposition/etching process. Finally, we will overview our teams recent work in extending focused electron beam induced deposition to three dimensions (3d). Appropriate control of the electron beam raster sequence provides a means to "lift" deposition off the substrate and thus the ability to print complex three dimensional structures. We will demonstrate our recent experimental and simulation results and introduce a computer aided design program that can turn an electron microscope into a 3d nanoscale printer. Finally, we will overview some recent nanoscale 3d applications and hierarchical synthesis that are emerging and are uniquely possible via 3d nanoscale printing via focused electron beam induced deposition.

Additive Manufacturing @ Ford – Moving Beyond Prototypes

Harold Sears
Ford Motor Company

BRIEF ABSTRACT

This talk will take you through the journey of the implementation of AM technologies at Ford and share with you the direction and growth strategies for the future. Ford has a long history of using additive manufacturing, however for many years it was simply a tool product development used for creating prototypes. As we move forward in time, we are moving beyond simply using it as a prototyping method and beginning to apply these technologies in the manufacturing environment.

BIO

Harold Sears, Rapid Manufacturing Technical Leader, Ford Motor Company.

Harold is Technical Leader of Additive Manufacturing Technologies for the Manufacturing organization at Ford Motor Company. He is known internally as Ford's "3D printing futurist" and is identified as a key person for driving Additive Manufacturing within Ford. He was part of an initial group of Ford employees who have followed 3D printing since its inception in the 1980's and helped the technology grow into what it has become today.

Harold has worked as an Operator, Lead Engineer, Supervisor, Technical Specialist and now a Technical Leader in Additive Manufacturing at Ford. In his current role, he has responsibility for the integration of Additive Manufacturing technologies within the global Manufacturing organization and acts as an internal consultant for the company.

Additive Manufacturing of Glass and Scalable Sub-Micron Surface Patterning

Edward C. Kinzel
Aerospace and Mechanical Engineering, University of Notre Dame

Abstract

Silicate glasses have unique properties including high transparency, low temperature sensitivity, and high chemical/electrical resistance. Additive Manufacturing (AM) provides the potential to create parts with complicated geometries over low production volumes as well as opening new possibilities for diverse applications ranging from functionally graded optics to integrated lab-on-a chip devices. This presentation describes ongoing work printing optically transparent glass using a new laser-heated, filament-fed process. A CO_2 laser is used to locally melt, continuously fed, small-diameter glass rods and fiber. 3D shapes are constructed by moving a 4-axis CNC stage relative to the intersection of the filament and the laser beam. Material consolidated by the melting process, solidifies out of the melt pool as the part translates relative to the laser beam allowing the deposition of free-standing transparent structures. Research towards the large-area low-cost fabrication of metasurfaces will also be presented. Microsphere Photolithography (MPL) is a practical, cost-effective nanofabrication technique. It uses self-assembled lattice microspheres in contact with a photoresist layer as an optical element. The microspheres focus incident light to a sub-diffraction array of photonic jets in the photoresist. A wide range of structures can be deposited on non-planar substrates. Work depositing functional metasurfaces will be presented including designs to control the emission of thermal radiation and index of refraction sensing on the tip of an optical fiber. Finally, effort to scale-up both processes will be described.

Biography

Edward Kinzel received his B.S., M.S. and Ph.D. in Mechanical Engineering from Purdue University in 2003, 2005, and 2010, respectively. His graduate work was focused on laser-based micro/nano fabrication including Laser Forward Transfer and Selective Laser Sintering of electronics as well as near-field direct-write nanolithography with sub-100 nm resolution. Following PhD, he was a postdoc in the Infrared Systems Laboratory (UCF:CREOL/UNCC) focusing on the design and application IR antennas, FSS/metasurfaces and their observation with Near Field Scanning Optical Microscopy. From 2012-2019 he was an was an Assistant/Associate Professor at the Missouri University of Science and Technology. In 2019, he joined the faculty of the Aerospace and Mechanical Engineering department at the University of Notre Dame. Dr. Kinzel's current research includes practical nanofabrication of FSS/metasurfaces for controlling thermal transport, additive manufacturing of glass for optical applications, and applying FSS/metasurfaces as well as IR/optical antennas as sensing elements and for energy harvesting. Dr. Kinzel is a member of ASME, SPIE, and IEEE and has authored/co-authored over 40 journal papers.

Exploiting Micro- & Nanoscale Phenomena for Developing new Manufacturing Capability at Small Dimensional Scales

Placid M. Ferreia
University of Illinois

Abstract:

Mechanics and transport at the micro- and nanoscale offer a rich set of controllable phenomena that can be exploited for the development of manufacturing processes compatible with these scales. This talk will develop this idea with two example processes: Solid-State Superionic Stamping, which exploits ionic transport and Laser Micro-Transfer Printing (LMTP), which exploits thermally driven thin-film delamination at the microscale.

Nano-patterning of silver and copper using chemical etch-based fabrication pathways has always been challenging for semiconductor industry. We exploit the high room-temperature ionic conductivity in silver and copper-based glassy electrolytes as the basis for patterning of metallic nanostructures giving rise to a facile, yet scalable, all solid-state electrochemical nanoimprinting process we call Solid-State Superionic Stamping (S4). The capabilities of this process and possible extensions will be discussed.

Motivated by heterogeneous functional integration, microscale assembly by transfer printing, specifically, laser micro-transfer printing will be discussed. A non-contact variant of micro-transfer printing, this process opens up new possibilities for micro-scale distribution of mechanical function to create mechanically active composites. The mechanics and applications of the process will be discussed.

About the Speaker:

Placid M. Ferreira is the Tungchao Julia Lu Professor of Mechanical Science and Engineering at Illinois. From 2003 to 2009, he was the director of the Center for Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS), an NSF-sponsored Nanoscale Science and Engineering Center after which he served as the Head of the Department of Mechanical Science and Engineering at Illinois until August 2015. He graduated with a PhD in Industrial Engineering from Purdue University in 1987, M.Tech (Mechanical) from IIT Bombay, 1982 and B.E. (Mechanical) for University of Bombay in 1980. He has been on the mechanical engineering faculty at Illinois since 1987, serving as the associate head for graduate programs and research from 1999 to 2002.

Professor Ferreira's research and teaching interests are in precision manufacturing and includes computer-controlled machines, nano-manufacturing and metrology. Professor Ferreira received NSF's Presidential Young Investigator Award in 1990, SME's Outstanding Young Investigator Award in 1991, University of Illinois' University Scholar Award in 1994, ASME’s Ennor Award for Manufacturing Technology in 2014. He is also a Fellow of ASME, SME and AAAS. He has served on the editorial board of a number of manufacturing-related journals.

Panelists

Open Innovation

- Larry Portaro, GE FirstBuild
- John Flynn, Fast Radius
- Nicole Williams, HIVE
- Adel Elmaghraby, University of Louisville

Investors Panel

- Paul Ehlinger, Venture Finance at KSTC
- Eric Dobson, Angel Capital Group
- Cy Megnin, Elevate Ventures
- Claudia Reuter, Techstars

Larry Portaro

Larry Portaro, is Executive Director of FirstBuild, a wholly owned subsidiary of GE Appliances, a Haier company. FirstBuild's mission is to innovate the next big idea in home appliances using outside-in innovation and rapid consumer feedback to fuel its design-build-sell model. FirstBuild's most successful product launches include the Opal Nugget Ice Maker, Paragon, Open Hearth Oven and the Forge Clear Ice System. FirstBuild, located on the University of Louisville campus, offers a free community makerspace, workshop and microfactory in 35,000 square feet of space. Every year, thousands of visitors come to showcase their creativity, share their passion projects, and see what FirstBuild is working on next.

Larry earned a Bachelor of Science in Electrical Engineering and a Master of Engineering in Electrical Engineering from the University of Louisville. He has 25+ years of experience at GE Appliances.

John Flynn

John Flynn leads Fast Radius's Enterprise Solutions team. In this role, Flynn leads Fast Radius's engineering team, and is responsible for the creation and execution of partnerships with key customers, developing and delivering solutions that drive successful outcomes across their organizations.

Prior to joining Fast Radius, Flynn spent the better part of a decade at The General Electric Company (NYSE: GE), rising through a series of leadership training programs focused on finance, operations, the customer experience, and commercial strategy. Most recently, he was a commercial sales and operations leader at GE Additive, a leading provider of metal additive machines and services.

Flynn holds a BA from Fordham University in New York City, NY.

Nicole Williams

Currently I am HIVE's Student Ambassador and Kindred Sr. Project Manager. I have been with Kindred for 14 years working on a variety of strategic company initiatives. Since we have started the HIVE partnership, I have worked closely with students and Kindred teams as we focus on developing innovative healthcare technology solutions.

Adel S. Elmaghraby

Adel S. Elmaghraby, an IEEE Senior Member, is professor and chair of the Computer Engineering and Computer Science Department at the University of Louisville. He has also held appointments at Carnegie Mellon's Software Engineering Institute and the University of Wisconsin-Madison, and has advised over 60 master's graduates and 24 doctoral graduates. His research and publications span intelligent systems, neural networks, cyber-security, visualization and simulation. The IEEE-Computer Society has recognized his work with multiple awards including a Golden Core membership.

Paul Ehlinger

Paul Ehlinger is currently the Fund Manager for the Kentucky Enterprise Fund. The Kentucky Enterprise Fund has $35M in assets under management having invested in over 130 early stage startup companies. While working with KEF, Paul has led investments into several companies and also passionately developed resources to build a larger regional investment community. Before joining KEF, Paul worked with Medtronic in Irvine, CA developing their next generation of flow-diverting stents for the treatment of brain aneurysms. Having grown tired of corporate life, he left Medtronic to help launch Wallaby Medical, a medical device startup which is currently securing FDA approval. Paul holds a BS and MS in biological engineering from the University of Missouri and University of California, respectively.

Eric Dobson

Eric Dobson is the Chief Executive Officer of the Angel Capital Group, a syndicate of 10 angel groups and funds. He spent the last 27 years working in government and the private sector, the last 17 in start-up technology ventures. He founded four, helped found six, advised dozens, and led investments in 25+ companies. Eric has served as the CEO of several companies in various phases of growth from startup to exit. He has served on a number of Board of Directors and Advisors with for profit and not-for-profit companies. He holds a BA from the University of Tennessee where he is also a Lecturer on Entrepreneurship in the Department of Management in the Haslam College of Business. He received a Masters of Science and Doctorate from the University of South Carolina. He now applies all the hard-earned knowledge and experience from these ventures and exploits to venture-style investing.

Cy Megnin

Cy Megnin has been an entrepreneur, founder and advisor for the past two decades. Past companies include Intel Capital portfolio company PrepFlash; an AI company that uses NLP to automatically create flashcards from any content, and CloudCoreo a configuration management company that garnered investment from Microsoft and ultimately sold to VMware. He was in the 2014 class of 40 under 40 for Professional Remodeler Magazine at the helm of the long running real estate investment firm OCPS and was twice featured on TLC's hit TV show "Flip That House". He is currently back in his hometown of Bloomington, IN with his wife Andrea and son Jack working for Elevate Ventures as an EIR, after spending the last 15 years in Austin, Seattle and the Bay area. He has a degree in Economics from Indiana University and an MBA from Baylor University, where he is an executive judge for their annual MBA Ethics competition.

Claudia Reuter

Claudia Reuter is the Managing Director for the Stanley+Techstars Additive Manufacturing Accelerator. Recognized by the Boston Business Journal as a 2016 Women to Watch in Science and Technology, and as a Changemaker by HUBWeek, she is an experienced entrepreneur and executive. Prior to joining Techstars, she served as the SVP of Digital Services & Labs for Houghton Mifflin Harcourt, and was the co-founder and CEO of SchoolChapters, Inc. She also currently serves on the Board of Directors at Lessonly, as a member of the Advisory Board at Greenfig, and as a member of the Editorial Advisory Board at Innovation Leader.

Session 1A: Additive Manufacturing Part I

Powder Packing and Thermal Conductivity in Selective Laser Melting

Shanshan Zhang[1], Brandon Lane[2], Justin Whiting[2], Kevin Chou[1]
[1]Department of Industrial Engineering, University of Louisville, Louisville, KY, 40292
[2]Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, 20899

Mechanical Properties and Functionalities of 3D Printed Architected Metamaterials

Yanyu Chen[1], Huan Jiang[2]
[1]Department of Mechanical Engineering, University of Louisville, KY 40292

Mechanical Properties and Corrosion Resistance of Laser – Powder Bed Fusion Processed Duplex stainless steel

Arulselvan Arumugham Akilan1, Chang Woo Gal1,2, Subrata Deb Nath1, Azim Gokce1,5, Harish Irrinki[1], Jerome Stanely[3], Emma Rebecca Clinning[4], Gautam Gupta[4], Seong Jin Park[2], Vamsi Krishna Balla[1,6], Sundar V. Atre[1*]
[1]Materials Innovation Guild, University of Louisville, Louisville KY 40208
[2]Department of Mechanical Engineering, POSTECH, Republic of Korea
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Powder Packing and Thermal Conductivity in Selective Laser Melting

Shanshan Zhang[1], Brandon Lane[2], Justin Whiting[2], Kevin Chou[1]

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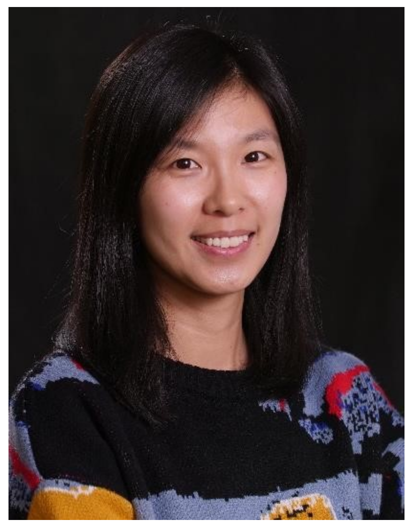
[2]*Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, 20899*

Abstract

Powder thermal properties play a critical role in laser powder-bed fusion (LPBF) additive manufacturing; specifically, the poor thermal conductivity of the metallic powder significantly affects process heat transfer, which can influence the melt pool characteristics, and consequently, the build part mechanical properties. Up to now, the fundamental of the powder bed thermal properties has not been well understood. Though it is widely known that metallic particles in a powder-bed have a lower thermal conductivity than the solid material, quantitative information has not been established and currently available equipment is not capable of measuring the powder-bed thermal diffusivity directly. The objective of this study is to indirectly measure the thermal conductivity of metallic powder in LPBF using specially designed samples, laser flash testing, finite element analysis and a multivariate inverse method. The results obtained so far consistently show that the powder thermal conductivity is approximately only 5% of the solid thermal conductivity for two different powder materials in a wide range of testing temperatures. This talk will detail the experimental and numerical approaches used in this research, including the sample designs, the LPBF build process, the laser flash test, heat transfer modeling, and the inverse method. Major findings from various studies including different materials, different sample geometries, and sintered powder, etc., will be presented.

Biography of Presenter



Shanshan Zhang is currently a Postdoctoral Associate at University of Louisville. She graduated from University of Louisville with a Ph.D. degree in Industrial Engineering in 2017. Her Ph.D. work was mainly about design, analysis and application of thin-featured cellular structures in metal laser powder bed fusion (LPBF). Previously, she gained her MS and BS degrees in Material Science from Northeastern University (China), focusing on heat treatment and microstructure characterization on aluminum alloys. Dr. Zhang's research interest includes product design and manufacturing, process control, metrology, and material characterization. Her recent research has been primarily focused on metal LPBF, including measurements of the thermal properties of metallic powder, the tensile property variability from different process conditions, and fundamental analysis and mechanical evaluation on surrogate defects in LPBF.

Mechanical Properties and Functionalities of 3D Printed Architected Metamaterials

Yanyu Chen[1], Huan Jiang[2], the presenter's name is **Yanyu Chen**

[1]Department of Mechanical Engineering, University of Louisville, KY 40292

Abstract

Architected metamaterials, which are rationally designed multiscale material systems, exhibit novel functionalities and unique properties that cannot be readily achieved in natural bulk solids. In addition to unusual mechanical and physical properties, such as high specific stiffness and strength, negative Poisson's ratio, and negative coefficient of thermal expansion, architected metamaterials have been designed and optimized for novel elastodynamic wave phenomena. One example of such architected metamaterials is phononic metamaterial, which consists of periodically topological structures and materials dispersions. These rationally designed structures enable the manipulation of propagating acoustic or elastic waves, but not simultaneously. Here we report a new type of three-dimensional (3D) architected hollow sphere foams that can attenuate acoustic and elastic waves synchronically. Our numerical simulation results reveal that the acoustic wave attenuation is attributed to local resonances in the drilled hollow spheres, which act as Helmholtz resonators. The elastic wave mitigation stems from Bragg scatterings in the 3D architected periodic hollow sphere foams. Notably, elastic wave band gap properties can be decoupled from acoustic wave and independently tuned by tailoring the connectivity among the hollow spheres. In addition, we fabricated the architected hollow sphere foams by using the 3D printing technique and experimentally demonstrated the existence of omnidirectional acoustic and elastic wave band gaps. Our findings reported here offer new opportunities to design lightweight architected metamaterials to control undesired noise and vibration over a wide range of frequency.

Biography of Presenter

Dr. Yanyu Chen is an assistant professor in the Department of Mechanical Engineering at the University of Louisville. Prior to this appointment, he was a postdoctoral fellow in the Transportation and Hydrogen Systems Center at National Renewable Energy Laboratory (NREL). He earned a Ph.D. degree in Mechanical Engineering from Stony Brook University. He also worked as a Structural Analysis Engineer at China Aerospace Science and Industry Corporation for about two years. His research interests include mechanical metamaterials, bioinspired composites, phononic metamaterials, and additive manufacturing.

Mechanical Properties and Corrosion Resistance of Laser – Powder Bed Fusion Processed Duplex stainless steel

Arulselvan Arumugham Akilan[1], Chang Woo Gal[1,2], Subrata Deb Nath[1], Azim Gokce[1,5], Harish Irrinki[1], Jerome Stanely[3], Emma Rebecca Clinning[4], Gautam Gupta[4], Seong Jin Park[2], Vamsi Krishna Balla[1,6], Sundar V. Atre[1*]

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ABSTRACT

Duplex stainless steel is a steel characterized by a two-phase microstructure consisting of approximately 50 % ferrite and 50% austenite. This two-phase microstructure provides the alloy with high strength and corrosion resistance under extreme environments by combining the good properties of both the constituent phases. Thus, duplex stainless steel has become a very important steel and finds interest in a wide range of applications. However, very few studies have been conducted to fabricate the duplex stainless steel parts via laser powder bed fusion (LPBF). In this study, physical, mechanical and corrosion properties of water-atomized duplex stainless steel processed by L-PBF were reported. The laser power and layer thickness were kept constant, and the hatch spacing along with scan speed were varied to understand their influence on the above properties. The corrosion properties including corrosion current, polarization resistance and corrosion rate were quantified from the Tafel plots. The results indicated that L-PBF fabricated duplex stainless steel offer superior mechanical and corrosion properties than wrought, powder metallurgy (PM) and metal injection moulded (MIM) samples.

BIOGRAPHY OF THE PRESENTER

Arulselvan Arumugham Akilan is a PhD student in Mechanical Engineering at the

University of Louisville. He has a Master's in Material Science from the Technical University of Darmstadt, Germany and a Bachelor's in Mechanical Engineering from India. His primary research areas are laser-based powder bed fusion (L-PBF) and finite element modelling of metal powders and bulk materials, respectively.

Session 1B: Technology Opportunities

KY Innovation: Growing and Strengthening the Startup Ecosystem

Brian Mefford

Louisville Forward

Mary Ellen Wiederwohl

Engineering Capstone Projects for Industry

Erica Gabbard, *University of Louisville, J.B. Speed School of Engineering, Director of Industry Engagement*

KY Innovation: Growing and Strengthening the Startup Ecosystem

Brian Mefford

Executive Director, KY Innovation

KY Innovation is the Kentucky Cabinet for Economic Development's team dedicated to helping courageous entrepreneurs, creative business founders, high-growth startups and savvy investors star in their own success stories. KY Innovation is to be the central hub for connecting startups to the right sources of connections, collaborators and capital to help companies imagine, launch, grow and scale.

In order to facilitate this mission and both grow and strengthen Kentucky's entrepreneurial ecosystem, KY Innovation has launched several initiatives. That includes Regional Innovation for Startups and Entrepreneurs (RISE), which represents the state's completely rejuvenated and refocused approach to building vibrant clusters of innovation across the state and growing the overall economy. This 120-county effort leverages each region's unique strengths for fostering innovation and unites universities, established companies and industry sectors, entrepreneurs, business accelerator and incubator programs and many other public and private entities.

KY Innovation also established the Commonwealth Commercialization Center (C3). The newly created science and technology non-profit that will be Kentucky's flagship for supporting and accelerating entrepreneurship, invention and innovation across the state. Led through a partnership between KY Innovation in the Cabinet for Economic Development, the University of Kentucky and University of Louisville, C3 will provide resources to all of the state's public universities and colleges in order to transition patents and IP into business growth through investment. One of the first programs of its kind in the United States, C3 seeks to fuel overall economic growth and make Kentucky a regional and national leader in commercialization and technology transfer.

BIO

Brian is executive director of the Cabinet for Economic Development's KY Innovation team. He previously founded Connected Nation Inc., a broadband services firm, where he served as CEO for nearly a decade. Spun off the startup CNX and led development of a software platform that allows government entities to partner with broadband service providers to share assets, information and processes to accelerate fiber broadband and 5G network growth. Mefford's background also includes consulting with Congress in 2008 leading up to the approval of the State Broadband Initiative and an advisory role with the FCC and US Commerce Department during creation of a national broadband map to support local broadband expansion. In 2016, he was appointed to the Federal Communication Commission's Broadband Task Force. Internationally, he has served as a US Ambassador to the International Telecommunications Union, was a technology advisor on the International Advisory Panel for the Prime Minister of Malaysia and served as a US advisor to the Institute of Rural Management Anand (IRMA) India. He currently serves as a director on the Board of Trustees of Centre College in Danville, KY and is Vice Chairman of the Intermodal Transpark Authority in Bowling Green, KY.

Chief, Louisville Forward

Mary Ellen Wiederwohl

Mary Ellen Wiederwohl joined Louisville Mayor Greg Fischer's administration in 2012, and in 2014 Fischer tapped her to lead Louisville Forward – the city's integrated approach to economic and community development. Louisville Forward combines business attraction, expansion, and retention activities with all the city's real estate functions and talent development to present a unified solution for job growth and quality of place. Louisville Forward has been named a Top Economic Development Organization five times by *Site Selection Magazine*, the leading trade publication for economic development, with announced projects totaling over $5.6 billion of investment, more than 23,000 new jobs and over 260 company locations since its creation 2014.

Mary Ellen has provided leadership for several of Mayor Fischer's major initiatives, including his strategic plan, the Vision Louisville 25-year advanced plan, the Move Louisville strategic multi-modal transportation plan, the city's first sustainability plan, the Global Louisville Action Plan and the Vision Russell Initiative, which has won three HUD Choice Neighborhoods grants.

Mary Ellen has been active in the civic and cultural life of Louisville for several years in many capacities. She is a Past President of the Junior League of Louisville, currently serves as a member of the Louisville Orchestra Board of Directors and Executive Committee, Greater Louisville Inc. (GLI) Board, and the Louisville Regional Airlift Development board. She also represents the Mayor and Louisville Metro Government on several boards, including KentuckianaWorks, Waterfront Development Corporation, Downtown Development Corporation, Trees Louisville, One West, and the Louisville Metro Housing Authority. She is a member of the International Women's Forum (IWF) and the Urban Land Institute (ULI), and completed ULI's Daniel Rose Fellowship in Public Leadership in 2013.

She is a proud graduate of the University of Louisville.

Mary Ellen believes fervently that everyone deserves a chance, sometimes we all need a break, and luck comes to those who work hard.

Engineering Capstone Projects for Industry

Erica Gabbard, *University of Louisville, J.B. Speed School of Engineering, Director of Industry Engagement*

Abstract

Senior design/capstone courses are required for undergraduate engineering students and are the culminating experience that allows them to put into practice the curriculum that they have been learning.

Students in capstone are typically 1-2 semesters from graduating and will have already completed three semesters of an engineering co-op. Students in the capstone course will be divided into teams of 3-5 members and will have on average 14 weeks to complete an industry project. These projects can be back burner ideas, current problems, or projects that are in need of a new prospective. Capstone projects can be completed with students majoring in bio engineering, chemical engineering, computer engineering, computer science, electrical engineering, industrial engineering, and mechanical engineering.

Biography of Presenter

Erica Gabbard is the Director of Industry Engagement at the University of Louisville J.B. Speed School of Engineering. She holds a Master of Science degree in Human Resource Education and Organizational Development and is a licensed Project Management Professional (PMP). Ms. Gabbard has over 10 years of experience in career development and employer relations. She currently serves as an executive committee member for the ACE Mentor program board in Louisville and is also involved with the Kentucky Associations of Colleges and Employers (KACE), Kentucky Career Development Association (KCDA), Young Professionals Association of Louisville (YPAL), and serves as a Staff Senator for UofL.

Session 2A: Cool MEMS Devices & Structures Part I

Advanced Microelectronics Collaboration: Quilt Packaging® and BioMEMS Integration by Indiana Integrated Circuits at MNTC

Jason M. Kulick[1], Jackson Lu[1], Carlos Ortega[1], Edit Varga[1], Seth Siders[1], Gary H. Bernstein[2],

[1]*Author's affiliation: Indiana Integrated Circuits, LLC*

[2]*Author's affiliation: University of Notre Dame*

Mass Production Rate Manufacturing of Polymer NanoFilms into Ultraflexible Suspended NEMS/MEMS Structures

Robert W. Cohn

ElectroOptics Research Institute & Nanotechnology Center, University of Louisville

DEVELOPING MEMS BISTABLE ACTUATORS

Dilan Ratnayake[1], Kevin M. Walsh[1]

[1]Electrical and Computer Engineering, University of Louisville

Advanced Microelectronics Collaboration: Quilt Packaging® and BioMEMS Integration by Indiana Integrated Circuits at MNTC

Jason M. Kulick[1], Jackson Lu[1], Carlos Ortega[1], Edit Varga[1], Seth Siders[1], Gary H. Bernstein[2],

[1]*Author's affiliation: Indiana Integrated Circuits, LLC*

[2]*Author's affiliation: University of Notre Dame*

Abstract

Indiana Integrated Circuits, LLC (IIC) has worked closely with the Micro/Nano Technology Center for several years, both as external users and by teaming with the Micro/Nano Technology Center (MNTC), to accomplish a variety of microfabrication goals for IIC customer projects. IIC develops and helps customers to implement advanced microelectronics technology that enables them to exceed current state-of-the-art for nextgeneration electronics systems. This is accomplished through a licensing business model which includes extensive prototyping and proof-of-concept work to develop, mature and transition advanced packaging and integration technologies. This presentation will include updated results and data on Quilt Packaging (QP) integration technology projects for which IIC utilized MNTC. These projects include defense and non-defense customers, both private and government entities. Selected results of defense-related applications that IIC has utilized MNTC to accomplish include radio-frequency/microwave systems, DCDC converter, satellite/space applications, curved imaging array, electronics miniaturization and ruggedization. IIC work with/at MNTC in non-defense applications include automotive (power electronics), scientific (high-energy particle detector architecture enabled by orthogonal chip integration), and healthcare (bio-MEMs).

Biography of Presenter

Jason Kulick is a co-founder of Indiana Integrated Circuits, and as President is responsible for assuring successful business growth through the selective development of new technology, the execution of contracted R&D, and the development of new products. His work has involved project management of equipment installation, semiconductor process development, laser diode fabrication & testing, advanced microchip assembly & packaging techniques, and the management of various R&D programs. Mr. Kulick has authored or co-authored over 30 papers & invited talks and is an inventor on over thirty issued and pending U.S. & international patents. Mr. Kulick received his Bachelor of Science degree in Electrical Engineering from the University of Notre Dame.

Mass Production Rate Manufacturing of Polymer NanoFilms into Ultraflexible Suspended NEMS/MEMS Structures

Robert W. Cohn

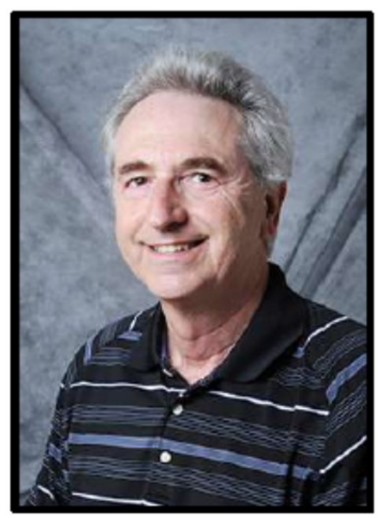
ElectroOptics Research Institute & Nanotechnology Center, University of Louisville

Abstract

Semiconductor device manufacture is one of the world's largest manufacturing activities. There is a continuing industry push, referred to as "More than Moore" (MtM), to integrate additional functions and materials into electronic devices. MtM devices will incorporate many soft, flexible and delicate materials (including biomaterials) that can be easily destroyed, or otherwise negatively affected, by conventional fabrication processes. One approach to adding and integrating soft suspended structures into electronic chips has been to form suspended structures (such as fibers, beaded fibers and localized membranes) by near-field, direct-write electrospinning or by brushing polymeric liquids that self-assemble into well-ordered arrays. These and other related methods do not simultaneously provide arbitrary patterning and high enough throughput to economically justify their use in existing mass production rate manufacturing systems. However, a new method, referred to as Shape Transformation

Photolithography (STP), overcomes these limitations. It projection prints holes through a suspended thin polymer film, followed by a thermal anneal that causes the film to flow and self-assemble into structures finer than the optical resolution limit. STP appears to be scalable to production rates of > 60 wafers/hr in 193 nm wafer steppers (as currently used in semiconductor factory front ends) and 300 m/min roll-to-roll processing. Experimental demonstrations of STP are described together with an extension that permits general 3D structures to be built by successive layer-by-layer STP. Examples will be given of how these suspended structures can be used, either directly or as sacrificial structures to fabricate complex 3D NEMS/MEMS.

Biography



Robert W. Cohn, Professor of Electrical and Computer Engineering, University of Louisville, has studied optical signal processing and holography, laser material processing, and nanofabrication by principles of selfassembly. From 1978-1989 he was a Member of the Technical Staff at Texas Instruments, where he performed research on optical, acoustic and microwave signal processing and signal processing devices. In 1999 Cohn was elected Fellow of the Optical Society of America for his research on optical signal processing and real time computer-generated holography.

DEVELOPING MEMS BISTABLE ACTUATORS

Dilan Ratnayake[1], Kevin M. Walsh[1]

[1]Electrical and Computer Engineering, University of Louisville

Abstract

This research study focused on fabricating several bistable dome-shaped diaphragms and determining if it was possible to switch their mechanical state thermally. Three different types of MEMS-based diaphragms were studied: oxide-polyimide diaphragms, oxide-aluminum diaphragms, and oxide-aluminum-polyimide diaphragms. In all cases, the compressive stress in the thermally-grown oxide layer was engineered to cause the released films to buckle. However, due to the thin oxide's fragile nature, it was determined that a stress-free structural layer was needed to produce nice uniform hemispherical domes. Polyimide was shown to be an excellent candidate material for the structural layer. Arrays of oxide-polyimide bilayer domes with diameters ranging from 100 µm to 700 µm were fabricated and found to be mechanically bistable at room temperature. With all three combinations of diaphragm materials, we experimentally found that there were two distinct regions of operation. All the structures were truly bistable and would remain in their 2nd state when mechanically switched using vacuum and then released. However, when the diameter was reduced to less than 250 µm, the structures were no longer bistable and would return to their original state once the vacuum was removed. All devices were thermally tested and only the 400 µm diaphragms successfully changed state with temperature. Approximately 50% of the 400 µm diameter oxide-aluminum-polyimide diaphragms switched their states from buckled down to buckled up with temperature. The transition occurred between 100 ℃ to 110 ℃. Analytical modeling using equations predicted a transition temperature of 44 ℃. Although it was possible to thermally actuate these devices once, it was found that they would not thermally actuate a second time.

Biography of Presenter

Dilan Ratnayake, PhD joined KY Multiscale Manufacturing and Nanointegration Node (MMNIN) in April 2019 as a Postdoctoral Associate. He has more than 9 years of handson experience in the area of semiconductor microfabrication and MEMS/Microelectronics devices in a class 100 cleanroom. He has worked at the GW Nanofabrication and Imaging Center as a Process Engineer before joined to KY MMNIN. Dr. Ratnayake received his PhD in Electrical Engineering and MS in Physics from the University of Louisville.

Symposium Electronic Proceedings

Session 2B: Manufacturing Core Facilities Part I

GE First Build
Larry Portaro

The Micro/Nano Technology Center: A Research Core Facility Open for Access
Dr. Julia Aebersold

A Look into CeNSE at the University of Kentucky: Cutting Edge Nanoscale Research at the Heart of KY
Jillian Cramer

GE FirstBuild

Larry Portaro
Executive Director, Firstbuild

Larry Portaro is Executive Director of FirstBuild, a wholly owned subsidiary of GE Appliances, a Haier company. FirstBuild's mission is to innovate the next big idea in home appliances using outside-in innovation and rapid consumer feedback to fuel its design-build-sell model. FirstBuild's most successful product launches include the Opal Nugget Ice Maker, Paragon, Open Hearth Oven and the Forge Clear Ice System. FirstBuild, located on the University of Louisville campus, offers a free community makerspace, workshop and microfactory in 35,000 square feet of space. Every year, thousands of visitors come to showcase their creativity, share their passion projects, and see what FirstBuild is working on next.

Larry earned a Bachelor of Science in Electrical Engineering and a Master of Engineering in Electrical Engineering from the University of Louisville. He has 25+ years of experience at GE Appliances.

The Micro/Nano Technology Center:
A Research Core Facility Open for Access

Julia Aebersold, Ph.D.[1]

[1]*Micro/Nano Technology Center, Speed School of Engineering, University of Louisville, Louisville, KY*

Abstract

The Micro/Nano Technology Center (MNTC) is a core research facility at the University of Louisville's class encompassing a $30 million class 100/1000 cleanroom facility and the Huson Imaging and Characterization Laboratory (HICL). Both labs are open access that support a wide range of research initiated by faculty, academic institutions, start-ups, medium and large businesses locally and around the country. Extensive capabilities reside within both facilities for imaging and characterization or development of applications in micro/nanotechnology, sensors, transducers, microelectromechanical systems (MEMS), advanced materials, biomedical, space, and governmental applications. This core facility is utilized by a wide variety of disciplines in Engineering along with Chemistry, Physics, and Medicine.

Capabilities of the center include a full array of equipment for deposition of varied materials from dielectrics to precious metals, photolithography, photomasks, dry and wet etching and high thermal processing. The Huson Imaging and Characterization Laboratory encompasses multiple Scanning Electron Microscopes (SEM) with electron dispersive spectroscopy (EDS) and variable pressure capabilities, Atomic Force Microscopes (AFM), thermal imaging, sputter coating for sample preparation, Parylene coatings and wire bonding capabilities.

Operations emphasize ease of access to the facilities, on-site fabrication services, protection of intellectual property (IP), a large array of capabilities and experience, online bill payment, competitive pricing and a business mindset.

Biography

Julia Aebersold, Ph.D., earned her doctorate in Mechanical Engineering from the University of Louisville in 2005. Her research developed a micro-electromechanical (MEMS)-based capacitive bending strain sensor with a biocompatible housing for a telemetric strain monitoring system. Julia holds a MEng (1994) and BS (1992) in Mechanical Engineering. After earning her Ph.D. she continued to perform federally funded research as a Research Scientist from 2005 until 2012 until she began managing the Micro/Nano Technology Center in 2012.

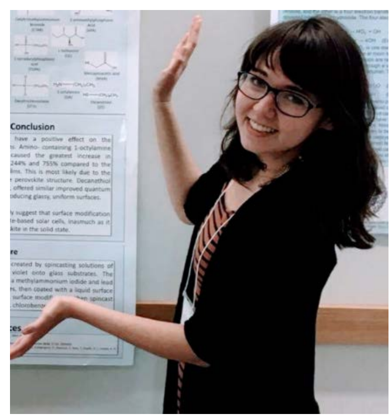
A Look into CeNSE at the University of Kentucky: Cutting Edge Nanoscale Research at the Heart of KY

Jillian Cramer

Abstract

The Center for Nanoscale Science and Engineering (CeNSE) is a multidisciplinary group of faculty, students, and staff at the University of Kentucky with a shared vision and a cutting-edge research facility to study and develop materials and devices at the nanoscale. From an initial investment of $2 million and an additional grant of $2.7 million from the National Science Foundation (NSF) EPSCoR grant, this center came to house specialty fabrication techniques for thin-film deposition, lithographic pattern definition, and etching. Most recently, CeNSE's capabilities have been furthered by the NSF NNCI grant, allowing the purchase of one of the highest resolution 3D printers commercially available: the Nanoscribe. The Nanoscribe will allow CeNSE's abilities to branch into new projects in medical research, mateirals science, and more. CeNSE complements the campus' other NNCI research cores, such as the Electron Microscopy Center, to help establish the University of Kentucky as a regional asset for nanoscale science. CeNSE is part of the newly launched University of Kentucky NNCI seed grant program, which is intended to spur collaboration with external and internal researchers in the region by providing funds for small or preliminary projects.

Biography of Presenter



Jillian Cramer is a recent graduate of the University of Oregon with a Master's in Photovoltaic & Semiconductor Device Processing, which was followed by a year-long industry internship in Transmission Electron Microscopy Applications Development at Thermo Fisher Scientific in Hillsboro, OR. She recently joined her alma mater, the University of Kentucky, in a joint position with the Center for Nanoscale Science & Engineering and the Electron Microscopy Center as NNCI coordinator and staff, helping with outreach efforts, project coordination, as well as hands-on tool training and operation.

Session 3A: Materials for Nanotechnology Part I

A Computer Engineering Approach To Design For 3D-Printing Manufacturability

Dr. Hank Dietz

Intercalation-Induced Phenomena in Layered and 2D Materials

Manthila Rajapakse[1], Rajib Musa[1], Jackson Walter[2], Riyadh Shah[1], Ming Yu[1], Gamini Sumanasekera[1,2] and **Jacek B. Jasinski[2]**

[1]*Department of Physics and Astronomy, University of Louisville, Louisville, KY 40292*

[2]*Conn Center for Renewable Energy Research, University of Louisville, Louisville, KY 40292*

Solid-Liquid-Vapor Etching of Negative Nanowires and Vapor-Liquid-Solid Metal Oxide Composite Materials

Alexandra J. Riddle[1], Lei Yu[1], Shanshan Wang[1], Beth S. Guiton[1*] [1]*Department of Chemistry, University of Kentucky*

A Computer Engineering Approach To Design For 3D-Printing Manufacturability

Henry Dietz

Department of Electrical and Computer Engineering, University of Kentucky `hankd@engr.uky.edu`
`Aggregate.Org/hankd`

The popular press tends to describe 3D printers as crude prototypes of the replicators seen in *Star Trek*, constructing arbitrary things as complete devices including various active components and a wide range of materials. The truth is that these machines primarily make parts, and in most cases that is how it should be; various components, from microprocessors to simple screws, can be produced more effectively using other means. Beyond that, 3D-printed parts are subject to many machine-dependent manufacturability constraints; designing within such constraints is the primary impediment to many potential uses. Thus, we have been working toward automating design for 3Dprinting manufacturability.

The main idea is that a design should not model an object, but be **a parameterized program describing the device in a structured, hierarchical, and composable way**. Such a program can be automatically transformed to better match the capabilities of the machines that will be used to produce parts – much as optimizing compilers rewrite a conventional computer program to better match the capabilities of the particular computer on which it will be executed.

Parametric Programmatic Tolerancing

As a simple example of programmatic design, consider specifying a statue with a removable rectangular base that is to firmly fit around the bottom allowing for printing tolerance. Using *OpenSCAD*, we could simply define an operator module to apply cylindrical tolerance offsets in x, y, and z:

```
module tol(xt=defxt, yt=defyt, zt=defzt) {
for(c=[0:1:$children-1]) minkowski() {   children(c);
scale([xt, yt, zt]) cylinder(); } }
```

```
difference() {base(80); tol() statue(80);} difference()
{base(); tol() statue();} difference() {base(); tol(yt=2)
statue();}
```

Although *OpenSCAD*'s operator modules and inheritance rules are unusual, most modern CAD systems internally specify designs as programs that can be parameterized with comparable flexibility.

Manufacturability Issues

For any 3D printing technology, some structures simply cannot be reliably printed. For example, the Unified Thread Standard (UTS) thread profile specifies 30° angles that are too shallow to selfsupport on most extrusion-based consumer printers. Attempting to print the standard thread profile (shown blue external, red internal) results in drooping that makes the thread unusable. However, compatible 1mm pitch M42 lens adapters are printable on sub-$300 printers using layers as thick as 0.25mm simply by increasing the angle within the UTS part envelope:

A 45° angle is printable by nearly all printers, but the choice of angle is printer-dependent and even more precise threads can be obtained by accounting droop. Similar design element/structure "substitutions" can enable making many complex objects. The tiny pliers (right) not only print assembled, but incorporate spanless hinge and spring in a single "metamaterial" part.

Compiler technology can automatically recognize and transform programmatic designs in these ways.

Status And Future Work

Compiler transformation technology is easy for us. Creating the library of transformations is a slow and continuing process – collaborators welcome. See **Aggregate.Org** for details and other projects.

Intercalation-Induced Phenomena in Layered and 2D Materials

Manthila Rajapakse[1], Rajib Musa[1], Jackson Walter[2], Riyadh Shah[1], Ming Yu[1], Gamini Sumanasekera[1,2] and **Jacek B. Jasinski[2]**
[1]*Department of Physics and Astronomy, University of Louisville, Louisville, KY 40292*
[2]*Conn Center for Renewable Energy Research, University of Louisville, Louisville, KY 40292*

Abstract

The discovery of graphene and other two-dimensional (2D) materials and the recent rapid growth in this field has led to the renewed interest in the intercalation as a powerful tool for the fabrication and processing of layered structures. In general, intercalation is a process of inserting foreign ions or molecules in-between weakly-bonded layers of layered materials. Different intercalation strategies have been developed, including chemical intercalation in gas or liquid phase, electrochemical intercalation in solid or liquid electrolytes, and the deposition of the species to be intercalated on top of the layered material under UHV conditions. Intercalation has been widely used for exfoliation and large-scale production of 2D materials. It has also been used effectively for modifying and tuning a wide range of properties (optical, magnetic, thermal, chemical, and catalytic, etc.) in layered materials. As shown by a number of recent studies, the intercalation of 2D structures differs often from that of bulk counterparts, which in many cases can lead to greatly improved properties. However, perhaps the most interesting is the fact, that the intercalation can also induce critical phenomena, such as phase transitions or quantum effects, in layered materials. Fundamental understanding of these phenomena and their mechanisms can lead to rational design of novel materials and device structures with novel functionalities. Intercalation-induced critical phenomena are often the result of significant charge transfer and structural changes, such as lattice expansion, increased strain, bonding reconstruction, etc., in the host 2D layered materials. We will discuss the fundamentals of these phenomena and some of the reported examples, as well as, report on our current project based on theoretical prediction of the Li intercalation-induced phase transition of black phosphorene to its more exotic allotrope, blue phosphorene.

Biography

Jacek B. Jasinski, a Research Scientist and Materials Characterization Theme Leader at the Conn Center for Renewable Energy Research at the University of Louisville, focuses on understanding the mechanisms underlying physical properties and functionality of technologically important materials. He has coauthored a book chapter and over 200 original research papers in refereed journals and conference proceedings. He is a guest editor of a special issue of ChemEngineering, serves as a proposal and journal reviewer, and is a co-organizer of scientific symposia at professional conferences and meetings, such as Materials Research Society Meetings.

Solid-Liquid-Vapor Etching of Negative Nanowires and Vapor-LiquidSolid Metal Oxide Composite Materials

<u>Alexandra J. Riddle</u>[1], Lei Yu[1], Shanshan Wang[1], Beth S. Guiton[1*] [1]*Department of Chemistry, University of Kentucky*

Abstract

A gold (Au) tip dissolved a tin dioxide (SnO_2) nanowire (NW) during *in situ* heating in a transmission electron microscope (TEM). We hypothesized that the combination of hightemperature and low-pressure atmosphere of the TEM caused the reverse reaction of the well-known vapor-liquid-solid (VLS) method commonly used to grow NWs. In this process, a metal catalyst adsorbs reactant vapor until it becomes supersaturated. The precipitation of the NW occurs at the liquid-solid interface, which ceases when there is no longer reactant vapor, and the diameter of the NW is determined by the diameter of the original catalyst. The reverse process, the solid-liquid-vapor (SLV) method occurs when atoms in a solid NW diffuse into the metal catalyst. Eventually, the metal catalyst becomes supersaturated and the vapor escapes at the liquid-vapor interface. Using these techniques, we proposed that metal catalysts could be extended to etch metal oxide surfaces, and after etching the metal catalyst could be used to grow a NW of a different material to form a crystalline interface. One of the central problems with fabricating effective devices is the energy loss at contacts or interfaces but through utilizing focused ion beam scanning electron microscopy (FIB-SEM) to make a lamella for high-resolution TEM imaging, we could elucidate the structure of these interfaces at the atomic/molecular level. Understanding the chemical structure at interfaces is both crucial and fascinating because diverse materials may interact in a variety of ways including atomic mixing of the two structures and/or the formation of an abrupt crystalline interface or gap.

Biography of Presenter

Alexandra Riddle is a PhD candidate in the Department of Chemistry at the University of Kentucky in Dr. Beth Guiton's research laboratory. Her research interests are to design, synthesize, and use high-resolution microscopy to uncover the structural properties of nanomaterials to understand the chemistry that occurs at interfaces. She has won UK's Chemistry department 100% Plus Award and A&S Certificate for Outstanding Teaching. Additionally, she is a member of Alpha Chi Sigma, an academic chemistry fraternity and took part in a science project-based program in collaboration with the College of Education. She obtained her BS degree in Chemistry from Gettysburg College in 2014 and won the Society for Applied Spectroscopy Undergraduate Student award for her work using resonance Raman spectroscopy to study the dissociation dynamics of episulfides under the direction of Dr. Michael Wedlock. She previously worked as a laboratory technician at Gettysburg College Department of Biology and Asbury Carbons.

Session 3B: Manufacturing Core Facilities Part II

Rapid Prototyping Center and Additive Manufacturing Competency Center
Tim Gornet

Electron Microscopy Center at the University of Kentucky
Nicolas J. Briot
University of Kentucky, College of Engineering, Electron Microscopy Center

Conn Center for Renewable Research
Mahhendra Sunkara and Thad Druffel
[1]*Conn Center for Renewable Energy Research*

Rapid Prototyping Center and Additive Manufacturing Competency Center

Tim Gornet
Manager of Operations, Rapid Prototyping Center

Bio

Tim Gornet is the Manager of Operations at the University of Louisville's Rapid Prototyping Center. He has been active in the additive manufacturing (AM)/3D printing field since 1988 when he ran an SLA 250 at GE Appliances. He is Past President of the Additive Manufacturing User's Group (AMUG), founded the Selective Laser Sintering User's Group and served as president 3 years, has been a board member for the Society of Manufacturing Engineers Rapid Technologies and Additive Manufacturing group and was recognized as one of the "Top 25 Most Influential People in RPD&M" by the TCT Magazine. He is a frequent contributor to the annual Wohlers Report and presents at numerous industry and academic conferences on AM. His research is in the area of polymer sintering and previous work includes pioneering the use of the Melt Index for determining powder quality and developing a multi-zone heating system that has now been commercialized. Recent funded research includes several ONR/AFRL SBIR/STTR projects on unique polymer laser sintering materials and high temperature polymer applications as well as development of new materials and processing parameters for Direct Metal Laser Sintering. In addition, he has led polymer laser sintering research programs with Boeing for novel aerospace application. His research area of interest are in Laser Sintering of Polymers including process control and optimization, mechanical properties, hardware improvements, materials research and development, and high temperature materials. In the area of powder bed metal additive manufacturing technologies his research includes material development, process and mechanical property optimization. He also performs applied research in design for Additive Manufacturing for polymers and metals. He received his Bachelor and Master of Engineering degrees from the University Of Louisville JB Speed School of Engineering and is completing his PhD work at the University of Sheffield (UK)

Electron Microscopy Center at the University of Kentucky

Nicolas J. Briot

University of Kentucky, College of Engineering, Electron Microscopy Center

Abstract

The Electron Microscopy Center (EMC) is a multi-user shared equipment center that serves the entire university community and industries locally and nationwide. During a typical year over 100 different customers are served, providing services for over $20 million in grant funds. The Electron Microscopy Center is part of the University of Kentucky College of Engineering and is located in the basement of the ASTeCC Building.

Over the past few years, top-of-the-art instruments have been installed at the Electron Microscopy Center, vastly expanding the characterization possibilities offered to the local scientific community. In addition to an XPS system and FIB-SEM dual beam (both installed in the past five years), the center has recently added a brand new TEM with advanced analytical capabilities ("Super-X EDS", dual EELS) and *in situ* TEM holders for cryo and heating experiments, electrothermal characterization and 3D tomography.

This presentation will offer an overview of the Electron Microscopy Center characterization capabilities and show some examples of data recently obatained on the new instruments.

Biography of Presenter

Nicolas Briot completed his undergraduate studies at the University of Burgundy in Dijon, France and worked for 2 years in the automotive industry before joining Dr. Balk's research group in 2009. He joined the Electron Microscopy Center during his last year as a PhD student in 2014 and, after graduation, became a full time staff member. In addition to sample preparation, his focus is the training of users and assistance to researchers on scanning electron microscopes and FIB-SEM.

Conn Center for Renewable Energy Research

Mahhendra Sunkara and Thad Druffel
[1]*Conn Center for Renewable Energy Research*

Abstract

The University of Louisville is answering Kentucky's call to lead research efforts in renewable energy research issues. UofL established the Conn Center for Renewable Energy Research at the J.B. Speed School of Engineering in 2009 in honor of major donors Hank and Rebecca Conn. Since 2009, Conn Center's research has advanced basic scientific knowledge, informed applied engineering know-how, and supported Kentucky's diversifying advanced manufacturing economy. The center provides analytical capabilities to materials and chemicals sector industries, research educational opportunities to PhD, masters, and bachelors students as well as outreach to middle and high school groups.The center advances the goal of renewable energy and promotes technologies, practices, and programs that increase efficiency for energy utilization. To accomplish these objectives, the Conn Center conducts and facilitates R&D on potentially commercializable renewable energy and energy efficiency technologies. The center promotes partnerships among colleges and universities, private industries, and non-profit organizations to actively pursue federally and privately funded research and development resources that are dedicated to renewable energy solutions in 7 themes. Conn Center employs top-notch scientists and engineers as theme leaders for directing these research thrusts and to enable collaborations with faculty researchers and industry partners worldwide. The Conn Center has developed unique, state-of the art, translational research facilities in the following areas: scalable manufacturing R&D of advanced nanoscale materials, roll-to-roll manufacturing R&D for solar technologies, and solid-state lithium ion battery fabrication.

Biography of Presenter

Mahendra Sunkara is the Director of Conn Center and Theme Leader for Advanced Energy Materials Theme. Dr. Sunkara received his B. Tech. degree in Chemical Engineering from Andhra University (India) in 1986, a M.S. in Chemical Engineering from Clarkson University in 1988, and a PhD in 1993 from Case Western Reserve. He did his PhD under guidance of Prof. John Angus on chemical vapor deposition of diamond. He worked at Faraday Technology, Inc. in Dayton, OH, from 1993-1996 as a Project Engineer before joining UofL as an assistant professor in 1996.

Session 4A: Bioengineering and Life Sciences

Synergistic Activity of Antiretrovirals co-administered with Q-GRFT Against HIV-1

Farnaz Minooei[1], Joel Fried[1], and **Jill M. Steinbach-Rankins[2]**
[1]Department of Chemical Engineering, University of Louisville
[2]Department of Bioengineering and Center for Predictive Medicine, University of Louisville

Effect of Acoustofluidic Flow on Intracellular Molecular Delivery

Connor S. Centner[1], Mariah C. Priddy[1], Paula J. Bates[2], Michael A. Menze[3], Jonathan A. Kopehchek[1]
[1]Dept. of Bioengineering, University of Louisville
[2]Dept. of Medicine, University of Louisville
[3]Dept. of Biology, University of Louisville

DNA-mediated hierarchical 3D superstructures of anisotropic gold nanoprisms

Emtias Chowdhury[1], Martin G. O'Toole[2]
Department of Chemistry, University of Louisville
Department of Bioengineering, University of Louisville

Development and Optimization of Dual Conjugated Gold Nanoparticles for Glioblastoma Therapies

Nicholas Allen[1], Rajat Chauhan[1], Paula Bates[2], Martin O'Toole[1,2]
[1] University of Louisville, J.B. Speed School of Engineering, Bioengineering Department,
[2]University of Louisville School of Medicine

Synergistic Activity of Antiretrovirals co-administered with Q-GRFT Against HIV-1

Farnaz Minooei[1], Joel Fried[1], and **Jill M. Steinbach-Rankins[2]**

[1]*Department of Chemical Engineering, University of Louisville*

[2]*Department of Bioengineering and Center for Predictive Medicine, University of Louisville*

Abstract

Human immunodeficiency virus (HIV) is spreading worldwide with about 5,500 new infections each day. A variety of antiretrovirals (ARVs) including Tenofovir (TFV), Dapivirine (DAP), and Raltegravir (RAL) have demonstrated effectiveness against HIV-1 by utilizing different mechanisms of action. In addition, the oxidation-resistant antiviral lectin, Q-Griffithsin (Q-GRFT), has demonstrated potent efficacy and safety against HIV1 and is the most potent biologic to-date. The purpose of this study is to co-administer these ARVs with free or encapsulated Q-GRFT in NPs to determine their efficacy against HIV-1 in vitro.

Poly(lactic-co-glycolic) acid (PLGA) NPs encapsulating Q-GRFT were synthesized using double emulsion technique. The morphology and size of NPs were assessed using scanning electron microscopy (SEM). The inhibitory activity of each active agent or co-administered active agents was assessed using an in vitro HIV-1 inhibition assay using TZM-bl cells and HIV-1 pseudovirus.

We have demonstrated that TFV, RAL, and DAP have synergistic interactions with QGRFT against HIV-1, with up to 5.5-fold reduction in half maximum inhibitory concentration (IC50) values for all drugs in the presence of Q-GRFT. The IC50 values for Q-GRFT also reduced up to 6-fold, when co-administered with these drugs. The synergistic interactions were maintained for Q-GRFT NPs in the presence of the mentioned antiretrovirals. The IC50 values of Q-GRFT NPs decreased up to 14-fold when it was co-administered with free drugs. These studies suggest that coadministration of either free or encapsulated Q-GRFT with active agents with different mechanisms of action in NPs may increase the prophylactic effect and decrease the dosage needed to attain efficacy against HIV-1 infections.

Biography of Presenter

Farnaz Minooei is a Ph.D. candidate in chemical engineering at the University of Louisville. Her research interest includes vaginal delivery against viral infections and developing biomaterial combinations to tailor the delivery of different microbicides. Currently, she is working on a project in collaboration with the Bioengineering department on developing delivery platforms composed of fibers and nanoparticles to sustain release of active agents and co-encapsulate different active agents to improve their potency and efficacy against viral infections.

Effect of Acoustofluidic Flow on Intracellular Molecular Delivery

Connor S. Centner[1], Mariah C. Priddy[1], Paula J. Bates[2], Michael A. Menze[3], Jonathan A. Kopehchek[1]

[1]*Dept. of Bioengineering, University of Louisville*

[2]*Dept. of Medicine, University of Louisville*

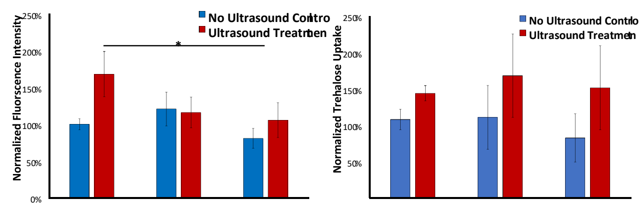
[3]*Dept. of Biology, University of Louisville*

Abstract:

Cell-based therapies is an expanding market for treatment of various diseases, but limitations currently exist such as inconsistent and inefficient molecular delivery. We are developing an acoustofluidic device to enhance molecular delivery and to increase consistency of molecular delivery into cells. Acoustofluidic devices were fabricated with PDMS utilizing standard photolithography techniques. Piezoelectric transducers were bonded to each device and controlled with an Arduino Uno to generated ultrasound (8 MHz, 50 kPa). Human erythrocytes or lung cancer cells (A549) were diluted in saline to $5x10^6$ cells/mL and $1x10^5$ cells/mL, respectively. Fluorescein (100 µg/mL) or trehalose

(200 mM) was added to sample prior to treatment. Lipid-coated microbubbles (60 µg/mL) were added to samples. Different channels widths were used to generate flow velocities of 1 cm/s, 4 cm/s, and 20 cm/s. Molecular delivery was determined with flow cytometry (fluorescein) or photometric enzymatic assay (trehalose). ANOVA with post-hoc analysis was utilized for statistical analysis. Higher uptake of fluorescein was observed in erythrocytes at 1 cm/s compared to no ultrasound controls (fig. 1). Additionally, 1 cm/s displayed

enhanced fluorescein intracellularly delivery compared to 20 cm/s.



Ultrasound treatment at 1 cm/s **Figure 1.** Processing of erythrocytes in acoustofluidic devices enhances intracellular delivery of fluorescein (left)

enhanced trehalose uptake in human and trehalose (right) compared to no ultrasound control lung cancer cells by 155 ± 63% groups (n=3/group, *$p < 0.05$). Flow velocity effected compared to no US control ($p<0.05$). These results indicated ultrasound enhances intracellular delivery and flow rates can affect effectiveness of acoustofluidic delivery. With additional development and optimization this platform technology could potentially enhance molecular delivery for a wide range of applications and may address current limitations with cell process for cell-based therapies.

Biography:

Connor S. Centner received his B.S. and MEng in Bioengineering in 2017 and 2018, respectively. He has held internships at a variety of companies such as Elite Biomedical Services, Bridgestone, and Cincinnati Children's Hospital. He is currently a Ph.D. student under guidance of Dr. Jonathan Kopechek. Connor's research focus is to develop an acoustofluidic system to address current limitations with cell processing for cell-based therapies.

DNA-mediated hierarchical 3D superstructures of anisotropic gold nanoprisms

Emtias Chowdhury[1], Martin G. O'Toole[2]

Department of Chemistry, University of Louisville

Department of Bioengineering, University of Louisville

Abstract

Particle assembly refers to an efficient strategy of organizing nanoscale and microscale objects into crystalline, patterned or other higher order functional materials.In the quest to derive new advanced and novel functional materials, where new collective properties and function can emerge, the field of particle assembly and supramolecular assembly continues to attract intense interest. Although several self assembly methods has been reported to design nanoparticle superstructures, DNA mediated assembly enables a high degree of control over particle assembly to form design-based nanostructures because of the exceptional molecular recognition, tunability, and predictability of the DNA ligands. Potential applications of these structures include catalysis, sensing, and optics. Here we report a DNA-mediated long range ordering of anisotropic gold nanoprism stacks to form hierarchical suprastructures. As gold nano prisms have length and width dimensions an order of magnitude greater than their depth, the most preferred binding pattern between is expected to be face-to-face interactions that maximize DNA-mediated hybridization interactions. In our study, under proper salt concentration and thermal annealing, GNPrisms were first assembled in a lamellar arrangement to form 1D stacks of length varying from 500 nm (10-12 monomer units) to over 1 micron (around 40 monomer units). The sharp melting transition, as monitored via UV-vis spectroscopy, confirmed dense a reversible DNA-mediated interaction between prisms. Then, long range ordering of 1D nanoprisms stacks, which acted as secondary building block, was accomplished with thermal anealing for 30 min to few hours long below melting temperature of 1D nanoprisms stacks.

Biography of Presenter

Md. Emtias Chowdhury was born in Chittagong, Bangladesh where he received his primary education. He attended the University of Chittagong and graduated in 2010 with a bachelor's degree in chemistry. He came to the United States to pursue his MS at the university of Maine in the spring of 2012 and finished his MS in the summer of 2014. Currently he is a PhD candidate in the department of chemistry at UofL.

Development and Optimization of Dual Conjugated Gold Nanoparticles for Glioblastoma Therapies

Nicholas Allen[1], Rajat Chauhan[1], Paula Bates[2], Martin O'Toole[1,2]
[1] *University of Louisville, J.B. Speed School of Engineering, Bioengineering Department,*
[2]*University of Louisville School of Medicine*

Abstract

Patients with primary brain glioblastomas (GBMs) have a 5% survival rate with standard therapies. Nanotherapeutic techniques, such as gold nanoparticles (AuNPs), have received increased attention due to their potential for improving drug efficacy, reducing adverse side effects, and decreasing therapy resistance. AS1411, a DNA aptamer, displays antibody like behavior in its folded state that preferentially targets GBM cell lines. These properties are greatly amplified by conjugating AS1411 through a thiol linkage (SH) to 4nm AuNPs. The objective of this work was to optimize an AS1411 AuNP based nanotherapy that can be used for the delivery of multiple AS1411-based anti-GBM therapies by coating the aptamer to AuNPs in two different ways: thiol- and ester bound conjugations. The thiol conjugation is more permanent and helps the particles retain their cancer targeting properties. The ester conjugation can be cleaved hydrolytically and release AS1411 from the AuNPs once inside of the cancer cells. Particles were characterized with UV-VIS, zeta potential and dynamic light scattering. AS1411dependent targeting of co-conjugated AuNPs in U87MGs was verified by comparing coconjugated particles bearing either AS1411 or control sequences *in vitro*. Treatment with co-conjugated particles on GBM cells (U87MGs) shows a reduction of up to 52.18% in U87MGs treated in optimally co-conjugated particles. Epifluorescent imaging further verified assay results. Future experiments will investigate endosomal trafficking and exploit micro-RNA inhibitors for combinatorial treatment of GBMs.

Biography of Presenter

Nick Allen, PhD Candidate, completed his B.S and M.Eng degrees in Bioengineering at UofL. During his undergrad, Nick had co-op placements at the Cardiovascular Innovation Institute, Brown Cancer Center, and Texas Heart Institute. Nick's M.Eng research, directed by Dr. Patricia Soucy, focused on examining global changes to cardiac extracellular matrix after radiation exposure. He was accepted into the Bioengineering doctoral program in the Fall of 2016 where he joined the Nanotherapeutics lab directed by Dr. Martin O'Toole working on synthesizing tumor targeting gold nanoparticles for glioblastoma applications.

Session 4B: Cool MEMS Devices and Structures Part II

Commercialization Opportunities with the University of Louisville

Kayla N. Meisner

Electronic Glaucoma Drainage Device

Saliya Kirigeegagage[1], Doug Jackson[2], Richard Eifferman[3], and John Naber[2]
[1]*Previously with the University of Louisville, Now with Hydromax USA, Louisville, KY*
[2]*University of Louisville, Department of Electrical and Computer Engineering* [3]*University of Louisville, Department of Ophthalmology*

Glancing Angle Deposition for Nanoporous Membranes

Chuang Qu, Bruce Alphenaar, Shamus McNamara, Kevin Walsh
Department of Electrical and Computer Engineering, University of Louisville, Louisville, KY, 40292 USA

Analysis of Carbonyls in Exhaled Breath of Smokers and Nonsmokers By A Microreactor Approach

Zhenzhen Xie[1], Qi Li[1], Michael H. Nantz[2], Xiao-an Fu[1]
[1]*Department of Chemical Engineering,*
[2]*Department of Chemistry, University of Louisville, Louisville, KY 40208*

Commercialization Opportunities with the University of Louisville

Kayla N. Meisner[1]

[1]*Commercialization EPI-Center, University of Louisville*

Abstract

The University of Louisville (UofL) has a rich history in working with partners to commercialize the innovations that have been developed by our faculty. UofL is also proud to have achieved what no other university has; the award of four prestigious translational research grants, including a Coulter Translational Partnership award, the National Institutes of Health REACH grant, the National Science Foundation I-Corps Site award and the National Science Foundation AWARE: ACCESS grant. All of these awards have been used by the University to further develop our innovations and to help prepare our entrepreneurial and innovative faculty, staff and students for success. In this presentation, you will learn how the University uses these programs to drive commercialization success and you will hear about some of the successes to date. You will also learn of promising new University technologies that cover a board variety of fields, including engineering, healthcare, advanced manufacturing, materials and software and how potential industry partners, entrepreneurs and investors can easily access them in order to build new business and develop new products for the benefit of society. We hope that you will consider UofL as your commercialization partner of choice.

Biography of Presenter

Kayla Meisner is a commericalization manager with the Commercialization EPI-Center, where her primary responsibilities involve assessing, licensing and managing technologies within the fields of engineering and physical sciences. Kayla earned her undergraduate degree in bioengineering from the University of Louisville. During her undergraduate education, Kayla interned for the Commercialization EPI-Center for two years. Kayla likes that her work allows her to have an impact on the entire licensing process, and she is motivated by the fact that successfully licensed technologies can benefit the lives of others.

Electronic Glaucoma Drainage Device

Saliya Kirigeegagage[1], Doug Jackson[2], Richard Eifferman[3,] and John Naber[2]

[1]Previously with the University of Louisville, Now with Hydromax USA, Louisville, KY

[2]University of Louisville, Department of Electrical and Computer Engineering [3]University of Louisville, Department of Ophthalmology

Glaucoma is a condition of the eye causing optic nerve damage resulting in vision loss. Glaucoma is directly correlated with elevated intraocular pressure (IOP) and thus IOP is medically managed. Drug resistant cases of glaucoma are often treated by installing a tube and plate style glaucoma drainage device (GDD). This GDD places a tube in the anterior chamber of the eye that is connected to a plate placed under the conjunctiva.

The electronic glaucoma drainage device (e-GDD) adds a pressure measurement function to the plate portion of the GDD allowing self-monitoring of IOP. The e-GGD consists of a tuned coil, RFID transponder integrated circuit, and a digital pressure sensor on a polyimide flexible substrate shaped to the plate outline. The low power sensor allows the circuit to operate on wireless power without batteries. The e-GDD circuit joins to plate body using cut-outs for the IC and the sensor that is placed at the tube-to-plate interface.

The circuit assembly is cast in PDMS to obtain a 0.7 mm thick layer over the circuit and a slightly thinner coating over the sensor. The encapsulated assembly is tested in a two chamber test fixture filled with saline. Pressure is applied to the tube end simulating the IOP applied in the anterior chamber of the eye. The plate portion of the device is placed in the second chamber and pressure is measured by the wireless e-GDD and a reference pressure sensor.

The test results show good agreement of the e-GDD to the reference sensor as well as negligible pressure drop across the tube. These results confirm the viability of a wireless pressure measurement in a simulated in-vivo condition. Biocompatibility studies will be the next step in this research effort follow by human trials.

Saliya Kirigeeganage was born in Kandy Sri Lanka. He received the B.Sc. degree (with honors) in Physics from the University of Peradeniya, Sri Lanka in 2010 and the M.Sc. degree in Physics from the University of Louisville, KY, in 2013 and his Ph.D. in Electrical Engineering from the University of Louisville, KY. He is currently a Data Engineer for Hydromax USA preforming scalable and distributed computing. He also designs embedded software for medical and wearable devices

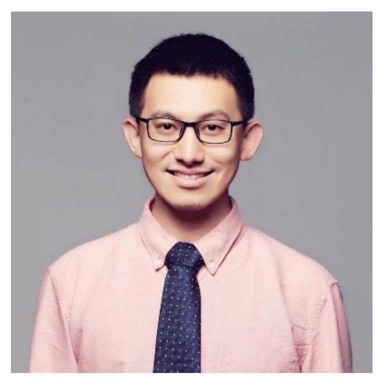
Glancing Angle Deposition for Nanoporous Membranes

Chuang Qu, Bruce Alphenaar, Shamus McNamara, Kevin Walsh
Department of Electrical and Computer Engineering, University of Louisville, Louisville, KY, 40292 USA

Abstract

Glancing angle deposition (GLAD) is a bottom-up nanofabrication technique. GLAD creates three-dimensional nanometer features by ballistic shadowing effect at oblique incident angles in physical vapor deposition (PVD) processes. Various nanofeatures such as nanopillars/columns, helices, and chevrons have been demonstrated by manipulating the substrate from PVD processes. The process is compatible with target material and substrate choices used in depositions, and the nanostructures created by GLAD are used as large-area devices for optical, energy and sensing applications. Although the concept of GLAD has been demonstrated, the theoretical study on feature control is still lacking. In this study, we provide a comprehensive study on controlling of the GLAD films. We conducted a series of experiments using electron-beam evaporation for GLAD. Process parameters including tilt angle and rotation speed of the substrate, and deposition rate are studied for controlling the size and shape of the features. The experimental results are in accordance with theoretical results. Finally, this study proposes to use GLAD to fabricate nanoporous membranes. Traditional topdown techniques for drilling holes inside a membrane are either incapable or costprohibitive to make nanometer holes in the membrane. GLAD, on the other hand, is suitable for the creation of the nanoporous membranes by simple inversion of the GLAD nanofeatures. The whole fabrication process for polyimide nanoporous membrane with GLAD is demonstrated. The nanoporous membrane is a great candidate for the aperture used in Knudsen pump. Experimental results for pumping performance are shown.

Biography of Presenter



Dr. Chuang Qu received his BE and ME in Thermal and Power Engineering from Dalian University of Technology, China in 2012 and 2014, respectively, and Ph.D. in Mechanical Engineering from Missouri University and Science and Technology in 2019.

He is currently a Postdoctoral Associate in the department of Speed School Electrical & Computer Engineering at the University of Louisville for the Kentucky Multi-Scale Manufacturing and Nano Integration Node (KY MMNIN). His research focuses on bottom-up manufacturing techniques, including thin film depositions, additive manufacturing, and self-assembly. He authored and co-authored 6 journal papers and 8 conference papers during his Ph.D study.

Analysis of Carbonyls in Exhaled Breath of Smokers and Nonsmokers By A Microreactor Approach

Zhenzhen Xie[1], Qi Li[1], Michael H. Nantz[2], Xiao-an Fu[1]
[1]*Department of Chemical Engineering,*
[2]*Department of Chemistry, University of Louisville, Louisville, KY 40208*

Abstract

Smoking may cause many diseases, for example, chronic obstructive pulmonary disease (COPD), cardiovascular disease and lung cancer. Tobacco smoking has a large effect on exhaled breath. Cigarette smoking is a mixture of more than 5000 chemical compounds and more than 60 are recognized to have a specific carcinogenic potential. For nonsmoking people, exposure to second hand smoke also increases the risk of lung cancer. The purpose of this study is to quantitative analysis of carbonyl volatile organic compounds (VOCs) exhaled breath and identification of VOC markers of smokers and nonsmokers using the unique silicon microreactor technology. The microreactor consists of thousands of micropillars coated with quaternary ammonium aminooxy salt for capturing trace carbonyl VOCs in exhaled breath by means of oximation reactions. Exhaled breath samples from smokers and nonsmokers were collected in Tedlar bags, and carbonyl compounds in the exhaled breath samples were captured by the silicon microreactors. The reacted ATM adducts were eluted out of the microreactor with methanol and were directly analyzed by nanospray Fourier transform ion cyclotron resonance (FT-ICR) mass spectrometry (MS). The results indicate that the concentration of formaldehyde, acetaldehyde, 2-hydroxy-acetaldehyde, and 3-hydroxy-2-butanone in the exhaled breath of smokers were significantly higher than that in the exhaled breath of nonsmokers. Acetaldehyde and formaldehyde are among most abundant compounds in tobacco smoke and are harmful to human health because they are very reactive. In conclusion, tobacco smoking causes significant high levels of formaldehyde and acetaldehyde in exhaled breath of smokers.

Biography of Presenter

Zhenzhen Xie obtained her master degree in Chemical Engineering Department at the University of Louisville in 2013 focusing on MOF-based catalytic performance and membrane for gas separation. Then she joined Dr. Xiaoan Fu's group at the University of Louisville where she obtained her Ph.D. degree in Chemical Engineering. She conducted research on gas sensors and microreactors to analyze trace volatile organic compounds in both environmental air and human exhaled breath samples. She is currently a postdoctoral research associate at the University of Louisville. Her research focuses on quantitative analysis of VOCs in breath samples and determines the biomarkers of lung cancer.

Symposium Electronic Proceedings

Session 5A: Additive Manufacturing Part II

Low Cost Additive Manufacturing Economic & Environmental Comparison with Conventional Injection Molding

Eric Wooldridge, PE, RA
Somerset Community College, KCTCS

A 3D Printed Microfluidic Mixing Chamber

Alexa M. Melvin[1], Nichola C. Garbett[2], Thomas J. Roussel[1]
[1]Department of Bioengineering, J.B. Speed School of Engineering, University of Louisville, Louisville, KY [2]Brown Cancer Center, School of Medicine, University of Louisville, Louisville, KY

Optimizing additive manufacturing of NiTi

SE Saghaian[1], M Nematollahi[2], GP Toker[1], A Hinojos[3], MJ Mills[3], M Elahinia[2], H Karaca[1]
1Smart Materials Laboratory, Department of Mechanical Engineering, University of Kentucky, Lexington, KY, USA
2Dynamic and Smart Systems Laboratory, Mechanical Industrial and Manufacturing Engineering Department, University of Toledo, OH, USA
[3]Materials Science and Engineering, The Ohio State University, Columbus, OH, USA.

Low Cost Additive Manufacturing Economic & Environmental Comparison with Conventional Injection Molding

Eric Wooldridge, PE, RA

Somerset Community College, KCTCS

Abstract

Additive manufacturing (AM) has quickly moved well beyond the novel approach of rapid prototyping to become a force of production. However, a hindrance to the adoption and integration AM within many small and medium production businesses is the cost of industrial AM equipment and, more importantly, the lack of the AM mindset. To address these obstacles and to accelerate AM integration throughout Kentucky, the low cost additive manufacturing (LCAM) production model is being utilized and disseminated across the state by the AM Center of Excellence at Somerset Community College. The model is built on the benefits of LCAM for rapid production scaling, developing the AM mentality, and providing "on-the-fly" product design changes with no lead times or retooling required. This presentation will outline the basic LCAM integration model with supporting case studies showing its potential benefits. The results of a streamlined comparative study of the environmental impacts of a unique consumer product produced by LCAM versus conventional plastic injection molding will also be discussed. The study revealed that for lower production run quantities, the LCAM production model was nearly seven times more beneficial in terms of environmental impacts over the conventional method of injection molding. The presentation will additionally reveal the comparative results of the economics and lead times of the two production methods. The results showed significant opportunities for small- and medium-sized producers for balancing lead times with low investment costs and instantaneous production design changes.

Biography of Presenter

Professor Wooldridge is a Registered Architect, a Professional Engineer in multiple disciplines including Architectural, Mechanical, and Manufacturing systems, and holds multiple patents. His Master's degree is in Manufacturing Systems Engineering with an additive manufacturing focus. A fourth generation cattle farmer, he also owns two private engineering and design firms and has designed buildings and systems all across the central and southern regions of Kentucky. Eric Wooldridge is a consulting reviewer for Autodesk's educational program and teaches courses in additive manufacturing, pre-engineering, generative design, and workforce leadership at Somerset Community College (SCC). Professor Wooldridge serves as faculty and PI on NSF, KCTCS TRAINS, and USDA grant projects, created KCTCS' first statewide 3D printing technician certificate program, and is the director of the KCTCS Additive Manufacturing Center of Excellence.

A 3D Printed Microfluidic Mixing Chamber

Alexa M. Melvin[1], Nichola C. Garbett[2], Thomas J. Roussel[1]

[1]Department of Bioengineering, J.B. Speed School of Engineering, University of Louisville, Louisville, KY [2]Brown Cancer Center, School of Medicine, University of Louisville, Louisville, KY

Abstract

The isolation of blood plasma from whole blood, which minimizes the interference of larger blood cells in a sample, is one of the most basic yet vital steps for many diagnostic techniques. Plasma contains important biomarkers that exhibit a litany of diagnostic characteristics. While several microfluidic devices have been developed to extract plasma, few use whole blood and generally suffer from low plasma yield and purity. Additionally, no studies have reported the use of an integrated microfluidic device to extract and dilute plasma. This study investigates a method to perform the mixing step using 3D printed manifolds.

Flow simulations were performed in COMSOL Multiphysics to determine suitable channel geometry. A meandering channel (L=43 mm, d=100 µm) was designed to mix two liquids with different concentrations. The channel design was exported into SolidWorks where inlet and outlet ports were added. The manifolds were printed using PLA on a DREMEL 3D45 FDM desktop printer and device performance was evaluated using colorimetric and pH tests. Mixing ratios were controlled by adjusting inlet flow rate. The colorimetric tests combined yellow and blue tinted water and adjustment of the dilution ratio generated predicted changes in green intensity. Parallel dilutions of 10 mM nitric acid to adjust pH showed high reproducibility for dilutions from 10:1 to 1:30 (n=3). This proof-of-concept study successfully demonstrated a method to dilute plasma samples with an inexpensive 3D printed manifold. Future studies include testing the manifolds with plasma, analyzing the protein concentration after mixing, and development of a plasma extraction chamber.

Biography of Presenter

Alexa Melvin is a Ph.D. student in the Interdisciplinary Studies with a Specialization in Translational Bioengineering (ISSTBE) program at the University of Louisville. She graduated from Saint Louis University in May 2017 with a B.S. in biomedical engineering.

Optimizing additive manufacturing of NiTi

SE Saghaian[1], M Nematollahi[2], GP Toker[1], A Hinojos[3], MJ Mills[3], M Elahinia[2], H Karaca[1]
1Smart Materials Laboratory, Department of Mechanical Engineering, University of Kentucky, Lexington, KY, USA
2Dynamic and Smart Systems Laboratory, Mechanical Industrial and Manufacturing Engineering Department, University of Toledo, OH, USA
[3]Materials Science and Engineering, The Ohio State University, Columbus, OH, USA.

Abstract

Any variation in the processing parameters of selective laser melting fabrication could impact the performance of the final product. In this study, the effects of laser power, scanning speed and hatch spacing on the NiTi shape memory alloys were evaluated. Multiple $Ni_{50.8}Ti_{49.2}$ samples were systematically fabricated with selected laser power from 50 to 250 W and their microstructure, transformation temperatures, texture, and shape memory response were investigated. It was demonstrated that with increasing laser power, scanning speed should be increased too.

Keywords: Shape Memory Alloys, Additive Manufacturing, NiTi, SLM, Laser Energy Density

Session 5B: Cool MEMS Devices & Structures Part III

Old Technology New Application: Applying Thermal Inkjet Technology to Emerging Fields

Glenn Edelen
Funai Lexington Technology Corporation

ChevBot: An Innovative Laser Driven Locomotive Microrobot

Zhong Yang, Mohammad N. Saadatzi, Ruoshi Zhang, Andriy Sherehiy, Danming Wei, and Dan O. Popa
Authors' affiliation: Next Generation Systems, University of Louisville

Design and Fabrication of Micro Structures toward Non-volatile Mechanical Memory Devices

Ji-Tzuoh Lin[1], Pranoy D. Shuvra[1]Shamus McNamara[1], Kevin M. Walsh[1]and Bruce Alphenaar[1]
[1]*Department of Electrical and computer Engineering, University of Louisville*

Old Technology, New Applications:
Applying Thermal Inkjet Technology to Emerging Fields

Glenn Edelen

Funai Lexington Technology Corporation

Abstract

Thermal inkjet technology has been available in consumer printers for over 30 years. During that time the technology has improved to the point that a drop of fluid with a volume of a few pico-liters can be placed within twenty microns of an intended target. This improvement in capability has been accompanied by continuous design and manufacturing optimizations. The result has been the production of more than a billion disposable, low cost, microfluidic devices. With the declining growth of consumer inkjet printing there a drive to find alternative uses for this technology. This presentation will provide an overview of the current state of the art as well as highlighting some potential new applications and markets for the technology.

Biography of Presenter

Glenn Edelen received his BS and MS in Electrical Engineering from the University of Louisville and is currently employed as a Senior Engineering Manager at Funai Lexington Technology Corporation. He is an inventor on 27 US patents primarily related to integrated circuit design and microfluidic devices.

ChevBot: An Innovative Laser Driven Locomotive Microrobot

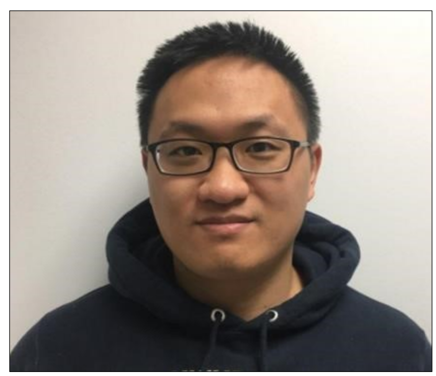
Zhong Yang, Mohammad N. Saadatzi, Ruoshi Zhang, Andriy Sherehiy, Danming Wei, and Dan O. Popa
Authors' affiliation: Next Generation Systems, University of Louisville

Abstract

In this paper, we present ChevBot, a light-actuated sub-millimetric crawler that can perform tasks equivalent to mobile robots in future microfactories for nano-biotechnology applications. ChevBot is a novel locomotor that uses light energy harvesting inducing thermal effects that generate motion in dry environments. The microrobot drive consists of Chevron Thermal Actuators (CTA), which are popular Micro Electro Mechanical (MEMS) drive systems based on a stick-and-slip locomotion mechanism.

In this paper, we put forth a comprehensive methodology for constructing ChevBot's lumped opto-thermo-mechanical dynamic model. We used an experimental data collection system, made in-house, to automate the process of laser power delivery to the ChevBot and perform system identification while tracking the robot motion. Simulation results using Finite Element Methods were used to compare the operating performance and the thermal time constant of ChevBots in two different operating conditions: one in which the robots are tethered to the MEMS substrate, and one in which they freely move on a 2D substrate. Experimental motion profiles collected with a laser range sensor were used to validate the dynamics of actuation and construct reduced order models of the CTA. A 1D dynamic model of ChevBot was then proposed, and tuned to experimentallycollected data. The model was then extended in 2D to study the expected motion of the robot under varying friction conditions.

Biography of Presenter



Zhong Yang is a PhD candidate with the Next Generation Systems (NGS) Research Group at University of Louisville, Louisville, KY. He received his B.Sc. in electrical and electronics engineering from the Tianjin University, China, in 2012, and his M.Sc. from University of Arizona in 2016. Then, he joined the NGS research Group as a graduate research assistant, with a background in software development, modeling and control and MEMS design. His current research interests include microrobots and reduce order modeling.

Design and Fabrication of Micro Structures toward Non-volatile Mechanical Memory Devices

Ji-Tzuoh Lin[1], Pranoy D. Shuvra[1]Shamus McNamara[1], Kevin M. Walsh[1]and Bruce Alphenaar[1]
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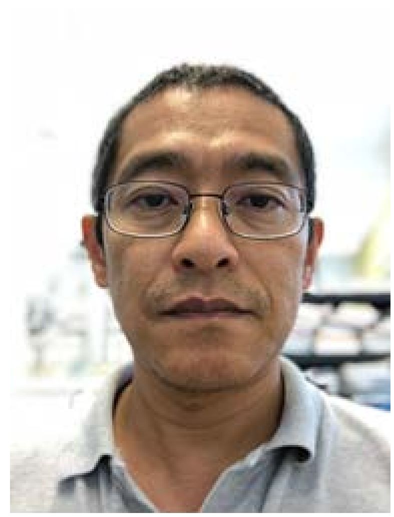
Abstract

Silicon microstructures exhibit excellent mechanical property and have been used in many modern applications such as navigation, mass sensing, and timing modules that would complement the solid state counterparts. Increasingly, in some area such as electrostatic switch, the MEMS devices would rival solid state with lower power consumption. More and more silicon microstructure applications are predicted, as we enter the more and more connected world with sensors and actuators, on earth or in space. One area of special interest is mechanical non-volatile memory device that would be used in space applications where ionizing radiation would affect the integrity or general performance of solid state device. This research reports the novel design and preliminary results of a mechanical memory device using micro buckled silicon beam and its piezoresistive property. The non-volatile memory concept relies on the bi-stable states and its respective resistance difference. Bi-stable state was realized by oxidation of a straight beam, with tensions from the grown oxide layer causing the beam to buckle. The resistance difference between two stated was simulated on an asymmetric base on either side of the buckled beam. Novel fabrication processes accompanying the design have also been developed, including shadow mask for selective oxide etching, metallization, and post oxidation process. The switch of the buckled states were realized preliminarily by mechanical actuation. Experiments showed that even the slightest buckled beam exhibits clear difference of the states. This buckled bi-stable states represents measureable 20 ppm resistance difference. Simulation predicts a similar results of our experiment.



Biography of Presenter

Ji-Tzuoh Lin, Ph.D. is a research scientist in the department of Electrical Engineering at University of Louisville. His research fields has been in the MEMS devices and energy harvesting areas. He is specifically interested in low power MEMS solutions for internet of things (IoT). Dr. Lin has one issue patent, two book chapters and more than 20 Journal publications. He has started his companies and received an SBIR award. He is currently working on subjects related to UV effects on silicon and GaN resonator and their low power applications.

Session 6A: Additive Manufacturing Part III

A little variation makes a big difference: effect of composition on microstructures and mechanical properties of 3D printed 17-4 PH stainless steel

Thomas Starr, Swathi Vunnam, Sean Dobson *University of Louisville, Louisville, KY USA*

Tailoring the properties of NiTiHf through selective laser melting process parameters

Guher P. Toker[1], Mohammadreza Nametolahi[2] Sayed Ehsan Saghaian[1], Mohammad Elahinia[2], Haluk E. Karaca[1]

[1]Department of Mechanical Engineering, University of Kentucky, Lexington, KY 40506-0503

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Metal Fused Filament Fabrication (MF3) of Bronze

Mohammad Qasim Shaikh, Paramjot Singh, Kavish Sudan, Kunal Kate, Sundar V. Atre*
Material Innovation Guild
University of Louisville, Louisville, KY 42017.

A little variation makes a big difference: effect of composition on microstructures and mechanical properties of 3D printed 17-4 PH stainless steel

Thomas Starr, Swathi Vunnam, Sean Dobson *University of Louisville, Louisville, KY USA*

Abstract

17-4 PH stainless steel exhibits a unique combination of high strength and corrosion resistance. It is the alloy of choice for many structural applications in corrosive environments, such as naval systems and medical implants. Custom and complex geometries can be produced using laser powder bed fusion (PBF), a common 3D printing (additive manufacturing) method for metal parts. However, small variations in the elemental composition and manufacturing method for 17-4PH stainless steel powder yield widely different phase compositions, microstructures and mechanical properties. These differences are uniquely related to the extremely high cooling rates created by the laser PBF process. New understanding of the complex solidification and phase transformation phenomena was needed ensure reliable performance of parts manufactured by this process.

Biography of Presenter

Dr. Thomas L. Starr is a professor in the Chemical Engineering Department at the University of Louisville and has led research in additive manufacturing/3D printing for over 20 years. His research accomplishments include evaluation of stereolithography (SLA) tooling for ceramic injection molding, use of powder delivery laser deposition (DMD) for combinatorial alloy development and his current work with powder bed laser sintering and melting (SLS and SLM) for additive manufacturing of plastic and metal parts. His work with polymer LS led to a new correlation among process parameters that better relates to mechanical performance. His research on mechanical properties of laser processed steel and titanium alloys produced new understanding of the fatigue performance of these materials. He recently led a multi-university program that aimed to create better qualification methods for powder bed fusion additive manufacturing processes for both polymers and metals.

Tailoring the properties of NiTiHf through selective laser melting process parameters

Guher P. Toker[1], Mohammadreza Nametolahi[2] Sayed Ehsan Saghaian[1], Mohammad Elahinia[2], Haluk E. Karaca[1]
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Selective laser melting (SLM) is a subgroup of Additive Manufacturing (AM) and an attractive fabrication method which allows creating dense and porous parts for desired applications. Fabrication parameters such as laser power, scanning speed, and energy density play significant roles in the mechanical and metallographic characteristic on the SLM fabricated parts. NiTiHf is the most promising high temperature shape memrory alloy to its lower cost and good shape memory properites. In this study, NiTiHf parts were fabricated via SLM technique by using pre-alloyed Ni-rich NiTiHf powders. Various combination of process parameters have been employed to fabricate and optimize the NiTiHf SLM parts; cracks, and porosity level has been investigated to determine the optimum process parameters. It was found that low energy density resulted in higher porosity level and low strength. Parts fabricated with high laser power and energy density are found to have high transfromation temertaures above 300 ^{o}C. Effects of aging on the shape memory properties were also investiagted.It was found that shape memory effect and superelasticity with recovery strain of about 2% in compression can be obtained in SLM fabricated NiTiHf alloys.

Biography of Presenter

I earned my bachelor degree in mechanical engineering from Suleyman Demirel University in 2012, and I obtained my first master degree in 2014 from Erciyes University, Turkey. I worked on composite materials during my master.

After completing my Master's degree at Erciyes, I received a highly competitive scholarship from the Turkish Ministry of Education to obtain my Master's and Doctoral Degrees overseas. I earned a second master degree from the University of Kentucky in 2018. The same year I started the Ph.D. program at the University of Kentucky. My research area high-temperature shape memory alloys and additive manufacturing.

Metal Fused Filament Fabrication (MF3) of Bronze

Mohammad Qasim Shaikh, Paramjot Singh, Kavish Sudan, Kunal Kate,
Sundar V. Atre*
Material Innovation Guild
University of Louisville, Louisville, KY 42017.

ABSTRACT

Additive manufacturing of metals using the fused filament fabrication (MF3) is an emerging topic to produce three dimensional metallic objects. The process operates with a solid cylindrical filament wire containing metallic powder in polymer binder. The filament is fed into a heated extruder and molten material is forced through a fine nozzle to be deposited as stacked layers to form an intended shape. The printed parts are then subjected to debinding for polymer removal and sintering at elevated temperature in inert atmosphere. In the present study, filaments were prepared out of bronze metal powder mixed with polymer binder. The bronze powder-polymer filament was used for printing test specimen to study the effects of various printing parameters on printed part properties evaluated through experimental work. Additionally, to study influence of combination effects of material properties, part design and slicing strategy have on the printed part properties that are important to design for MF3 a finite element-based simulation solution, Digimat was used. Simulations were conducted with the same process input as experiments, excluding material definition due to non-availability of MF3 material database. Comparison between experimental and simulation results identified the need of material characterization, material model definition and process modeling to be refined to simulate MF3 process.

BIOGRAPHY OF PRESENTER

Mohammad Qasim Shaikh is a Ph.D. student in Mechanical Engineering at University of Louisville. His research focus in additive manufacturing (AM) includes metal fused filament fabrication (MF3) in terms of understanding the interrelationship of processing conditionpolymer compound attributes - end product properties. Physical and mechanical properties as a result of material process-part variations are investigated through experiments and finite element (FE) based simulation tools.

Qasim has 12+ years of industrial experience with BASF and Solvay in the areas of polymers, automotive applications, CAE simulations, injection molding, additive manufacturing (SLS) and application/ design development.

Session 6B: Materials for Nanotechnology Part II

Determining the Structure and Stability of Thermoelectric La3-xTe4-Ni Composites using High-Resolution and In-Situ TEM

M. P. Thomas[1], A. Ullah[1], D. Cheikh[2], S. K. Bux[2], and B. S. Guiton*[1]
[1]Department of Chemistry, University of Kentucky, Lexington, Kentucky, USA
[2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

In situ Transmission Electron Microscopy Studies of Metal to Insulator Transition in Tungsten Doped Vanadium Dioxide (V1-xWxO2, x= 0.0, 0.01)

Ahamed Ullah, Melonie P. Thomas, Chloe C. Porter and Beth S. Guiton*
Department of Chemistry, University of Kentucky,
Lexington, KY 40506, United States

Adsorption and Opto-electronic Properties of Phosphorene

Manthila Rajapakse[1], Gamini Sumanasekera[1,2], Jacek Jasinski[2], Ming Yu[1], Rajib Musa[1]
[1] Department of Physics and Astronomy, University of Louisville, Louisville, KY, 40292, United States [2]Conn Center for Renewable Energy, University of Louisville, Louisville, KY, 40292, United States

Determining the Structure and Stability of Thermoelectric $La_{3-x}Te_4$-Ni Composites using High-Resolution and *In-Situ* TEM

M. P. Thomas[1], A. Ullah[1], D. Cheikh[2], S. K. Bux[2], and B. S. Guiton*[1]

[1]*Department of Chemistry, University of Kentucky, Lexington, Kentucky, USA*

[2]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*

Abstract

For many years, NASA has employed thermoelectric materials (TE) in radioisotope thermoelectric generators to convert heat generated from radioactive decay to electrical power in their missions. The efficiency of a TE material is characterized by its

$6SS^2TT$ dimensionless figure of merit, zT. $zzTT =$ ____ where б, S, T, and К are electrical κ

conductivity, Seebeck coefficient, temperature, and thermal conductivity, respectively. Lanthanum telluride ($La_{3-x}Te_4$), is a TE material with a zT of 1.1 at 1275 K at x = 0.23. It has been shown that the zT can be increased by 30% when nickel (Ni) nanoparticle (NP) inclusions are introduced to the $LaTe_{1.46}$ matrix. We hypothesize that coherent interfaces between $LaTe_{1.46}$/Ni permit low electrical resistivity and these interfaces are spread out sufficiently to maintain a low thermal conductivity. These interfaces are likely a key factor determining the stability and performance of the $LaTe_{1.46}$-Ni composites, but their role and nature are not well understood. We postulate that the presence of a reaction layer at the interface can cause the observed enhancement in zT. Furthermore, it is important to determine the stability of $LaTe_{1.46}$/Ni interface in deep-space conditions and the effect of heat and oxygen on the mechanisms and kinetics of interface degradation. Here, we show the sample preparation methods and high-resolution structural characterization of $LaTe_{1.46}$/Ni TE composites and their interfaces at high vacuum and ambient temperature conditions, using Transmission Electron Microscopy (TEM) and Energy Dispersive X-ray Spectroscopy (EDS). We further demonstrate the $LaTe_{1.46}$/Ni interface degradation over its operating temperature range (25-1000^{o}C), in the presence and absence of oxygen, in real time, using *in-situ* TEM.

Biography of Presenter

Melonie Thomas is a PhD candidate and a member of the Guiton research group at the Department of Chemistry, University of Kentucky. She's currently based full time at the Oak Ridge National Laboratory (ORNL) and her doctoral research investigates the mechanisms of crystal growth and structural phase transformation of solid state chemistry processes at atomic resolution in real time using in situ transmission electron microscopy. Melonie received the A&S Dean's Competitive Graduate Fellowship in the Spring 2018 semester. She has also won several awards including Outstanding Graduate Student Research Award and Outstanding Oral Qualifier Award.

In situ Transmission Electron Microscopy Studies of Metal to Insulator Transition in Tungsten Doped Vanadium Dioxide ($V_{1-x}W_xO_2$, x= 0.0, 0.01)

<u>Ahamed Ullah</u>, Melonie P. Thomas, Chloe C. Porter and Beth S. Guiton*

Department of Chemistry, University of Kentucky,

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Abstract

Vanadium dioxide (VO_2) is a well-known strongly co-related material which exhibits a metal to insulator transition (MIT) close to room temperature (= ~341 K). A structural transformation from a low-temperature monoclinic (insulator) to a hightemperature rutile (metallic phase) structure is observed during this MIT. The electrical resistivity also undergoes a sharp change (by a factor of 10^4-10^5) at = ~341 K. Due to this unique property, VO_2 has gained a substantial interest for various applications such as Mott transistor, memristors, smart windows, and artificial neuron networks. Tuning of the MIT temperature in VO_2 is possible by introducing stress and chemical dopants for various application purpose. The knowledge of the underlying mechanism of the MIT temperature variation as a function of dopant concentration is still lacking and needs a robust fundamental approach for investigation. Using *in-situ* biasing in a transmission electron microscopy (TEM), we designed a project to explore the effect of tungsten (W) doping on the phase transitions of $V_{1-x}W_xO_2$ (x=0.0 and 0.01) nanowires/beams, as a function of electrical response. Single crystalline $V_{1-x}W_xO_2$ (x=0.0 and 0.01) nanobeams were synthesized hydrothermally at 250 °C for seven days. Systematic characterizations were carried out using powder X-ray diffraction (XRD), scanning electron microscopy (SEM), electron dispersive X-ray spectroscopy (EDS), X-ray photoelectron spectroscopy (XPS) and TEM. Focused ion beam scanning electron microscopy (FIB-SEM) was used to fabricate a nanochip device with the nanobeam and then used to carry out in-situ biasing TEM experiments to observe the structural transformation and the change in the electrical properties of the materials in real time. High-resolution TEM micrographs of the nanobeams from in-situ experiments were further analyzed to determine the phase transition in detail.

Biography of Presenter

Ahamed Ullah is a PhD candidate in the Department of Chemistry at the University of Kentucky under the supervision of Beth S. Guiton. He obtained his BS degree in Chemistry and MS degree in Inorganic and Analytical Chemistry from the University of Dhaka, Bangladesh in 2011. His research interests are understanding the phase transformation in nanostructured VO_2 and studying the interface of cathode and anode materials for a solid-state sodium ion battery using in situ biasing in the transmission electron microscope.

Adsorption and Opto-electronic Properties of Phosphorene

Manthila Rajapakse[1], Gamini Sumanasekera[1,2], Jacek Jasinski[2], Ming Yu[1], Rajib Musa[1]

[1] Department of Physics and Astronomy, University of Louisville, Louisville, KY, 40292, United States [2]Conn Center for Renewable Energy, University of Louisville, Louisville, KY, 40292, United States

Abstract

Phosphorene based field effect transistors (FETs) were fabricated to show the versatility and potential of two dimensional (2-D) sensors and optoelectronic devices. FETs were fabricated by simply depositing phosphorene on aluminum inter-digitated electrodes from a dispersion in dimethyl formamide (DMF). As phosphorene has been found to be unstable under ambient conditions, the interplay between device performance and environmental conditions were studied using *in-situ* transport measurements. Phosphorene was exposed to varying light and gaseous environments to understand its performance under different external stimuli. It was found that both light and gases can have extreme impacts on the properties of phosphorene. The sensor properties can be explained as due to the modulation of the Schottky barrier (formed at the phosphorenealuminum interface) due to the exposed gas. The photoresponse is also explained as due to the influence of photocarriers (generated in the semiconductor and the metal) on the Schottky barrier.

Biography of Presenter

Manthila Rajapakse is a PhD student from the Department of physics, University of Louisville. He has got his bachelor's degree in 2015 from University of Peradeniya, Sri Lanka and master's degree in 2017 from the University of Louisville. He is working on the

synthesis and properties of phosphorene and other 2D materials under the supervision of Dr.Gamini Sumanasekera (Department of Physics, University of Louisville) and Dr.Jacek Jasinski (Conn Center for Renewable Energy Research, University of Louisville).

Poster Abstracts

Nanosecond Pulsed Laser Deposition of Pb Thin Film on Si (111)

Bektur Abdisatarov[1], Devon Loomis[1], Mikhail Khenner2*, Ali Oguz Er1*.
[1]Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101 USA
[2]Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101 USA

Layer-Dependent Hydrazine Adsorption Properties in WS2

Adel Alruqi[1],**Md Rajib Khan Musa**[2],Rong Zhao[3],Congyan Zhang7[4],Jacek Jasinski[5],Ming Yu[6],Gamini Sumanasekera
[1,2,6] Author's affiliation: Department of Physics & Astronomy, University of Louisville, Louisville, Kentucky 40292, United States
[5,7] Author's affiliation: Conn Center for Renewable Energy Research, University of Louisville, Louisville, 6 Kentucky 40292, United States
[3,4]Author's affiliation: Department of Physics and Department of Computer Science, Southern University and A&M College, Baton Rouge, Louisiana 8 70813, United States

Achromatic Metalenses

Fatih Balli[1], Mansoor Sultan[1], Sarah Lami[1], J. Todd Hastings[1] *[1] University of Kentucky, Lexington, KY 40506, USA*

Pathogenic bacterial deactivation in human blood by using Graphene quantum dot as an effective photodynamic therapy agent

Ermek Belekov[1], Lauren Cooper[2], Khomidkhodza Kholikov[1], Ali Oguz Er[1]
[1]Department of Physics & Astronomy, Western Kentucky University, Bowling Green, KY 42101
[2]Department of Mechanical Engineering, Western Kentucky University, Bowling Green, KY 42101

Plasmonic Nanostructures using Cell-less Liquid-Phase Electron Beam Induced Deposition

Samaneh Esfandiarpour and Todd Hastings *University of Kentucky*

Advanced Corrosion Studies of Laser-Powder Bed Processed 420 Stainless Steel

Alexander J. Gupta[1], Sachin Poduval[1], Subrata Deb Nath[2], Theodore Kalbfleisch II[1], Sundar V. Atre[2]*, and Gautam Gupta[1]*
[1]Department of Chemical Engineering, University of Louisville, Louisville, KY 40208 [2]Materials Innovation Guild, University of Louisville, Louisville, KY 40208
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Gas sensor array for detecting acetone by using functionalized alkylurea thiol gold nanoparticle

Sujoy Halder[1], Zhenzhen Xie[1], Prasadi Adhihetty[2], Michael H. Nantz[2], Xiao-An Fu[1]
[1]Department of Chemical Engineering, [2]Department of Chemistry, University of Louisville, Louisville, Kentucky, USA

Design and development of the Semi-Automated process of Solarpede microrobot assembly

Mariah Brooke Hall

A laser pre-deposition heating technique to improve the interface healing in FFF-3D printed Ultem 1010

Pu Han, Alireza Tofangchi, Anagh Deshpande, Sihan Zhang, Keng Hsu
J. B. Speed School of Engineering. University of Louisville, Louisville, USA

Tactile Sensors for User Interface in Adaptive Robotic Nursing Assistant

Penelope Jankoski[1],
[1]Next Generation Systems Lab Group, University of Louisville

SolarPede: A Novel Stick-and-Slip, Light-Powered, Micro-Crawler

Jordan F. Klotz[1], Danming Wei[1], Zhong Yang[1], Ruoshi Zhang[1], Andriy Sherehiy[1], Mohammad N. Saadatzi[1], and Dan O. Popa[1]
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Focused Electron Beam induced Etching of Copper

Sarah K. Lami[1], G. Smith[1], and J. Todd Hastings[1]
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Germanium Photo-gated Bipolar Junction Transistor to Detect Infrared Light

Michael David Martin[1], Camille V Reyes[2], Shamus McNamara[2], Frank Kenneth Hopkins[3], John Jones[3]
[1]Micro/Nano Technology Center, University of Louisville
[2]Dept of Electrical and Computer Engineering, University of Louisville [3]Air Force Research Laboratory (AFRL/RX), Wright-Patterson AFB

Embedded Sensing Capabilities in an FDM Printed Object

Garrett McGrady, **Neel Jain**, Douglas Jackson, Dr. Kevin Walsh University of Louisville

Characterization of Light Propagation in a Multimode Optical-fiber using Mie Scattering

Arianna Meenakshi McNamara[1], Shamus McNamara[1], Michael Martin[1], Frank Kenneth Hopkins[2], David E. Zelmon[2]
[1]University of Louisville
[2]Air Force Research Laboratory (AFRL/RX), Wright-Patterson AFB

Characterization of New Microreactors for Preconcentration of Carbonyl Compounds

J.D. Morris[1], Q. LI[1], Z. Xie[1], M.H. Nantz[2], X.A. Fu[1]
[1]Department of Chemical Engineering, [2]Department of Chemistry
University of Louisville, Louisville, KY 40208

Deuterium termination of diamond transistors for increased durability

Ross H. Parish[1,2], Shamus McNamara[2], William F. Paxton[3], Kevin M. Walsh[2], Mahendra Sunkara[3]
[1]Yale University, New Haven, Connecticut
[2]Micro/Nano Technology Center, University of Louisville, Louisville, Kentucky
[3]Conn Renewable Energy Center, University of Louisville, Louisville, Kentucky

How coalescence manipulation of landed drops can be useful in inkjet printing

Md Mahmudur Rahman[1], Stuart J Williams[1] *[1]University of Louisville*

Process Characterization of the Microscale Deposition Tools

Zane Ronau

Flexible Tactile Electronic Skin Arrays for Safe and Intuitive Physical HumanRobot Interaction

Mohammad Nasser Saadatzi[1], Joshua Baptist[1], Zhong Yang[1], Ruoshi Zhang[1], and Dan Popa[1]
[1]Next Generation Systems Research Group, University of Louisville

Low Cost MEMS Style Sensors for Education

Jacob Schopp, Shamus McNamara
Electrical and Computer Engineering, University of Louisville, Louisville, KY

Use of Microvalves and Air Pressure in a Refreshable Braille Display

Spencer Sherlock, Dr. Shamus McNamara
University of Louisville, Louisville, KY

MRI Nexus system: Development of a Multiscale Additive Manufacturing Instrument with Integrated 3D Printing and Robotic Assembly

Andriy Sherehiy[1], Antoine C. Blasiak[1,2], Danming Wei[1], Dilan Ratnayake[1], Garrett E. McGrady[1], Brooke Hall[1], Challa Sushmita[1], Amirhossein Ghahremani[1], Alireza Tofangchi[1], Kevin M. Walsh[1], Keng Hsu[1], Cindy Harnett[1], Thad Druffel[1], Dan Popa[1]
[1]*University of Louisville*
[2]*École nationale supérieure de mécanique et des microtechniques, Besancon*

A Study of Pore Formation During Single Layer and Multiple Layer Build by Selective Laser Melting

Subin Shrestha, Sabina Chertmanova, Kevin Chou J.B. Speed School of Engineering

Corrosion Properties of Inconel 625 Processed by Laser-Powder Bed Fusion

Kavish Sudan[1], Subrata Deb Nath[1], Azim Gökçe[1], Alexander J. Gupta[2], Gautam Gupta[2], Sundar V. Atre[1] and Kunal Kate[1]*
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3D Printed Color Filters

Mansoor A. Sultan[1] and J. Todd Hastings[1]
[1] *Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40506*

CHARACTERIZING THE NANOSCRIBE PHOTONIC GT SYSTEM FOR FABRICATING MEMS BISTABLE STRUCTURES

Kevin Tobin[1], Dilan Ratnayake[2], Kevin Walsh[2]
[1]*Mechanical Engineering, Lipscomb University*
[2]*Electrical and Computer Engineering, University of Louisville*

SYNTHESIS AND EXFOLIATION OF BLACK PHOSPHORUS

Jackson Walter[1], Riyadh Shah[2], Manthila Rajapakse[2], Gamini Sumanasekera[1,2], Jacek B. Jasinski[1]
[1]*Conn Center for Renewable Energy Research, University of Louisville*
[2]*Department of Physics and Astronomy, University of Louisville*

Design, Analysis, and Characterization of a Novel 4-DOF Microrobots

Danming Wei, Mariah B Hall, Ruoshi Zhang, Andriy Sherehiy, Zhong Yang, Dan O. Popa
Department of Electrical and Computer Engineering, University of Louisville, danming.wei@louisville.edu

Replica Root Form Dental Implant: Proof of Concept

Peter S. Wulff, [1] William C. Scarf, [2] Timothy J. Gornet, [3] Gary E. Graf, [3] Aly A. Farag,[3] Kelsey M. Phillips, [1] and **Lawrence Gettleman**[1]
Departments of Oral Health & Rehabilitation[1], and Surgical & Hospital Dentistry[2], University of Louisville School of Dentistry, and Department of Mechanical Engineering[3], Speed Scientific School, University of Louisville, Louisville, Kentucky

Wafer-scale microfactories with assembled MEMS microrobots for nanotechnology applications

Ruoshi Zhang, Andriy Sherehiy, Danming Wei, Zhong Yang, Jordan Klotz, M Nasser Saadatzi, Dan O. Popa
University of Louisville

Nanosecond Pulsed Laser Deposition of Pb Thin Film on Si (111)

Bektur Abdisatarov[1], Devon Loomis[1], Mikhail Khenner2*, Ali Oguz Er1*.

[1]*Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101 USA*
[2]*Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101 USA*

Abstract

Pb thin film was deposited onto a Si (111) substrate by pulsed laser deposition (PLD). The Pb target was ablated with a Q-switched 1064 Nd:YAG pulsed laser with 5 nanosecond pulse width, 10 Hz repetition rate, and 1 mm beam diameter. Laser energy density, temperature wavelength and the number of pulses were changed. Different thicknesses of the film ranging from 5 to 70 nm were obtained. Crystal structures of the films were measured using scanning electron microscopy, x-ray diffraction, and atomic force microscopy. Our results show that laser energy density, wavelength, and temperature play an important role in morphology. In addition, quantum size effects (QSE) were observed on the ultra-thin films and coarsening effects were observed on the films that underwent high-temperature deposition. Experimental observation is supported by theoretical simulations. Ongoing results of Pb film growth on a copper sample will also be presented.

Biography of Presenter

Bektur Abdisatarov is a graduate student in Physics and Astronomy department at Western Kentucky University since 2018. He participated in local and International Mathematical Olympiads (IMO) and won prizes in 2009-2010. He holds a bachelor's degrees in Mathematics and Electrical Electronics Engineering from Dokuz Eylul University. Mr. Abdisatarov has a special interest in information security. "Aman Electronics LLC" company created by him in 2016.

Layer-Dependent Hydrazine Adsorption Properties in WS2

Adel Alruqi[1],**Md Rajib Khan Musa**[2],Rong Zhao[3],Congyan Zhang[7][4],Jacek Jasinski[5],Ming Yu[6],Gamini Sumanasekera

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Abstract

We have developed a novel technique to fabricate two-dimensional (2-D) material based devices. We synthesized WS2 with varying number of layers and studied the adsorption/desorption properties of hydrazine by measuring the electrical resistance in-situ. The layer dependent resistive response was interpreted as due to the charge transfer from N2H4 to WS2 as well as the trapping of N2H4 molecules within the layers of WS2 causing charge redistribution and possible chemical reactions. The experimental results are explained with the help of computational calculations performed by employing the density functional theory (DFT) framework, as implemented in the Vienna Ab-initio Simulation Package (VASP). Our method was further extended to fabricate 2-D heterostructures of WS2/graphene. The temperature and magnetic field dependence of the resistance of such heterostructures was found to obey the 2D Mott variable range hopping transport mechanism. Finally, we synthesized 2-D vertically stacked tunnel junctions consisting of Graphene/h-BN/Graphene and the tunneling characteristics were measured for varying tunnel barrier thicknesses.

Biography of Presenter

Md Rajib Khan Musa is a graduate student at physics and astronomy department Of University of Louisville, kentucky. Currently he is working on computational condensed matter physics.His research goal is to understand the structural and electrical properties of materials using Density Functional Theory (DFT) and molecular dynamics simulation.

Achromatic Metalenses

Fatih Balli[1], Mansoor Sultan[1], Sarah Lami[1], J. Todd Hastings[1] [1] *University of Kentucky, Lexington, KY 40506, USA*

Abstract

Metamaterials have a variety of applications in optical systems. A number of recent efforts in metamaterials have focused on ultra-thin optical elements or so called metalens. Compared to their refractive counterparts, they offer light, miniaturized structures with better performance. The design principle is based on refracting light through quasiperiodic nanopillars. Current metalens designs suffer from off-axis and chromatic aberrations. In this work, we propose a Hybrid Achromatic Metalens design (HAML) with high efficiency in the near-infrared band. We propose a deterministic way to impose phase shift variations over the lens. Our method does not require an iterative algorithm, which decreases design time significantly compared to diffractive achromatic alternatives. Our simulation results show an improvement in focusing efficiency compared to competitive technologies over a wide bandwidth in the NIR. We verify our results by fabricating lenses with two-photon lithography and measuring focusing efficiency and focal length as a function of wavelength. When compared to traditional lithography, our method provides straightforward fabrication in three dimensions and allows customized lens production. Replication by molding would enable mass production with low cost.

Fatih Balli

Fatih Balli received the B.Sc. degree in mechanical engineering (2011) and M.Sc. degree in physics (2014) from Middle East Technical University, Turkey. He was awarded with fellowships for exchange and German language programs in Ruhr University Bochum (2010) and Hamburg University of Technology (2012). He worked in ASELSAN defense factory in Turkey as an optical engineer and designed wide angle zoom lens daylight camera objectives and infrared wide angle lenses (2012-2015). He is currently teaching assistant and Ph.D. candidate in the Physics & Astronomy department at the University of Kentucky. His research interests are optical design as well as optical and magnetic metamaterials.

Pathogenic bacterial deactivation in human blood by using Graphene quantum dot as an effective photodynamic therapy agent

Ermek Belekov[1], Lauren Cooper[2], Khomidkhodza Kholikov[1], Ali Oguz Er[1]

[1]*Department of Physics & Astronomy, Western Kentucky University, Bowling Green, KY 42101*

[2]*Department of Mechanical Engineering, Western Kentucky University, Bowling Green, KY 42101*

Abstract

Antibiotics are commonly used in bacterial infection. However, the widespread use of antibiotics has resulted in the emergence of multidrug-resistant or pathogenic bacterial strains. Consequently, the need for developing new bactericidal materials and techniques arose. Photodynamic therapy (PDT) is proposed as an alternative approach. In PDT, light interacts with certain materials and chemicals to induce damage to bacteria. Graphene quantum dots (GQD) are one of the most promising antimicrobial agents since they possess high germicidal activity against a broad range of microbes. In our project, we aim to investigate an effective, inexpensive and available compound which will hold even higher antimicrobial activity and lower toxicity toward human blood. For this purposes, we used GQD and methylene blue (MB). GQDs were grown by focusing nanosecond laser pulses into benzene and were later combined with MB. The Gram-negative bacteria, *Escherichia coli*, and Gram-positive bacteria, *Micrococcus luteus,* were deactivated by GQD/MB. Detailed characterization was performed with transmission electron microscopy (TEM), scanning electron microscopy (SEM), Fouriertransform infrared (FTIR), UV-Visible (UV-Vis), and photoluminescence (PL) spectra. Further, ongoing experiment on the germicidal affects of different nanoparticles such as silver (Ag), and aluminum (Al) with MB will be presented.

Biography of Presenter

Belekov Ermek enrolled to master program of Physics and Astronomy department at Western Kentucky University in August 2018. He received his bachelor degree in Physics from Middle East Technical University, Ankara, Turkey in 2017. His research interests are Photodynamic Therapy, Optoelectronics, and Medical Physics. He is currently involved with ongoing Photodynamic Therapy, and photonics related projects in Dr. Er’s group.

Plasmonic Nanostructures using Cell-less Liquid-Phase Electron Beam Induced Deposition

Samaneh Esfandiarpour and Todd Hastings *University of Kentucky*

Abstract

Certain metallic nanostructures, typically silver and gold, support localized surfaceplasmon resonances (LSPR) that confine electromagnetic fields at the nanoscale. Electron-beam induced deposition (EBID) is appealing for rapid-prototyping of such structures and for deterministically placing them in more complex devices However, the low purity of gold from organic precursors, the limited availability and handling difficulties of inorganic gold precursors, and the almost complete absence of silver precursors have limited gas-phase EBID for plasmonics applications.

To address these, we are studying EBID of silver nanostructures from bulk liquids. Here we show that silver nanostructures deposited from liquid precursors on bulk substrates support LSPR. Optical spectroscopy is used to measure the scattering spectrum of the deposited silver structures in the visible to near-infrared region. To verify the measured data we also simulated the silver deposits with a numerical approach using finite difference time domain (FDTD) method.

Deposition was conducted with a 30kV accelerating voltage in a FEI Quanta 250 FEG ESEM. Specifically, an aqueous silver nitrate solution was used to deposit silver on oxidized silicon and sapphire substrates. The solution also contained a surfactant, sodium dodecyl sulfate (SDS) and/or Brij, to improve wetting and reduce the liquid layer thickness.

Biography of Presenter

Samaneh Esfandiarpour received the B.Sc. and M.Sc. degrees in electrical engineering and is currently pursuing her Ph.D. at the University of Kentucky. She is focusing on rapid prototyping of nanostructures with electron beam induced processing. She has worked as a teaching assistant and a research assistant while completing her doctoral studies. Prior to the program, she was employed by the Iran Telecommunication Research Center as a research assistant working in the area of antenna and microwave device design. Her primary areas of interest include nanofabrication, electron microscopy, plasmonics and photonics.

Advanced Corrosion Studies of Laser-Powder Bed Processed 420 Stainless Steel

Alexander J. Gupta[1], Sachin Poduval[1], Subrata Deb Nath[2], Theodore Kalbfleisch II[1], Sundar V. Atre[2]*, and Gautam Gupta[1]*
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Abstract

The high corrosion resistance and excellent mechanical properties of AISI 420 stainless steel make the alloy an especially suitable material for fabrication of medical tools and devices. Furthermore, laser-powder bed fusion (L-PBF) facilitates fabrication of unique or specialized metal parts via additive manufacturing. However, little work has been reported on the corrosion properties of L-PBF 420 stainless steel. In this study, two electrochemical techniques are employed to evaluate the corrosion behavior of L-PBF specimens: Tafel curve 4-parameter fitting (TC4) and electrochemical impedance spectroscopy (EIS). Parameters describing corrosion behavior include polarization resistance, Tafel constants, and corrosion current. The corrosion properties of L-PBF test coupons were compared to those of wrought samples. We determined that the L-PBF test coupon fabricated in this study has a significantly higher polarization resistance than the wrought coupon and corrodes significantly slower than the wrought coupon. Microstructural features of the samples before and after corrosion were also elucidated via electron microscopy (SEM).

Biography of Presenter

Alex Gupta is a PhD Candidate in Chemical Engineering at the University of Louisville with a background in Chemistry. He entered the PhD program at University of Louisville in fall of 2017 and was awarded the University Fellowship. He has since published research in journals including CrystEngComm, Nanotechnology, and ChemNanoMat. His current research interests include water electrolysis, materials science, and corrosion.

Gas sensor array for detecting acetone by using functionalized alkylurea thiol gold nanoparticle

Sujoy Halder[1], Zhenzhen Xie[1], Prasadi Adhihetty[2], Michael H. Nantz[2], Xiao-An Fu[1]
[1]Department of Chemical Engineering, [2]Department of Chemistry, University of Louisville, Louisville, Kentucky, USA

Abstract

Gas sensor arrays are promising for detecting volatile organic compounds (VOCs) in air and exhaled breath. Acetone is one of the most abundant VOCs in air, a widely used solvent in laboratory and industries, and affects human health adversely. Also, acetone is an endogenous product of human metabolism with different concentrations in exhaled breath depending on the health condition. The purpose of this abstract is to demonstrate the design, fabrication, and testing of gold nanoparticle-based gas sensor array containing four interdigitated electrodes (IDE) which can perform simultaneous testing of different sensor materials to detect acetone. Gold nanoparticle-based gas sensors can support surface modification for accommodating thiols. Moreover, gold nanoparticlebased gas sensors provide several superiorities over conventional metal oxide based gas sensors, including lower power consumption, simple to operate, and good chemical selectivity for specific compounds. The sensor chips are fabricated on silicon wafer by MEMS technique using light-field photomask. Each chip size is 1cm x 1cm with IDE diameter of 2 mm. Pt/Cr metals are deposited by sputtering and the fabrication is completed by lift-off process. The results demonstrated that gold nanoparticles (AuNPs) functionalized with a designed thiol monolayer improves sensitivity and selectivity toward a particular VOCs. AuNPs based gas sensor functionalized with alkylurea thiol show a linear relationship between responses in a wide range of acetone concentration from 10 ppb to 1 ppm. The sensor array has a short recovery time and can operate at room temperature and ambient conditions. This device can be simultaneously used to detect other VOCs.

Biography

Sujoy Halder is a Ph.D. student in Chemical Engineering at the University of Louisville. He received a bachelor degree in Chemical Engineering from Shahjalal University of Science & Technology in Bangladesh. His research focuses on fabricating gas sensors for environmental applications and biomedical research. He had four years of work experience in the petrochemical industry as a process engineer.

Design and development of the Semi-Automated process of Solarpede microrobot assembly

Mariah Brooke Hall

Abstract

The Nexus Microassembly system was designed and built to enable assembly of the Micro-Electro-Mechanical Systems (MEMS) based structures. Because of the specific applications Nexus Microassembly system combines the tools, such as a precise motorized stages, sample chuck holding Si dies, cameras with tube lenses, and custom made end effectors, which allow manipulation of the MEMS components with a good control and precision. The goal of this project is to develop semi-automated assembly process of MEMS based robots with a focus on a specific type of a microrobot - Solarpede. Solarpede is a solar powered micro-crawler with 8 legs which are driven with the help of the thermoelectric actuators. Solarpede is intended to operate in a micro-factory where it could function as a conveyor for transportation purposes. The semi-automation process of the Nexus Microassembly is being realized with the help of National Instrument's LabVIEW software. General control scheme includes automation of selected motions of the sample chuck and end effectors based on the feedback received from the cameras and interpreted by National Instrument's Vision Assistant. The Labview program with user interface will include three main categories: vision, user prompts, and motion. During operation the program will prompt the user to check on its performance and ask for instruction on fine movements as necessary. As a result semi-automation of the assembly process of the Solarpede will simplify, streamline, and provide better control. In the future this program could be used as a template for automation process of the MEMS based robots.

Biography of Presenter

Brooke Hall is currently a second year Electrical and Computer Engineering student at The J.B. Speed School of Engineering. She previously attended Morehead State University as a Craft Academy student where she received her high school diploma. She became a part of the Next Generation Systems (NGS) group in October 2018 and was able to accept a Research Experience for Undergraduates (REU) this summer where she will present her work with MEMS assembly at a convocation hosted by Cornell University in August.

A laser pre-deposition heating technique to improve the interface healing in FFF-3D printed Ultem 1010

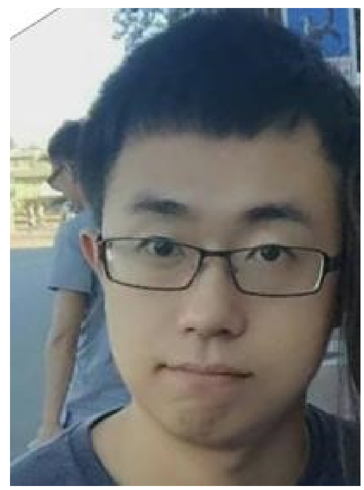
Pu Han, Alireza Tofangchi, Anagh Deshpande, Sihan Zhang, Keng Hsu

J. B. Speed School of Engineering. University of Louisville, Louisville, USA

Abstract

Fused Filament Fabrication (FFF) has become a preferred method for polymer additive manufacturing due to its flexibility and cost-effectiveness. However, parts fabricated using this method suffer from low mechanical strength especially along the build direction. To address this problem, an in-process laser with local pre-deposition heating technique is presented to enhance thermal diffusion across the inter-layer interface and subsequently increase interlayer bonding strength along the build direction. In this work, the effect of laser pre-deposition heating on tensile strength; polymer kinetic before and after extrusion including nozzle flow; 90 °exit turn, reptation model and re-entanglement are reported. With the application of laser heating, 82.8% of the isotropic for tensile strength was achieved (ratio of strength along build-direction to strength along in-plane direction) as well as an increase of 178% in tensile strength compared to the control sample. Evidence for Isotropic behavior at the fracture surface was also observed using a Scanning Electron Microscope.

Biography of Presenter



Pu Han is a PhD candidate in Mechanical Engineering from University of Louisville. He obtained his bachelor's degree in Materials Physics from Nanchang University in 2013, and his master's degree in Materials Science and Engineering from Arizona State University in 2015. As a part of his PhD research, he is focusing on developing novel methods to improve polymer and metal additive manufacturing processes by understanding the interaction of materials with heat and ultrasonic energy. Pu Han's research interests include additive manufacturing, materials characterization, solid state physics.

Tactile Sensors for User Interface in Adaptive Robotic Nursing Assistant

Penelope Jankoski[1],

[1]*Next Generation Systems Lab Group, University of Louisville*

Significant advancements of service robot technologies have been made in healthcare; however, with such advancements there are increased expectations of the ways robots can interact with humans and their environment. Morri's Theory of the Uncanny Valley, extended by Ishaguro, speculates that any robot intended to interact with humans at a complex level cannot appear too human or machine like, nor can there exist a mismatch between task complexity and appearance. This implies that robots must respond to their environment by receiving inputs and generating reactions that are equal to the complexity of tasks and robots' appearance for people to accept them. Otherwise, a mismatch between expectations and reality of the dynamic abilities of robots creates feelings of dissent. These subconscious expectations have led to advancements in sensing capabilities and haptic interfaces in robotics required to complete complex and dynamic tasks. The Adaptive Robotic Nursing Assistant (ARNA) is designed to decrease the cognitive and physical burden on nurses in their daily tasks, aiding in patient monitoring and walking scenarios. Currently, ARNA's haptic interface is composed of the handle bar grip equipped with electronic skin, containing a flexible tactile sensor arrays, made up of many micron sized sensors. ARNA's tactile sensors enhance the physical Human-Robot Interaction (pHRI), and allow the robot to dynamically engage in sensing. Development of the haptic capabilities of ARNA with SkinSim, an open source simulation that demonstrates the sensing capabilities, will improve ARNA's ability to engage with its environment.

SolarPede: A Novel Stick-and-Slip, Light-Powered, Micro-Crawler

Jordan F. Klotz[1], Danming Wei[1], Zhong Yang[1], Ruoshi Zhang[1], Andriy Sherehiy[1], Mohammad N. Saadatzi[1], and Dan O. Popa[1]

[1]Author's affiliation: Next Generation Systems, University of Louisville.

Abstract

In this paper we present recent research results aimed at creating mobile micro-robotic agents powered by light energy. The SolarPede is a second-generation, cm-scale microcrawler equipped with a legged locomotion system and an electronic backpack, targeting micro-factory applications. This novel micro-robot is an advancement in functionality and design over its decade-old predecessor, the ARRIpede, and includes technological advancements such as Bluetooth wireless communication, light power, and omnidirectional mobility on a flat substrate. The robot body consists of Micro-ElectroMechanical System (MEMS) electrothermal actuators and micro-assembled vertical legs. Attached to the body is an electronic backpack realized using a custom-made Printed Circuit Board and interfaced to the body via a wire-bonded package. A simulation model for the SolarPede was created to predict system behavior and dynamic operation, and to serve as a design tool. Simulation results of leg motion were compared with experimental displacement measurements and the model was extended to the operation of the microrobot in "belly-up" conveyor mode. Finally, optical microscopy was employed to experimentally measure the omni-directional motion of the SolarPede, and the robot power balance under a Solar simulator lamp was experimentally confirmed, thus validating the concept. Results suggest that continuous velocities of 15 µm/s can be achieved by the micro-robot in untethered operation. The body of your abstract begins here.

Biography of Presenter

Jordan is a student and the University of Louisville who earned a bachelor's degree in Electrical Engineering at the J. B. Speed School. He is now a researcher at NGS working towards a master's degree with a thesis in micro robotics. He specializes in PCB design and has used these skills a member of the robotic skin project, ARNA, and Micro Robotics project. His research focus today is with the micro robotics team working on SolarPede, the next generation light powered micro crawler. Jordan served as first author for a paper presenting the design and validation for SolarPede which was recently accepted to the MARSS conference in Helsinki, Finland.

Focused Electron Beam induced Etching of Copper

Sarah K. Lami[1], G. Smith[1], and J. Todd Hastings[1]

[1] *Electrical and Computer Engineering, Univ. of Kentucky, Lexington, KY 40506*

Abstract

Focused ion and electron beams are routinely used to locally add or subtract materials at the nanoscale. This process is important for editing and debug of integrated circuits. In addition, it enables nanoscale rapid prototyping and interconnection of top-down and bottom-up nano-systems. Applications of beam-induced etching often require selective material removal and protection of underlying nanostructures; however, ion-beams exhibit low selectivity and induce damage. E-beam etching with gaseous reactants relies on producing a volatile byproduct, and thus cannot etch many important materials such as copper. Liquid, rather than gas, phase focused electron beam induced processes may overcome these drawbacks. Liquid chemistry enables one to etch materials with soluable, rather than voltile, products and can provide high selectivity with little damage. Here we present a comprehensive investigation of e-beam induced copper etching in aqeuous sulfuric acid and a predictive model for the etch process. We used Monte Carlo simulation to calculate electron energy loss in the liquid and coupled it with finite element modeling of reactions and mass transport in the liquid. Excellent agreement between simulated and experimental etch rates was obtained using data from the radiation chemical and electron microscopy literature without any fitting parameters. Under the conditions considered here, etch rate increases with both liquid thickness and beam current, but in a nonlinear fashion governed by electron energy loss, dose rate, and reactions in the liquid.

Sarah Lami

Sarah Lami is a Ph.D. candidate in Electrical and Computer Engineering at the University of Kentucky. She received her M.S. in Electrical and Communication Engineering from Al Nahrain University, Baghdad, Iraq, in 2007. Her research interests are in the area of micro/nano technologies with a particular focus on developing techniques and devices in printed electronics, bioelectronics, and nanophotonics. She was previously a lecturer at Babylon Technical institute and a Technical Engineer at Philips Medical Systems Agency.

She is a recipient of the Higher Committee for Education and Development Scholarship from Iraq. She received the best overall poster award at EIPBN 2018 (Puerto Rico, USA) and the best Ph.D. student poster award for the University of Kentucky ECE Research Symposium. During the past year her papers have been accepted for publication in *Nanoscale*, *Nanotechnology*, and the 2018 IEEE 8th Annual Computing and Communication Workshop and Conference.

Germanium Photo-gated Bipolar Junction Transistor to Detect Infrared Light

Michael David Martin[1], Camille V Reyes[2], Shamus McNamara[2], Frank Kenneth Hopkins[3], John Jones[3]
[1]Micro/Nano Technology Center, University of Louisville
[2]Dept of Electrical and Computer Engineering, University of Louisville [3]Air Force Research Laboratory (AFRL/RX), Wright-Patterson AFB

Abstract

The goal of the project is to investigate a photon-gated bipolar junction transistor (BJT) that utilizes a germanium-silicon interface to enable high-gain light detection with select performance figures-of-merit that exceed those of traditional avalanche photodiodes. The structure of the unique photo-BJT design sandwiches the transistor's base between the emitter and collector horizontally rather than the traditional vertical layout. The substrate is silicon with a small germanium base centered on top. Aluminum contacts for the emitter and collector sit on top of the silicon on either side of the germanium, allowing for two parallel npn transistors, one with a germanium base and one with a silicon base. Although the project is still in the fabrication phase, simulations for the photo-BJT design yield a high calculated gain due to the physics of the Si-Ge interface. Collaborators at the Air Force Research Laboratory (AFRL) are depositing the germanium film utilizing pulsed laser deposition (PLD) and then characterizing the germanium via Hall measurements and X-ray diffraction. PLD uses high power laser pulses to vaporize material from a target and into a plasma plume which then condenses onto a substrate as a thin layer. Capacitance-voltage test wafers are also being fabricated to test various oxides, such as SiO_2 and Al_2O_3, and verify that all layers deposited onto the substrate are of high quality.

Biography

Michael Martin has 25 years experience in various microfabrication techniques ranging from conventional photolithography to micro milling and excimer laser microfabrication. He holds a B.S. in physics from Austin Peay State University, Clarksville TN, an M.S. in physics from the University of Louisville and is a part-time PhD student in the University of Louisville physics department.

Embedded Sensing Capabilities in an FDM Printed Object

Garrett McGrady, **Neel Jain**, Douglas Jackson, Dr. Kevin Walsh
University of Louisville

Abstract

Purpose

The objective of this paper is to demonstrate the flexure properties of ABS plastic in a 3D printed object as a mode to enable embedded pressure sensing capabilities. Developing the potential for non-static 3D parts broadens the scope of fused deposition modeling (FDM) to include printable 'smart' objects that utilize intrinsic material properties to act as microphones, load sensors, accelerometers, etc.

Findings

Diaphragms of 1mm thickness exhibited a greater range of deformation than 2mm diaphragms over the same domain of input pressures. Securing a strain gage directly on top of the diaphragm traced a reference pressure more closely than diaphragms with the strain gage embedded halfway into the diaphragm. An additional strain gage was suspended above the secured gage, inside the 3D printed cavity. The additional gage allowed for a half-bridge circuit in lieu of the quarter-bridge circuit; furthermore, the half-bridge circuit minimized drift due to temperature change. The ABS diaphragm showed no significant signs of elastic hysteresis or nonlinear buckling. Sealed with 100% acetone, the diaphragm leaked ~50x slower than as-printed sensors. After pressurizing and depressurizing the devices multiple times, they output pressure readouts that were consistent and repeatable for any given pressure within the operational range.

Impact

The repeatability of each of the final generation sensors indicates that 'smart' objects printed using an FDM process could be individually calibrated to make repeatable recordings. This work demonstrates a concept overlooked previous to now—FDM printed objects are not limited to static models. Altering FDM's bottom-up process can allow for easily embedding sensing elements that result in printed objects which are functional on the mesoscale.

Biography of Presenter

Neel Jain is an engineering undergraduate student at the University of Louisville. He is currently studying Electrical Engineering and has done an internship at CMTA Engineers in Prospect, KY.

Characterization of Light Propagation in a Multimode Optical-fiber using Mie Scattering

Arianna Meenakshi McNamara[1], Shamus McNamara[1], Michael Martin[1], Frank Kenneth Hopkins[2], David E. Zelmon[2]
[1]*University of Louisville*
[2]*Air Force Research Laboratory (AFRL/RX), Wright-Patterson AFB*

We present a new approach to characterize fiber-optic modes, power, and attenuation based upon sampling the confined light using a trivial quantity of Mie scattering. The fiber outcouplers traditionally used for sampling the confined light in optical fiber could be replaced with this much-less complicated approach. Mie scattering is the scattering of light by particles similar in size to the wavelength of the light, and these scattering centers may naturally occur or be engineered into the fiber to be characterized. The goal of the project is to use a planar photodiode array to detect the scattered light and determine the modes and power in an optical fiber that 'glows' due to Mie scattering. The photodiode array is currently being fabricated, and is composed of 57 diodes in three 60o concentric circle slices. Light with a frequency greater than the single mode cutoff frequency will propagate with multiple sets of angular and radial dependencies. The design will allow us to identify the modes propagating within the fiber, and their respective intensities, because we are expecting only LP01 and LP11 modes to propagate in the fiber. Assuming a uniform defect density, we have calculated the expected light intensity due to Mie scattering on the photodiode array by integrating the mode light intensity in a slice of the fiber and then integrating over the length of that fiber. Our results from these calculations show that the expected light intensity in the plane of the photodiode sensor array matches very closely with the modes, so we can expect to identify them with the proposed photodiode array.

Biography of Presenter

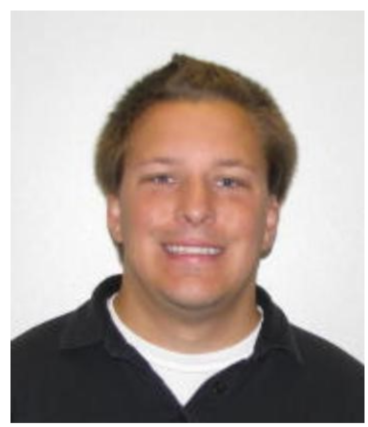
Arianna Meenakshi McNamara is a homeschooled high-school student who is entering her senior year. She has been working on this research project since the beginning of 2019.

Characterization of New Microreactors for Preconcentration of Carbonyl Compounds

J.D. Morris[1], Q. LI[1], Z. Xie[1], M.H. Nantz[2], X.A. Fu[1]
[1]Department of Chemical Engineering, [2]Department of Chemistry
University of Louisville, Louisville, KY 40208

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. Breath analysis is a very promising tool for diagnosis of these diseases. We have developed a silicon microreactor with custom-engineered surface functionality for capture and analysis of ketones and aldehydes in exhaled breath. The purpose of this abstract is to characterize and model a new generation microreactors with different structures in order to optimize the design to maximize allowable sample flow rates for high capture efficiencies. Several designs of the microreactors were fabricated and tested for the capture of carbonyl compounds. The designs used different micropillar shapes and different lengths of the microreactors. The custom-engineered surface functionality was realized by adsorbing quaternary ammonium aminooxy salt, 2-(aminooxy) ethyl-N, N, N-trimethylammonium iodide (ATM), on the surfaces of micropillars in the microreactor. The adducts of ATM reacted with carbonyl compounds were analyzed using UHPLC-MS. The reaction kinetics was measured and the sample flow rate effect on the capture efficiencies of carbonyl compounds were determined. A model was established to predict the relationship between capture efficiencies of carbonyl compounds and the sample flow rate for a specific microreactor length. The model can fit the experimental data well. In conclusion, a new microreactor with triangular micropillar array and a length of 21 mm can capture above 90% carbonyl compounds in breath samples at a sample flow rate of 7 mL/min. A model was established to predict the capture efficiencies related to the sample flow rate.



Biography of Presenter

James Morris is a second year PhD student at University of Louisville in Chemical Engineering under Dr. Xiao-An Fu. He earned his B.S. in Chemical engineering in 2014 from Trine University in Angola, IN. Then he worked at Cummins Inc. until August 2018 in Cummins Emissions Solutions developing and testing flow through catalysts for diesel applications.

Deuterium termination of diamond transistors for increased durability

Ross H. Parish[1,2], Shamus McNamara[2], William F. Paxton[3], Kevin M. Walsh[2], Mahendra Sunkara[3]
[1]Yale University, New Haven, Connecticut
[2]Micro/Nano Technology Center, University of Louisville, Louisville, Kentucky
[3]Conn Renewable Energy Center, University of Louisville, Louisville, Kentucky

Abstract

Diamond is under active research as a semiconductor to replace silicon in high-power and high-frequency transistor applications. Its properties of thermal conductivity, breakdown voltage, and radiation tolerance are even more favorable than those of other wide-bandgap (WBG) materials such as silicon carbide (SiC) and gallium nitride (GaN). Diamond is a strong insulator as a pure material, yet it is easily modified to exhibit superb p-type conductivity. To exploit this, common practice is to hydrogenate the surface and create a thin layer of 2-dimensional hole gas (2DHG), allowing current to pass through a channel between metal contacts. Although most studies of 2DHG diamond transistors have not focused on durability, it is known that hydrogen can easily detach from the surface of diamond over time, and that process can accelerate when exposed to air, water, or heat, even under a protective aluminum oxide layer. Deuterium, a heavy isotope of hydrogen, is a promising substitute for the latter, because it has the same chemical properties but double the mass, making it less susceptible to detach from the substrate. In testing, transistors of deuterium-treated diamond ought to show similar current, voltage, and resistance to hydrogenated ones, but degrade less over time.

Biography of Presenter

Ross Parish is a third-year student at Yale University pursuing a B.S. in Mechanical Engineering. This summer, he is working on a diamond transistor research project at the University of Louisville Micro/Nano Technology Center (MNTC).

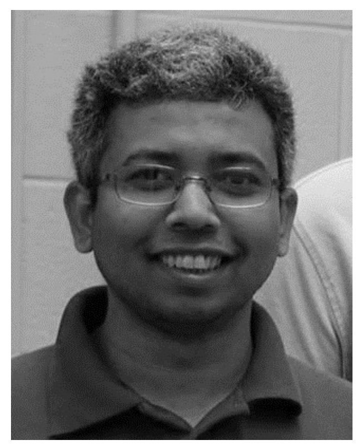
How coalescence manipulation of landed drops can be useful in inkjet printing

Md Mahmudur Rahman[1], Stuart J Williams[1] [1]*University of Louisville*

Abstract

Because of low cost and easy to implement, 3D inkjet printing has wide applications from metal and polymer objects, biological tissue, dental, electronics, optics to wearable sensors/devices. While different methods have been adopted on dispensing drops on the substrate, acquiring desired crystal structure and better printing resolution while maintaining structural intricacy is still a challenge. After landing drops on the substrate, they may coalesce together and can form continuous print. Therefore, it is imperative to know the coalescence dynamics of landed drops for better printing quality. Recently we showed that initial dynamics of liquid drop coalescence depends on Ohnesorge number while the later dynamics depend on boundary conditions. We viewed internal fluid flow of two-dimensional coalescing drops and developed scaling laws for three-dimensional drop coalescence for different viscous liquids which can tell precise bridge growth rate of coalescing drops. For unbounded drops, viscous resistance in coalescence happens in bridge region and at larger extent in merging interface region. If drops are bounded on a substrate, another viscous resistance (due to adhesion to the substrate) will slow down the coalescing process. When two drops are coalescing, a third drop can be placed nearby the bridge region of coalescing drops. This process can go on until the entire printing area is covered. Process parameters have to be chosen from coalescence and evaporation dynamics based on the droplet and substrate properties. This way uniform thickness of the printed layer and uniform morphological structure can be achieved and thus coffee ring effect and other structural anomaly such as spatial gradient of nanoparticles/microparticles concentration can be eliminated.

Biography of Presenter



Md Mahmudur (Rony) Rahman is a PhD candidate working with Dr. Stuart J Williams at University of Louisville. Rony completed his MS from University of Nebraska-Lincoln. His research at UofL focuses on two concentrations: (1) hydrodynamics of drop coalescence; (2) colloid structure formation due to hydrodynamic interactions. He recently published an article entitled as “Viscous resistance in drop coalescence” in Physics of Fluids. His research is supported by NASA EPSCoR NNX14AN28A. He was awarded an NSF Innovation Corps grant in 2017.

Process Characterization of the Microscale Deposition Tools.

Zane Ronau

Abstract

Recent advancement in 3-D printing technology, such as Ink and Aerosol Jetting, introduced novel tools enabling fabrication of the multiscale structures (submicron to millimeter size) which could be applied for the assembly or integration of the Micro-Electro-Mechanical Systems (MEMS). In this study we present results of the Ink and Aerosol Jet printing process characterization realized with the help of the Nordson EFD PICO Pulse and Optomec Aerosol Jet Print Engine. PICO pulse system allows controlled and precise deposition of the fluid at nanoLiter scale. This property could be utilized for controlled deposition of the viscose UV curable adhesives which are used for the MEMS robots assembly. The Aerosol Jet system enables printing of the 40 – 100 micron features with sub/few micron thickness e.g. conducting lines and patterns. This has a wide range of possible applications that include flexible electronics and sensors which can be manipulated to meet the user's specific requirements. For future automation of the PICO Pulse and Aerosol Jet printing processes and instrument integration with other tools (e.g. Nexus Multi-Scale Robotics System) a number of experiments were designed and conducted in order to achieve printing process control and formulate specific recipes.

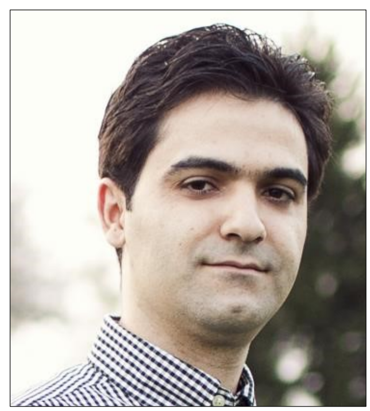
Flexible Electronic Skin Arrays for Safe and Intuitive Physical HumanRobot Interaction

Mohammad Nasser Saadatzi[1], Joshua Baptist[1], Zhong Yang[1], Ruoshi Zhang[1], and Dan Popa[1]
[1]Next Generation Systems Research Group, University of Louisville

Abstract

Artificial robot skins capable of tactile feedback are anticipated to revolutionize how robots perceive their immediate surroundings and how they collaborate with humans on tasks more complicated and dynamic than currently possible. In this study, a flexible robot skin array was fabricated which consisted of an array of piezoresistive polymeric strain gauges micro-patterned on a flexible polyimide, and encased inside a compliant encapsulant. The strain gauges featured a biaxial symmetric response, avoiding insensitive regions in their vicinity thanks to their novel circular geometry. The proposed gauge structure was first modeled using multiphysics finite element analysis (FEA) software in order to investigate a variety of geometry specifications. Following simulation, gauges with the optimal structure parameters were printed onto a polyimide film using photolithographic processes. Subsequently, PEDOT:PSS, a piezoresistive polymer, was lithographicallypatterned on top of the strain gauges via spin-coating and wet loft-off. In this investigation, a novel thermal compensation technique was proposed by homogeneous integration of strain gauges on the opposite sides of a flexible carrier. The temperature-compensated sensor not only gained a 10-fold attenuation in temperature sensitivity, but also featured a double sensitivity in terms of strain measurement. Next, in order to provide mechanical compliance and robustness against collision, a multi-step casting process was utilized to mold silicone polymer all around the sensor array. The robot skin's behavior was investigated in terms of characteristic curve, hysteresis, spatial sensitivity, temperature sensitivity, and bandwidth. The empirical data were found to be in close agreement with the simulation trends obtained from FEA modeling in terms of biaxial sensitivity and circular symmetry.

Biography of Presenter



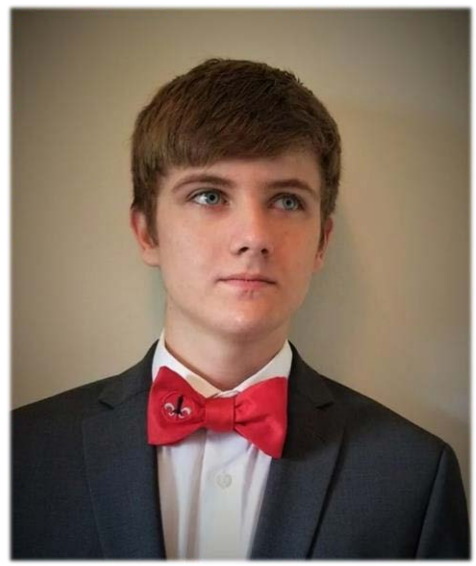
Mohammad Nasser Saadatzi is a Research Associate with the Next Generation Systems (NGS) research group at the University of Louisville, in Louisville, KY. He received a Ph.D. degree in Electrical and Computer Engineering from the University of Louisville, KY in 2016, with a focus on machine learning, wearable computing, and human-robot and humancomputer interaction technologies. His current research interests are advanced human-machine interfaces, assistive robotics, instrumentation, and automatic control systems.

Low Cost MEMS Style Sensors for Education

<u>Jacob Schopp</u>, Shamus McNamara
Electrical and Computer Engineering, University of Louisville, Louisville, KY

Abstract

The goal of this project is to develop MEMS style devices can be designed and fabricated by students in classroom environments at a low cost. Conventional equipment may be used to create macroscale versions of microscale MEMS devices. Using a laser cutter, devices can be made that emulate the behavior of common sensors. Laser cut acrylic and conductive paint can be used to fashion an accelerometer where resistance will change with strain and capacitance will change with displacement. Both methods of measurement were attempted and show promise for further development. A conventional benchtop multimeter with SCPI was used to perform batches of automated four terminal resistance measurements. In the case of capacitance, voltage measurements an Arduino were taken to measure an increasing voltage over time with a known resistance and voltage. We found measuring change in resistance to be preferable and more easily achieved with easily accessible equipment.



Biography of Presenter

Jacob Schopp is an Electrical Engineering student at the University of Louisville. He is a CPU architecture hobbyist, and is a member of River City Rocketry.

MRI Nexus system: Development of a Multiscale Additive Manufacturing Instrument with Integrated 3D Printing and Robotic Assembly

Andriy Sherehiy[1], Antoine C. Blasiak[1,2], Danming Wei[1], Dilan Ratnayake[1], Garrett E. McGrady[1], Brooke Hall[1], Challa Sushmita[1], Amirhossein Ghahremani[1], Alireza Tofangchi[1], Kevin M. Walsh[1], Keng Hsu[1], Cindy Harnett[1], Thad Druffel[1], Dan Popa[1]

[1]*University of Louisville*

[2]*École nationale supérieure de mécanique et des microtechniques, Besancon*

Abstract:

The goal of this project is development of Nexus system, an instrument for flexible multiscale manufacturing of Micro/Nano Opto Electro Mechanical Systems (MOEMS/NEMS), by precision robotic assembly and additive manufacturing. Nexus is a novel robotic platform for multiscale integration of miniature devices and systems, such as wearable MEMS sensor fabrics, microrobots for wafer scale microfactories, tactile robot skins, next generation energy storage, nanostructured plasmonic devices and biosensors. The proposed instrument will have the flexibility to fixture, position, transport and assemble components across a wide-spectrum of dimention scales (100nm to 1m), and will provide unparalleled additive process capabilities such as 3D printing through both aerosol jetting and ultrasonic bonding and printing, thin film photonic sintering, fiber loom weaving and in-situ MEMS packaging and interconnect formation. The Nexus will automate basic processes such as additive deposition, sintering, assembly, and packaging leading to better control and consistency in development of micro/nanosystem prototypes. As a part of the project we will design, build and test the instrument, therefore in order to realize this plan in our project team we have assembled a unique blend of expertise in precision robotics (Popa), distributed MOEMS sensing (Harnett), nanostructured thin-films (Druffel), additive manufacturing (Hsu), and multiscale MEMS integration (Walsh). Here we present the basic design of the Nexus system with description of the specific processing tools, plan of their integration, and initial results of additive deposition (Ink and Aerosol Jet printing) process characterization.

Andriy Sherehiy is currently a Postdoctoral Research Associate at Next Generation Systems group of Speed School, University of Louisville. He received his PhD degree from the University of Lousiville in 2014.

Use of Microvalves and Air Pressure in a Refreshable Braille Display

<u>Spencer Sherlock</u>, Dr. Shamus McNamara
University of Louisville, Louisville, KY

Abstract

This overall goal of this work is to develop a refreshable Braille display that shows rows of text and graphics. This would be a revolutionary advance for seeing-impaired persons. The combination of MEMS strained multilayer microvalves alongside an elastic film presents a promising method for creating a compact and refreshable braille display that is actuated using air pressure. A grid of braille standard perforations, 1.5 mm diameter, 0.6 mm height, and 2.3 mm spacing between dots are formed in a polymer sheet and an elastic layer bonded to it. Using an air reservoir, pressure is applied to raise the elastic layer to the standard height. With this set-up, the microvalves can be placed across the air channels of each braille dot. An exhaust channel with a separate microvalve can be activated to allow for the release of pressure from the channel. This can be utilized alongside the elastic layer to create a grid of dots that can be electronically raised and

$qqmm^{44}$ $EEhh^{33}$ lowered. To create a prototype, the equations $\omega\omega_{mmmmmm} = _{664466}$ and $66 = _{1111}\,(11-\gamma\gamma 11)$ were used to find a test material that could be raised to the required 0.6 mm using 100 KPa of pressure. The chosen material as the elastic layer is a latex sheet of .1524 mm thickness. The prototype polymer sheet used was a 3/8 inch acrylic sheet.

Biography of Presenter

Spencer Sherlock is a first-year student at the University of Louisville, pursuing a degree in Electrical Engineering. He is working with the summer research program under Dr. McNamara.

A Study of Pore Formation during Single Layer and Multiple Layer Build by Selective Laser Melting

Subin Shrestha, Sabina Chertmanova, Kevin Chou J.B. Speed School of Engineering

Abstract

Selective laser melting (SLM) is a powder bed metal additive manufacturing (AM) process with the capability of freeform fabrication. Laser power, scanning speed, hatch spacing, etc. are the important process parameters which determine the part quality during the fabrication process. Depending upon the process parameters used, different types of pores may form. Hence, the effect of individual parameters on the porosity should be investigated, and the pores formed should be characterized to avoid the porosities with proper selection of the process parameters. In this study, different hatch spacings were used to fabricate single layer and multiple layers, and its effect on porosity was investigated by using microcomputed tomography. The combination of laser power (100 W, 150 W, 175 W, and 195W) and scan speeds (600 mm/s, 800 mm/s, 1000 mm/s and 1200 mm/s) which resulted in the least number of pores were selected from the previous single-track experiment. Six levels of hatch spacings were selected based on the track width to form single and multiple layers: 60%, 70%, 80%, 90%, 120% and 150% of track widths. For the single layer, the variation in keyhole porosity within the given window of parameters were found to be attributed to the variation in the hatch spacing. During the multilayer formation, the pores found at low hatch spacings were keyhole pores and pores formed at higher hatch spacings tended to be lack of fusion pores.

Biography of Presenter

This summer Sabina Chertmanova, an Undergraduate Research Assistant worked alongside with Subin Shrestha and Dr. Kevin Chou on this study. Sabina is originally from Russia but has spent most of her life here in Louisville. She is a senior in the Department of Mechanical Engineering at the University of Louisville and is a first generation student in her family. Aside from her classes, Sabina has co-oped with SABIC, a manufacturing company active in petrochemicals, industrial polymers, fertilizers and metals, and is involved with the TRIO and LSAMP organizations on campus. Sabina truly enjoys learning and even works both as a peer and group tutor here at UofL and lastly, she is very passionate about representation and the diversity that she finds here!

Corrosion Properties of Inconel 625 Processed by Laser-Powder Bed Fusion

Kavish Sudan[1], Subrata Deb Nath[1], Azim Gökçe[1], Alexander J. Gupta[2], Gautam Gupta[2], Sundar V. Atre[1] and Kunal Kate[1]*

[1]*Materials Innovation Guild, University of Louisville, Louisville, KY 40208*

[2]*Department of Chemical Engineering, University of Louisville, Louisville, KY 40208*

Abstract

Inconel 625 (IN625) is a nickel-based solid solution strengthening superalloy, which exhibits high mechanical strength, high temperature resistance, and excellent corrosion resistance. These properties make IN625 ideal for use in extreme environments such as those encountered in marine or space applications. Inconel 625 components have been manufactured using several conventional manufacturing processes such as casting, powder metallurgy, spray forming, weld overlaying and co-extrusion of piping components. However, machining IN625 components into elaborate shapes is remarkably difficult and expensive by subtractive manufacturing, due to the material is characterized by high hardness and high-temperature strength as well as low thermal diffusivity. The fabrication of IN625 parts via laser-powder bed fusion (L-PBF) has been reported, but little is known about the relationship between various process parameters and the corrosion properties of the resulting part. In this study, two nondestructive techniques based on alternating current frequency response analysis – electrochemical impedance spectroscopy (EIS) and electrochemical frequency modulation (EFM) – were employed to determine parameters including polarization resistance, Tafel constants, and corrosion current for L-PBF IN625 specimens under various process conditions. Furthermore, microstructural properties of the specimens were analyzed via electron microscopy (SEM) and x-ray diffraction (XRD) to understand property-microstructure relationships.

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Biography of Presenter

Kavish Sudan is currently pursuing M.Sc. in Mechanical Engineering at University of Louisville and working as a Graduate Research Assistant with Materials Innovation Guild. His core interests are design, simulations and fabrication of near net shape parts using additive manufacturing process. He is currently working on the investigation of the effects of process parameters and feedstock attributes on the prepared filament, green part and hence the sintered part in Metal Fused Filament Fabrication process. Additionally, he is working on studying the effect of process parameters and HIP-ing on the corrosion properties of Inconel 625 processed by LPBF.

As a CTO, he mentored a student team to design and examine the business model of a 3D Printed Therapeutic Reagent Delivery Device. He is passionate to implement 3D printing in industries as a complementary to the existing technologies. Mr. Sudan won the NSF-MPIF Student grant for the year 2019. He received his B.E. in Mechanical Engineering from University Of Jammu, India.

3D Printed Color Filters

Mansoor A. Sultan[1] and J. Todd Hastings[1]

[1] *Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40506*

Abstract

Color filters are essential in a wide range of applications such as digital cameras, projectors, displays, spectral imaging, and spectroscopy. Most filters are composed of colored dyes, which are vulnerable to mechanical and environmental conditions and difficult to tune, or dielectric multilayers, which are costly and difficult to combine in a single system. Therefore, structure-based color filters have been of great interest because of their durability, wide tunability, and ease of integration. This work presents the design and fabrication of low cost, robust structure-based color filters. These filters will provide significant advantages for both digital and hyperspectral imaging. The fabrication process for the proposed filters resembled 3D printing, and is based on direct laser writing (DLW) of a polymeric material using two-photon lithography. Filters for visible and near-infrared wavelengths were designed using finite difference time domain (FDTD) simulations. Direct laser writing parameters were established to yield the desired spectral bands and most efficient fabrication. Measurement of the filters' optical transmission spectra agreed well with simulation, and showed peak transmissions of 70% to 90% at different center wavelengths between 450 to 1000 nm.

Biography

Mansoor A. Sultan is a PhD candidate at the University of Kentucky in the Department of Electrical and Computer Engineering. Mansoor got his B.Eng. degree in Medical instrumentation engineering from Technical college of Mosul in Iraq (currently known as Northern Technical University) 2005. He got the M.Sc. in Electrical Engineering from the University of Kentucky in 2015. His research interest includes Nano-fabrication, Lithography, Photonics and Optics.

CHARACTERIZING THE NANOSCRIBE PHOTONIC GT SYSTEM FOR FABRICATING MEMS BISTABLE STRUCTURES

Kevin Tobin[1], Dilan Ratnayake[2], Kevin Walsh[2]

[1]*Mechanical Engineering, Lipscomb University*

[2]*Electrical and Computer Engineering, University of Louisville*

Abstract

In this research project, we explore if the Nanoscribe Photonic GT system can be used to fabricate bistable MEMS (microelectromechanical systems) structures. Bistable MEMS devices typically consist of thin diaphragms and cantilevers, which require precise control of its micro- and nano-scale structural features to function properly. The Nanoscribe Photonic GT tool is an advanced 3D printer that uses a two-photon polymerization process to print three-dimensional features as small as 160nm. Therefore, it should be a viable manufacturing candidate for quickly producing such bistable devices. In this research, we explored various design considerations, print job preparation strategies, printer settings, printing materials and printing substrates. Designs were printed on silicon wafers, ITO covered glass, and glass. For the cases of silicon and ITO covered glass, we used IP-S photoresist and a 25X objective, as recommended by the vendor. For glass, we used IP-Dip resist and a 63X objective. Various printer settings were examined in each case. The less viscous IP-Dip resist proved problematic as many of the thin overhang structures of the MEMS bistable device failed by collapsing. We obtained better results with the thicker IP-S resist and the 25X objective. This poster will review the parameter space we examined and show our novel results.

Biography of Presenter

Kevin Tobin is an REU Research Intern with KY Multiscale Manufacturing and Nanointegration Node. Kevin is an undergraduate student at Lipscomb University, majoring in Mechanical Engineering with a minor in Applied Math. Kevin is a recipient of Lipscomb's Presidential Scholarship and an Eagle Scout.

SYNTHESIS AND EXFOLIATION OF BLACK PHOSPHORUS

Jackson Walter[1], Riyadh Shah[2], Manthila Rajapakse[2], Gamini Sumanasekera[1,2], Jacek B. Jasinski[1] [1]*Conn Center for Renewable Energy Research, University of Louisville*
[2]*Department of Physics and Astronomy, University of Louisville*

Here we report our current research on the synthesis and liquid exfoliation of black phosphorus (BP). The objective of this study is to establish a method of producing stable samples of phosphorene flakes with well-controlled morphological parameters, including their lateral size and number of layers. Such samples are needed for fundamental studies of phosphorene and for the fabrication of devices based on this novel two-dimensional (2D) material. Exfoliation is a well-recognized top-down approach for obtaining 2D materials from their bulk counterparts. It has been successfully demonstrated for the fabrication of various 2D materials, including graphene, h-BN, and transition metal dichalcogenides. Since BP is the bulk analog of phosphorene, i.e., consists of stacked, van der Waals (vdW)-bonded phosphorene layers, its exfoliation can be used as a direct method of producing phosphorene sheets (flakes). In our approach, we first synthesize crystals of BP by using a short transport growth method and red phosphorous as an inexpensive precursor. Quartz glass ampules filled with tin (Sn), tin iodide (SnI_4), and red phosphorus are evacuated to 10^{-6} Torr, sealed using an oxy-acetylene flame torch, and annealed in a quartz tube furnace. By using a two-zone furnace and a well-controlled temperature gradient, we can obtain high-quality BP crystals. Once the BP is synthesized, the material is suspended in a solvent and sonicated to break weak vdW bonds between the layers and separate BP crystals into 2D flakes of phosphorene. Subsequent centrifugation is performed to separate the phosphorene into fractions of flakes with a different number of layers. The sonication is done using different solvents and over varying lengths of time to determine the optimal exfoliation conditions. For the solvent, we are testing dimethylformamide (DMF), dimethyl sulfoxide (DMSO), DMF with sodium dodecyl sulfate (SDS) added to lower the surface tension, and deoxygenated water. The flake size distribution and thickness, phosphorene stability, and dispersion stability are the properties that need to be controlled.

Jackson Walter is an undergraduate student in chemical engineering at the University of Louisville. He currently works on research of 2D materials at the Conn Center for Renewable Energy Research with the materials characterization group.

Design, Analysis, and Characterization of a Novel 4-DOF Microrobots

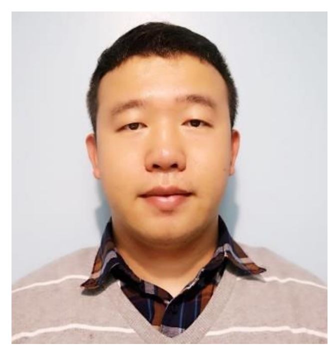
Danming Wei, Mariah B Hall, Ruoshi Zhang, Andriy Sherehiy, Zhong Yang, Dan O. Popa
Department of Electrical and Computer Engineering, University of Louisville, danming.wei@louisville.edu

Abstract

The goal of this research is to develop and improve a new type of 3-dimensional microrobot called Solid Articulated Four Axes Microrobot (sAFAM). The sAFAM is an evolutionary improvement of a previous microrobot which was driven by two coupled inplane MEMS X-Y stages along with an epoxied cable. The sAFAM was designed to replace the cable traction system with an unibody arm that can be assembled into the inplane X-Y stages, which simplifies the assembly process complexity and improves the microrobot precision. The sAFAM structure was simulated by finite element analysis (FEA), predicting a 13µm x 47 µm x 115 µm workspace and verifying appropriate concentration of stresses during actuation. The resolution, repeatability, and workspace of the microrobot were then measured experimentally via optical microscopy and laser ranging, indicating a 16 µm x 20 µm x 118 µm dimension workspace. Experiments also indicate that the motion resolution and repeatability of the microrobot varies depending on the location of the end-effector in space, but generally the range is between 20nm (minimum) and 150 nm (maximum). Thus, sAFAM has the potential for future use as an assist micro/nano manipulation tool in the scanning electron microscope (SEM) or in conjunction with an atomic force microscope (AFM).

Biography of Presenter

Danming Wei was born in Shenyang, China, in 1987. He received his B.S. degree in Electrical Engineering from Dalian Jiaotong University, China, in 2011, his M.S degree of Chemistry from Western Kentucky University, Kentucky, in 2016 and M.S. degree of Electrical Engineering from University of Louisville, Kentucky, in 2018. Currently, he continues studies pursue Ph.D. degree in Electrical Engineering at University of Louisville. He served as a graduate research assistant in Institute of Combustion Science and Environmental Technology (ICSET) at Western Kentucky University from 2013 to 2016. In 2016, he joined the Next Generation System (NGS) group as a research assistant where he worked in the area of Multiscale Robotics, Microsystems and MEMS control. He represented NGS group at 2017 IEEE International Conference on Robotics and Automation Mobile Microrobotics Challenges and achieved the second place in the final competition.



Replica Root Form Dental Implant: Proof of Concept

Peter S. Wulff, [1] William C. Scarf, [2] Timothy J. Gornet, [3] Gary E. Graf, [3] Aly A. Farag,[3] Kelsey M. Phillips, [1] and **Lawrence Gettleman**[1]

Departments of Oral Health & Rehabilitation[1], and Surgical & Hospital Dentistry[2], University of Louisville School of Dentistry, and Department of Mechanical Engineering[3], Speed Scientific School, University of Louisville, Louisville, Kentucky

Many patients loose teeth but retain supporting bone and its periodontal ligament. New engineering and clinical procedures can be used to replicate the crown and root in artificial materials before the failing tooth is ever extracted, and implant a perfect substitute attached by the periodontal membrane, not bony attachment.

Objectives: Determine the feasibility of making a replica implant of a tooth using current technology, initially in fresh *ex vivo* hog jaws in this study. **Clinical indications** *a)* vertical cracks/horizontal tooth fractures, *b)* deep coronal/cervical caries; *c)* coronal caries under reusable prostheses; *d)* root/chamber perforations; *e)* internal/external resorption; *f)* endodontic failures; and/or. *g*) lower cost alternative to endodontic treatment of the tooth/post reinforcement/crown.

Methods: Cone beam computerized tomographic files of individual teeth were generated from a hog jaw using the ULSD iCAT 17-19 machine. A digital file of the lower right second deciduous premolar was generated with a 3DSlicer, blocking the pulp chamber and selecting the contrast level limited to the tooth exterior. The DICOM file was converted to STL for additive replication in the UofL Rapid Prototyping Center using High Temperature Selective Laser Sintering to generate Nylon-12 replicas of the tooth. Future replicas may be made in metals, polymers or ceramics. The *ex vivo* tooth was then extracted from the hog jaw and the replica tooth immediately implanted, similar to replanting an avulsed tooth.

Results: After troubleshooting the digital file compatibility and precision/accuracy of the CBCT image, the replica was successfully prototyped.

Conclusion: After prototyping a replica implant tooth from Nylon-12, we need to address the accuracy of this replica implant versus the tooth. The digital process could be automated. Animal studies should be conducted to determine biocompatibility of various replica implant materials, verified histologically, before human clinical trials. Surface modification for connective tissue attachment to the root portion should be explored, and cervical membrane placement in animal models used to prevent epithelial migration around the fresh replica implant.

Six new technologies are contemplated: 1) CBCT scanning, 2) additive or subtractive CAD/CAM, 3) surface modification of root surfaces, 4) overnight delivery if not done on-site, 5), non-destructive dissection of the attachment membrane, and 6) and membrane control of gingival epithelium.

The body of your abstract begins here. This section should be roughly 250 words. Please use 12 point Ariel font, 1.15 line spacing, and 1-inch margins. If you are reporting on research, your abstract should contain the purpose, the main materials and methods used, the main results obtained, and the main conclusions of the work. No figures or tables are required, but can be included if you wish. If your talk is less research-oriented and more informational, please provide a nice concise overview about the topic you plan to present. The abstracts will be used to complete the agenda for the 2-day symposium. Abstracts are due July 1, 2018 and are to be submitted through the symposium website. Since the symposium will attract a very interdisciplinary audience spanning various fields of advanced manufacturing, industry and academia, please write your abstract so that it is both understandable and of interest to someone with a basic understanding of science, but not necessarily an expert in your field of study. We suggest you download this WORD template and use it directly. After you have filled it in completely with your information (including the bio and photograph of the presenter below), please convert it to a single page PDF document and upload it to the Symposium website per instructions in the Call for Abstracts web page. These files will be compiled and distributed electronically to the attendees at the symposium. The headshots of the presenters will help with networking.

Biography of Presenter

Lawrence Gettleman attended Rutgers (B.A. psychology 1962), the Harvard School of Dental Medicine (D.M.D., 1966), and St. Louis University (M.S.D, 1968) for post-doctoral dental specialty and research training. He served in the US Public Health Service in a research lab in San Francisco and returned to the Harvard faculty as assistant professor from 1971-76. He moved to the LSU School of Dentistry and Gulf South Research Institute in New Orleans, before joining the University of Louisville School of Dentistry faculty in 1990. He has maintained a private practice of restorative dentistry and prosthodontics, and has 80 research publications, 14 book chapters, 150 research abstracts, and 3 patents. He has mentored 34 pre- and post-doctoral degree students and is a fellow of 4 honor societies. He has been principal or co-investigator on 13 NIH grants and was the principal investigator of a $2.9 million NIH clinical trial research grant in maxillofacial prosthetics in 2003-2009. He is now in emeritus status as professor of prosthodontics and biomaterials at the School of Dentistry.

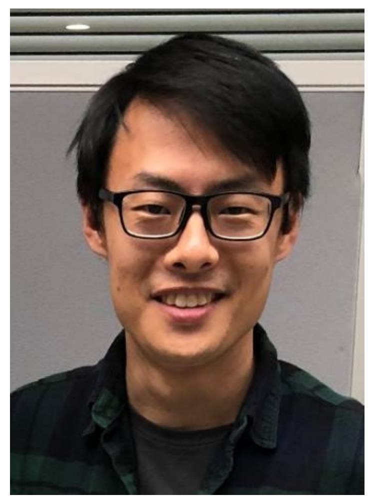
Wafer-scale microfactories with assembled MEMS microrobots for nanotechnology applications

Ruoshi Zhang, Andriy Sherehiy, Danming Wei, Zhong Yang, Jordan Klotz, M Nasser Saadatzi, Dan O. Popa
University of Louisville

Abstract

Microfactories have long been envisioned as a stepping stone toward automated nanomanufacturing with the help from microrobots. Among numerous challenges in realizing such miniature systems, the most significant ones are achieving nanometer-level accuracy while maintaining affordable cost, long term reliability and scalability. Our research investigates top-down, automated robot architectures that progressively handle parts at the meso (cm-mm), micro (mm-µm), and nano (µm-nm) scales. During past work, we consistently addressed the question of "What are the design rules governing the way robotic hardware is put together to guarantee high assembly yields and reliable operation at small scales?". The N^3 system was proposed as a future wafer-scale microfactory for nanotechnology with thousands of assembled modular microrobots alongside their control circuitry. The Next Generation Systems group (NGS) at the University of Louisville is working on three types of microrobots for the next generation wafer-scale microfactory, including a mm-scale robotic arm (sAFAM), a solar actuated cm-size crawler (SolarPede), and a sub-millimetric laser driven locomotor (ChevBot).

Biography of Presenter



Ruoshi Zhang received his bachelor's degree of Telecommunication Engineering at Tianjin University, China in 2012. Later, he pursuits a MS at University of Texas at Arlington in Electrical Engineering Department. Currently, Ruoshi is a PhD. Candidate of Speed school of Engineering at University of Louisville. His research focuses on design, fabrication and validation of silicon based microrobotics, with application of microfactory. Ruoshi is the author of 8 conference papers and 1 journal papers published by IEEE, Springer and SPIE.