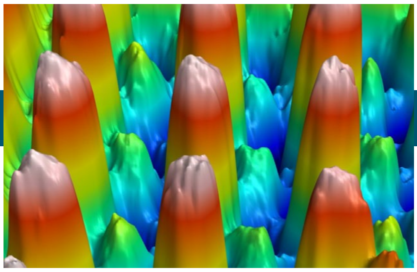
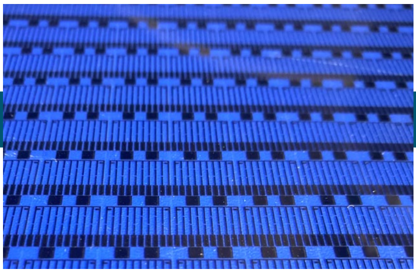
106th IUVSTA Workshop on Laser Patterning and Surface Modification for Bioengineering, Energy, and Optoelectronics Applications

February 17 – 20, 2025
The Rose Event Center – 1119 Washington Ave., Golden, CO USA 80401

The workshop includes Plenary Talks, Panel Discussions, Poster Sessions, Networking Meals, Short Courses, & Tours of Local Laboratories





Lasers provide access to materials processing space otherwise unattainable for realization of novel materials and technologies in diverse areas of high impact.

Example topics of interest include:

- Rapid patterning of features for optical and electronic devices without photolithography for sensors, IoT devices, and energy harvesting systems
- Laser-based materials conversion and synthesis in applications including low-power computing, multifunctional 'More than Moore' electronic device technology, and photocatalysis applications
- Laser processing in additive manufacturing and other production processes for healthcare applications (medical diagnostics and biosensors, prosthetics and implants) and sustainable energy production (solar arrays, reducing friction and wear)

Only a limited number of poster presentations will be accepted so act quicky to submit an abstract for the workshop poster session!

Workshop organizers:

***Christopher Muratore** *IUVSTA SED Chair* (University of Dayton, Dayton, OH, USA)

Shahram Amini (Pulse Technologies, Quakertown, PA, USA)

Blake Corrigan (Keyence Corporation, Denver, CO, USA)

Andy Korenyi-Both (Woodward Corporation, Fort Collins, CO, USA)

Mike Simmons (Intellivation Inc., Loveland, CO, USA)

Andrey Voevodin (University of North Texas, Dallas, TX, USA)

**Contact: cmuratore1@udayton.edu for workshop information and additional details*

SVC Workshop Partner

CLICK HERE to submit an abstract to 2025 Workshop on Laser Patterning and Surface Modification for Bioengineering, Energy, and Optoelectronics Applications

MESSAGE FROM THE **ORGANIZERS**

We are pleased to host a series of keynote talks by leaders pioneering diverse technological applications bound by the common thread of laser-based methods of materials synthesis and surface patterning. Rapid, low-cost device fabrication coupled with non-equilibrium processing allows access to materials processing space otherwise unattainable for realization of novel materials, devices, and technologies in areas of high economic, societal, and environmental impact. In addition to our keynote speakers, we encourage attendees to submit for poster presentations. We will have a poster flash session for all presenters to introduce their works prior to the poster session.

Laser processes addressed by speakers include:

- rapid patterning of microelectronic devices without photolithography (sensors, medical implants, and hardware for experiments & IoT devices)
- laser-based conversion and synthesis of high quality, crystalline materials (energy harvesting, low-power computing, multifunctional 'More than Moore' electronic device technology, and large area photocatalysts)
- control of nano-micro scale surface morphology (cell adhesion, directed fluid flow)

The city of Golden, Colorado was selected for the workshop venue for its status as an iconic city of the American West nestled in the foothills of the Rocky Mountains and within easy reach of the USA's top winter resorts during peak mountain snow season. The Rose Event center in downtown Golden, is one of the oldest buildings in the city. This venue provides a sophisticated atmosphere promoting exchange of information and networking essential to the success of the event. Additionally, excursions to the famed Coors Brewery, CoorsTek Ceramic manufacturing facility, and the Colorado School of Mines with one of the largest operational university research foundries are all within easy walking distance of the workshop meeting venue. The National Renewable Energy Laboratory, leaders in laser processing and other operations of interest to prospective workshop attendees, is also located in Golden, and attendees will have an opportunity to tour this advanced facility. Please join us for what promises to be a productive and impactful event.

Organizing Committee:

Christopher Muratore *University of Dayton, Dayton, OH, USA*

Shahram Amini *Pulse Technologies, Quakertown, PA, USA*

Liz Josephson *Intellivation Inc., Loveland, CO, USA*

Andy Korenyi-Both *Woodward Corporation, Fort Collins, CO, USA*

Blake Corrigan *Keyence Corporation, Denver, CO, USA*

Mike Simmons *Intellivation Inc., Loveland, CO, USA*

Andrey Voevodin *University of North Texas, Dallas, TX, USA*

Frank Zimone *Society of Vacuum Coaters, Albuquerque, NM, USA*

Workshop Schedule

	Monday | February 17, 2025	Tuesday | February 18, 2025	Wednesday | February 19, 2025	Thursday | February 20, 2025
8:30 A.M.		**Sponsored Breakfast** The Rose Event Center	**Sponsored Breakfast** The Rose Event Center	**Sponsored Breakfast** The Rose Event Center
9:00 A.M.	**Short Course #1** Introduction to Flexible Electronics *(Christopher Muratore | University of Dayton)*	*15 Minute Passing Break*		
9:15 A.M.		*Welcome - Introduction*	*Welcome - Introduction*	*Welcome - Introduction*
9:30 A.M.		**Keynote Talk #1** *(Michael Thompson | Cornell)*	**Keynote Talk #6** *(Joy Goekel | Colorado School of Mines)*	**Keynote Talk #9** *(Blake Corrigan | Keyence Corporation)*
10:15 A.M.		**Keynote Talk #2** *(Brian Everhart | Air Force Research Laboratory)*	**Colorado School of Mines Tour**	**Keynote Talk #10** *(Mike Simmons | Intellivation)*
11:00 A.M.		***Discussion***		**Keynote Talk #11** *(Bertrand J. Tremolet de Villers | National Renewable Energy Laboratory)*
11:30 A.M.		**Keynote Talk #3** *(Mostofa Bedewy | University of Pittsburgh)*		***Wrap Up and Future Directions***
12:00 P.M.				
12:15 P.M.		***Discussion***		
12:30 P.M.		**Sponsored Lunch** The Rose Event Center	**Sponsored Lunch** The Rose Event Center	**Sponsored Lunch** The Rose Event Center
1:00 P.M.	**Short Course #2** Advanced Laser-based Materials Processing *(Mostofa Bedewy | University of Pittsburgh)*			
1:15 P.M.			***Poster Session***	**National Renewable Energy Laboratory Tour**
1:30 P.M.		**Keynote Talk #4** *(Shahram Amini | Pulse Technologies)*		
2:15 P.M.		**Keynote Talk #5** *(Miguel Manso Silván | Autonomous University of Madrid)*	**Keynote Talk #7** *(Rahul Rao | Air Force Research Laboratory)*	
3:00 P.M.		***Discussion***	**Keynote Talk #8** *(Masoud Mahjouri-Samani | Auburn Unviversity)*	
3:30 P.M.		**Flash Poster Session**		
4:00 P.M.		*30 Minute Passing Break*	***Discussion***	
4:15 P.M.			**CoorTek Ceramics Tour**	
4:30 P.M.		**Coors Brewery Tour**		
5:30 P.M.	**Welcome Reception and Workshop Overview** (Sponsored Event) The Rose Event Center			

For more information, contact Christopher Muratore, *IUVSTA SED Chair:* cmuratore1@udayton.edu

SVC *Workshop Partner*

Tuesday, February 18, 9:30 A.M.

Laser Spike Annealing and Autonomous High-Throughput Metastable Phase Exploration: Expanding Materials Discovery Across Composition, Time, and Temperature

Michael Thompson, *Cornell University, Materials Science and Engineering, Ithaca, NY USA,* mot1@cornell.edu

"Engineered" materials today rely on kinetically trapped metastable structures, from precipitation hardened aluminum to impurity doping in semiconductors. Composition plays a key role, but equally critical is the thermal history as materials evolve through cascading metastable states toward the final equilibrium. The search for new metastable materials has accelerated tremendously, powered by DFT and high-throughput characterization. But while DFT may predict phases, experimental studies remain critical to establish processing conditions to realize such new and exciting materials.

Laser spike annealing (LSA) developed to anneal ion implantation damage in Si, with processing to temperatures exceeding 2000 K with durations from 50 ms to 20 ms (up to 10^7 K/s). We have extended LSA to a high-throughput lateral gradient LSA (lgLSA) variant for exploration of metastable phase formation in thin films, searching simultaneously across composition and processing spaces. Using spatially resolved probes (e.g., optical spectroscopy, synchrotron-based X-rays); the time-temperature-composition behavior of a composition library can often be assessed in as little as a few hours. Using example alloy systems, I will show several novel characteristics of metastable phase development that arise on these timescales.

We have further augmented lgLSA with an artificial intelligence based Scientific Autonomous Reasoning Agent (SARA) to develop efficient experimental workflows to exploit sub-minute experimental loop times. Utilizing lgLSA with X-rays characterization at the Cornell High Energy Synchrotron Source, SARA's autonomous agents can explore over 25,000 experimental conditions per hour, rapidly accelerating understanding of phase development.

Finally, I will discuss recent work on µs time-resolved phase formation during LSA. New continuous phase transformations have been identified in several systems on LSA timescales, bypassing conventional nucleation and growth that dominate at longer times. This new kinetic understanding will be critical to exploit some of the unique opportunities afforded by laser processing.

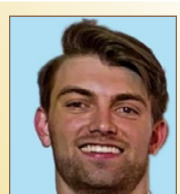
Dr. Michael Thompson is the Dwight C. Baum Professor of Engineering in Materials Science and Engineering at Cornell University. He received his BS in Applied Physics from CalTech in 1979 and a PhD in Applied and Engineering Physics at Cornell in 1984. Over the past 40 years, he has focused on understanding the behavior of thin film materials under laser exposure, from pulsed laser processing at quench rates up to 1012 K/s to current efforts with scanned CW laser annealing of complex oxide thin films at rates as low as 104 K/s. Research on semiconductor dopant activation ultimately resulted in the development of Laser Spike Annealing (LSA) as a tool for silicon high volume manufacturing. Current research activities include ion-implant doping and (laser) annealing of ultrawide-bandgap (UWBG) semiconductors, and ultra-high throughput autonomous exploration of metastable phase formation in oxide and metal alloys using lateral gradient laser spike annealing.

Tuesday, February 18, 10:15 A.M.

Exploiting Laser Processing Phase Diagrams for 2D Materials and Thin Film Oxides

Brian Everhart, *Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, OH USA,* brian.everhart.4.ctr@afrl.af.mil

High throughput, data-driven processing and characterization techniques are becoming increasingly necessary for navigation of the multivariate parameter space characteristic of 2D materials synthesis. This talk focuses on a high-throughput approach for designing and customizing a broad spectrum of 2D materials. By leveraging thin film phase diagrams, material properties can be tailored for diverse applications including sensing, electronics, optical coatings, and environmental remediation. This technique employs laser-processing to induce locally constrained crystallization, oxidation, and defect formation in metal and transition metal dichalcogenide (TMD) thin films. By maintaining precise spatial and temporal control of laser power, exposure time, and gas composition, sub-micron spatial resolution of chemical composition, crystallinity, and even defect concentration can be achieved. Coupled with in-situ and high-throughput ex-situ characterization, this process allows for the rapid evaluation of structure-property relationships and subsequent device design. The presented work explores this process for the synthesis of non-equilibrium oxides under microsecond reaction times in controlled gas atmosphere and reveals the unique role of laser processing in the fabrication of high-quality metal selenide thin films. The laser processing technique has also demonstrated potential for tailoring electronic and optical properties of metallic and semiconducting films, as well as the fabrication of thin film photocatalytic materials.



Dr. Brian Everhart is a National Research Council Postdoctoral Fellow in the Electronic Materials Branch at the Air Force Research Laboratory (AFRL) in Dayton, Ohio. He received his doctorate in Chemical Engineering at Kansas State University in December of 2022, and has since dedicated his early career to the pursuit of novel methods for nanomaterial synthesis. He has led efforts at AFRL in laser processing of various thin film materials including 2D materials, oxides, and perovskites, and was recently awarded the 2024 Graeme E. Murch Award for his research.

Keynote Speakers

Tuesday, February 18, 11:30 A.M.

Laser-Induced Graphene Coatings on Polymers for Biomedical Devices

Mostofa Bedewy, *University of Pittsburgh, Mechanical and Materials Engineering, Pittsburgh, PA USA*, mbedewy@pitt.edu

Nanocarbons like graphene and related materials are promising for various biomedical applications; however, major manufacturing challenges still hinder our ability to scalably produce graphene with tailored morphology and surface chemistry, especially on flexible and polymeric substrates. While chemical vapor deposition (CVD) processes enable the synthesis of high-quality graphene, the typically high temperatures in such reactors limit the choice of substrates to silicon, quartz, metals, or other temperature-resistant materials. On the other hand, emerging flexible devices, such as implantable surgical meshes and biosensors require the fabrication of such nanocarbon coatings and electrodes directly on polymers. Unlike different transfer techniques of CVD-grown nanocarbons, or printing methods from inks, this talk will focus on a bottom-up approach for directly growing different types of graphenic nanocarbons on aromatic polymers by laser irradiation. The speaker will present an approach that leverages this direct-write process, often referred to as laser-induced graphene (LIG), for creating spatially varying morphologies and chemical compositions of LIG electrodes, by leveraging gradients of laser fluence. Three distinct morphologies are identified, and process control map is generated for maximizing the electrical conductivity of these porous graphene for biomedical devices. Moreover, this talk will introduce a method for controlling heteroatom doping of LIG based on controlling the molecular structure of the polymer being lased, i.e., by introducing sulfur- and fluorine- containing backbones. We demonstrate superhydrophobic and parahydrophobic surface properties for the fluorine-doped LIG patterns. We also show antibacterial properties of LIG coated surgical devices. Finally, a demonstration of these functional doped LIG electrodes as electrochemical biosensors will be presented for the detection of the neurotransmitter dopamine with nanomolar sensitivity.

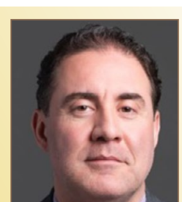
Dr. Mostafa Bedewy is an Associate Professor of Mechanical Engineering & Materials Science, Chemical & Petroleum Engineering (secondary appointment), and Industrial Engineering (secondary appointment) at the University of Pittsburgh, where he leads the NanoProduct Lab (www.nanoproductlab.com). Before that, he was a Postdoctoral Associate at the Massachusetts Institute of Technology (MIT) in the area of bionanofabrication with Professor Karl Berggren in the Research Lab for Electronics (RLE). Also, he worked previously as a Postdoc and as a graduate student at the MIT Laboratory for Manufacturing and Productivity (LMP), working with Professor John Hart on in situ characterization of carbon nanotube catalytic growth. In 2013, he completed his PhD at the University of Michigan in Ann Arbor, where he worked with Professor Hart on studying the population dynamics and the collective mechanochemical factors governing the growth and self-organization of filamentary nanostructures. He holds a Bachelor's degree (honors) in Mechanical Design and Production Engineering (2006) and a Master's degree in Mechanical Engineering (2009), both from Cairo University.

Tuesday, February 18, 1:30 P.M.

Hierarchical Surface Restructuring: The Technology of the Future for Sustainable, High Performing and Multifunctional Neural Interfacing Electrodes and Microelectrode Arrays

Shahram Amini, *Pulse Technologies, Quakertown, PA USA*, samini@pulsetechnologies.com

Recent advancements in implantable neural interfacing devices have led to significant breakthroughs in neurostimulation and cardiac rhythm management, enabling precise neural stimulation and signal recording for the treatment of various neurological and cardiac disorders. To enhance the specificity, functionality, and overall performance of these devices, electrodes, and microelectrode arrays—the core components of most emerging devices—must be further miniaturized and demonstrate exceptional electrochemical performance with neural tissue. Since the selective and targeted stimulation of small populations of neurons near implantable electrodes is crucial for their success, the trajectory for further refinement of neural interfacing devices largely depends on increasing electrode miniaturization, which enables higher spatial resolution, precision, and reliability. However, challenges remain in optimizing electrode performance, commercial viability, manufacturability, and sustainability. In this presentation, several key areas of innovation will be explored. First, the miniaturization and electrochemical enhancement of femtosecond-laser hierarchically restructured electrodes, which demonstrate unprecedented improvements in performance, will be discussed. Second, the development of multifunctional, high-performing antibacterial electrodes designed to combat post-implantation infections while maintaining superior electrochemical properties will be highlighted. Advancements in ultra-thin, flexible electrodes for invasive nervous system applications will also be presented, with a focus on their enhanced electrochemical properties and mechanical stability. Finally, a sustainable alternative to platinum group metal electrodes will be presented, showcasing how titanium-based electrodes, restructured using a novel reactive hierarchical surface restructuring platform, achieve superior electrochemical performance and provide a low-cost, sustainable solution for long-term neurostimulation and cardiac rhythm management devices.



Dr. Shahram Amini is currently the Vice President of R&D at Pulse Technologies Inc., an Integer Holdings company. With over two decades of experience in research management and technology innovation, Dr. Amini has successfully driven the development and commercialization of cutting-edge materials and products across diverse industries, including automotive, aerospace, and medical devices. Additionally, Dr. Amini serves as a visiting professor and sits on the advisory board of the Biomedical Engineering Department at the University of Connecticut. His research focuses on the design of hierarchical surfaces, coatings, thin films, and hybrid surface solutions for medical devices as well as advanced materials, measurements, and manufacturing technologies for extreme and harsh environments. As the founder of several R&D centers, he has led multidisciplinary teams and gained international recognition through numerous patents and scholarly publications. Dr. Amini earned his Ph.D. in Materials Science and Engineering from Drexel University in 2008, following his M.Sc. and B.Sc. degrees in Metallurgy and Materials Science from Sharif University of Technology and Shiraz University, respectively. He also completed a postdoctoral fellowship at the National Hypersonic Science Center at the University of California, Santa Barbara, and served as a visiting researcher at the Materials Department of Queen Mary, University of London, England, and a visiting professor in the Department of Physics and Astronomy at Rowan University.

Tuesday, February 18, 2:15 P.M.

Controlling Cell-material Interactions Through Laser Modification of Surface Chemistry and Topography

Miguel Manso Silván, *Universidad Autónoma de Madrid, Department of Applied Physics, Madrid, Spain,* miguel.manso@uam.es

Laser surface modification is a key surface engineering technique allowing controlled surface chemistry and topography modifications. An appropriate selection of the laser source and operation mode allows modifying not only bulk, but also thin film materials. Relevantly, this is key for the control/biomimetics of cell-surface interactions, which rely in an appropriate design of hierarchical surface tension contrasts. With the main objective in mind of trapping or guiding cells on surfaces, the presentation will describe, mainly through collaborative research, the use of lasers in different regimes to modify the surface of different materials, including semiconductors, orthopedic alloys, and ceramic metallic thin films. It is shown how by direct ablation, nanostructured ablation products or by the smart organization of laser induced periodic surface structures, one can design surfaces leading to astonishing cell adhesion and migration. The functionality of the laser processed surface structures is demonstrated through the culture of HeLa or human Mesenchymal Stem Cells, a pluripotent cell line with direct and indirect therapeutic abilities.

Prof. Manso began his research training alternately between Universidad Autónoma de Madrid (UAM, Spain) and Institut National Polytechnique de Grenoble (France) where he combined thin film growth techniques and advanced characterization for the description of new bioceramic interfaces on titanium-based coatings. After the PhD, he began a Postdoctoral period at the Joint Research Center (Ispra, Italy). He carried out a study of micro and nanostructuring of biofunctional coatings, which is still his active field of study at UAM, incorporating a multi-technique approach in processing and characterization, which includes laser modification. In particular, his work with laser surface modification has been focused on the study of cell-material interactions and in the engineering of cell-guides and cell-traps.

Wednesday, February 19, 9:30 A.M.

Laser Processing Effects on Properties in Additive Manufacturing

Joy Goekel, *Colorado School of Mines, Mechanical Engineering, Golden, CO USA,* joygockel@mines.edu

Additive manufacturing (AM) is unique because the material is created at the same time as the component and the performance is intrinsically connected back to the manufacturing process. This creates challenges in ensuring part quality and predicting mechanical properties, but also provides opportunities for novel materials processing. In metal AM, the formation of microstructure and defects, their effect on mechanical performance and the detection of these features while the part is being built are critical challenges impacting the quality of AM parts. This seminar will present a breadth of interdisciplinary work including the effect of processing parameters, influence of machine hardware, in-situ monitoring, and multi-material structures. Through a fundamental understanding of the composition-processing-structure-properties-performance relationships, AM processes can be confidently applied for critical applications.

Dr. Joy Gockel is an associate professor in Mechanical Engineering at Colorado School of Mines and her research spans several aspects of additive manufacturing (AM). She joined Mines from Wright State University where she was an assistant professor in Mechanical and Materials Engineering. Prior to her faculty position, she was a Lead Engineer at GE Aviation's Additive Technology Center. She earned her PhD in Mechanical Engineering from Carnegie Mellon University, supported by a NDSEG Fellowship, and received her BS and MS degrees from Wright State University. She has been awarded the 2020 ASTM International Additive Manufacturing Young Professional Award, and the 2021 TMS Young Leader Professional Development Award.

Wednesday, February 19, 2:15 P.M.

Advanced Machine Learning Decision Policies for Diameter Control of Carbon Nanotubes in a Laser-based CVD System

Rahul Rao, *Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, OH USA*, rahul.rao.2@us.af.mil

The diameters of single-walled carbon nanotubes (SWCNTs) are directly related to their electronic properties, making diameter control highly desirable for a number of applications. Here we utilized a machine learning planner based on the Expected Improvement decision policy that mapped regions where growth was feasible vs.

not feasible and further optimized synthesis conditions to selectively grow SWCNTs within a narrow diameter range. We maximized two ranges corresponding to Raman radial breathing mode frequencies around 265 and 225 cm^{-1} (SWCNT diameters around 0.92 and 1.06 nm, respectively), and our planner found optimal synthesis conditions within a hundred experiments. Extensive post-growth characterization showed high selectivity in the optimized growth experiments compared to the unoptimized growth experiments. Remarkably, our planner revealed significantly different synthesis conditions for maximizing the two diameter ranges in spite of their relative closeness. Our study shows the promise for machine learning-driven diameter optimization and paves the way towards chirality-controlled SWCNT growth.

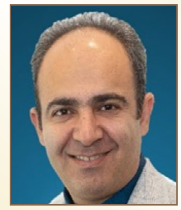
Dr. Rahul Rao is a Research Scientist at the Air Force Research Laboratory at the Wright Patterson Air Force Base in Ohio, in the Polymers and Specialty Materials Branch. He obtained a Ph.D. in Physics from Clemson University in 2007. His research interests include synthesis and optical spectroscopy (Raman, photoluminescence and FT-IR) of nanomaterials. His recent research focus has been on in situ studies of growth and defect evolution in carbon nanotubes, and various 2D materials - graphene, transition metal chalcogenides, and new and emerging 2D materials such as metal thiophosphates.

Wednesday, February 19, 3:00 P.M.

Laser Nanomanufacturing and Patterning of Emerging Materials and Devices

Masoud Mahjouri-Samani, *Auburn University, Electrical and Computer Engineering Department, Auburn, AL USA,* Mahjouri@auburn.edu

The move toward Industry 4.0, the rise of quantum sciences, and the integration of AI in manufacturing require the right processing, diagnostics, and metrology tools with precision in time, space, and energy scales. Lasers are one of the smartest quantum tools, with spatiotemporal and energy precision compatible with AI and potential autonomous manufacturing on Earth and in space. This talk will cover an overview of our research efforts in laser-based synthesis and processing of nano/quantum materials and devices. I will discuss some of the laser-based synthesis techniques we have developed to control the growth of 2D quantum materials, including time-resolved laser-CVD growth of single crystalline flakes down to 50ms time scales for the first time as well as crystal growth with tunable vacancies. I will discuss the hybrid laser surface processing and modification technique for enhanced growth of 2D materials with applications in energy and biomedical devices. I will further highlight our condensed phase growth approach compatible with direct laser writing/crystallization and wafer-scale device integration. I will also present our novel multi-laser dry printing technology for printing various materials and hybrid structures on different substrates for electronics, sensors, semiconductors, and energy devices. These laser-based approaches provide unique synthesis and processing opportunities that are not easily accessible through conventional methods.



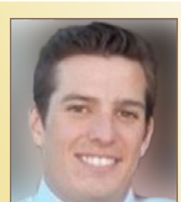
Dr. Mahjouri-Samani is an associate professor of electrical and computer engineering (ECE) at Auburn University, leading the Laser-Assisted Science and Engineering group (LASE). He is also the founder and president of NanoPrintek, the world's first dry multi-material printing technology. He received his BS (2008) and Ph.D. (2013) degrees in ECE from the University of Nebraska-Lincoln, working in the laser-assisted nanoengineering lab (LANE), and spent four years as a postdoctoral research associate at Oak Ridge National Laboratory (ORNL) working on laser-based materials synthesis, processing, and diagnostics. Dr. Mahjouri-Samani's research group is focused on investigating the laser-material interactions in laser-based synthesis, laser processing, and laser diagnostics of emerging nano/quantum materials and devices. His current research activities include: Pioneering the laser-based additive nanomanufacturing of multifunctional materials and hybrid structures; Understanding the laser-materials interactions in additive manufacturing processes; Investigating the laser-based synthesis and processing of nanoscale and quantum materials; and Bridging AM, AI, and quantum materials research.

Thursday, February 20, 9:30 A.M.

Innovations in High-speed Scanning Laser Systems for Materials Processing

Blake Corrigan, *Keyence Corporation, Denver, CO USA,* Blake.Corrigan@keyence.com

High speed scanning laser technology is a key enabler for high-throughput materials production to eliminate slow and costly patterning and thermal annealing steps. Additionally, materials process space inaccessible with conventional processes can be explored and exploited for unique functionality. A review of state of the art scanning laser products and the future of laser processing of materials will be presented. Important developments include high-resolution spatial mapping for alignment of features, access to broad ranges of scan rates and laser conditions (e.g., laser power, frequency, and focal position), autofocusing on three dimensional surfaces, and approaches for high-speed rastering will all be discussed.



Blake Corrigan is a Sales Engineer at Keyence Corporation. He has been with Keyence since 2014. He received a Bachelor's degree in Business from the University of Colorado at Boulder in 2011.

Keynote Speakers

Thursday, February 20, 10:15 A.M.

Laser Processing for High-Volume Roll-to-Roll Production of 2D Electronic Devices

Mike Simmons, *Intellivation LLC, Loveland, CO USA*, MSimmons@intellivation.com

Laser patterning of conductive vacuum deposited thin films and laser crystallization of ultra-thin semi-conducting materials was employed for production of low cost/high throughput flexible electronic devices. This approach provides versatility, accelerated development cycles, and manufacturing scalability for electronic devices. Optimizing performance by adjusting device architecture by altering laser scanning patterns is straightforward and has minimal or no impact on cost of materials, processing time, or requirements for additional resources e.g., mask fabrication etc. Surface roughness on flexible glass after ablation-based patterning of metal contacts was reduced to <1nm to enable application of continuous, ultra-thin layers of transition metal dichalcogenide semiconducting material. This material was laser crystallized to optimize performance. A case study of these production processes to fabricate a sensing platform capable of detecting both airborne inhalation hazards and proteins in biological samples is presented. In this application, laser conditions were used to impart additional functionality to devices, such as control the flow of fluids. Integration of laser technology in a roll-to-roll system is amenable to high-throughput contactless quality control using spectroscopy and other methods.

Dr. Mike Simmons is the CEO & President of Intellivation, a manufacturer of roll-to-roll coaters and pioneer in process development of laser-patterned 2D electronic devices with laser annealed semiconducting materials. Pilot scale demonstrations of >100,000 2D devices with excellent reproducibility have been achieved using this method. Mike founded Intellivation in 2009 and has grown the company into a leader supplier for R2R vacuum deposition systems. Mike's commitment to the vacuum industry involves being a Board Director of the Society of Vacuum Coaters (SVC), an SVC Instructor for Web Coating, Chair of AIMCAL's Vacuum Web Coating Committee, RMCAVS Chair, an active member of AVS and continuous support of the vacuum community through multiple initiatives and sponsorships. Mike earned his mechanical engineering degree (BSME) from the University of Idaho where he graduated with honors, and is a licensed Professional Engineer. Mike has published multiple technical papers and presented at global conferences on Vacuum Coating Processes, including but not limited to Vacuum Technology and State of the Art Roll to Roll Equipment and Processes.

Thursday, February 20, 11:00 A.M.

Characterization of Ultrafast-laser Ablation of Micro-structures in Li-ion Battery Anode and Cathode Materials: Morphology, Rate, and Efficiency

Bertrand J. Tremolet de Villers, *National Renewable Energy Laboratory, Golden, CO, USA*, Bertrand.Tremolet@nrel.gov

Characterization of the rate and quality of ultrafast-laser ablation of Li-ion battery (LIB) electrode materials is presented for a collection of common and next-generation electrodes. Laser ablated micro-structures on the surface of LIB electrodes have been shown to provide dramatic enhancement of high-rate capability and electrode wetting. However, industrial adoption is hampered by a lack of data enabling informed choice of laser parameters and predicting process throughput. This work bridges this gap by providing characterization of the ablation process at more laser parameters (laser fluence and number of pulses used) than are currently available in the literature. Further, we expand on previous graphite and lithium iron phosphate (LFP) ablation work by extending ablation characterization to new LIB materials, providing high data resolution, and adopting new characterization metrics which are relevant for industrial application of this technology. Ablated pores are characterized by their ablated depth, volume, and how the depth and volume ablation rate changes as a function of pore depth. Finally, we provide a detailed characterization of the morphology of laser ablated micro-structures which informs how material and laser parameters affect the quality of laser-processed electrodes.

Dr. Bertrand J. Tremolet de Villers received his Ph.D. in Physical Chemistry from UCLA in 2011 and has been with NREL for over 11 years working at the forefront of sustainable energy technology.

Short Courses

Monday, February 17, 9:00 A.M.

Short Course: **Introduction to Flexible Electronics**

Christopher Muratore, *University of Dayton, Department of Chemical and Materials Engineering, Dayton, OH USA*, Cmuratore1@udayton.edu

1. Flexible electronics overview
   a. Applications
   b. General Concepts
   c. Performance potential
   d. Market/application projections
2. Evolution of synthesis & fabrication of flexible electronic materials
   a. Thinning Silicon and other device materials brittle in bulk form
   b. Organic polymeric electronic materials
   c. Ultra-thin, or 2D materials
3. Synthesis and processing methods for flexible electronics
   a. Substrate considerations and preparation
   b. Deposition and transfer
   c. Masking and patterning
   d. Photonic annealing
4. Mechanical and electronic properties of flexible electronic devices
   a. Limitations on flex – performance vs. strain
   b. Lifetime dependence on strain
5. Challenges unique to flexible electronics
   a. Thermal management
   b. Maintaining device performance under repeated strains

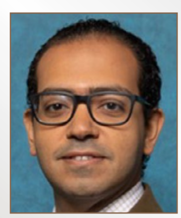
Dr. Christopher Muratore is the Ohio Research Scholars Endowed Chair Professor in the Chemical and Materials Engineering Department at the University of Dayton. Prior to joining the University in 2012, Professor Muratore led different teams in advanced materials research efforts for 10 years at the Air Force Research Laboratory (AFRL). Muratore is currently involved with joint research efforts in areas of flexible electronics, bioengineering, and 2D materials with AFRL, along with mutual academic and industrial partners. He was a post-doc in the Plasma Physics Division at the US Naval Research Lab after completing his Ph.D in Materials Science from the Colorado School of Mines in 2002. Throughout his research career, Muratore's work has focused on fundamental materials discoveries in the lab followed by technical maturation efforts in thin film and surface engineering technology for diverse applications ranging from mass-produced 2D electronic biological sensors to mechanical assemblies for use in high temperature aerospace environments. He has published over 105 peer-reviewed articles and has 14 patents granted or pending. Muratore is an AVS Fellow.

Monday, February 17, 1:00 P.M.

Short Course: **Advanced Laser-based Materials Processing**

Mostofa Bedewy, *University of Pittsburgh Mechanical and Materials Engineering, Pittsburgh, PA USA*, mbedewy@pitt.edu

1. Laser processing overview
   a. Advantages and capability over conventional proceses
   b. Environmental and economic impact
2. High-speed patterning
   a. Ablation with conventional lasers vs. ultra-fast lasers
   b. Strategies for retaining smooth surface morphology
3. Materials transformations
   a. Crystallization
   b. Defect formation
4. Non-equilibrium processing
   a. Meta-stable phase formation
   b. Implications of heating/cooling rates
5. Challenges to conquer
   a. Surface roughness
   b. Debris formation
   c. Homogeneity over large areas and depths



Dr. Mostafa Bedewy is an Associate Professor of Mechanical Engineering & Materials Science, Chemical & Petroleum Engineering (secondary appointment), and Industrial Engineering (secondary appointment) at the University of Pittsburgh, where he leads the NanoProduct Lab (www.nanoproductlab.com). Before that, he was a Postdoctoral Associate at the Massachusetts Institute of Technology (MIT) in the area of bionanofabrication with Professor Karl Berggren in the Research Lab for Electronics (RLE). Also, he worked previously as a Postdoc and as a graduate student at the MIT Laboratory for Manufacturing and Productivity (LMP), working with Professor John Hart on in situ characterization of carbon nanotube catalytic growth. In 2013, he completed his PhD at the University of Michigan in Ann Arbor, where he worked with Professor Hart on studying the population dynamics and the collective mechanochemical factors governing the growth and self-organization of filamentary nanostructures. He holds a Bachelor's degree (honors) in Mechanical Design and Production Engineering (2006) and a Master's degree in Mechanical Engineering (2009), both from Cairo University.

Venue | Hotels

The Rose Event Center

1119 Washington Ave., Golden, CO 80401
Telephone: (720) 638-5597
https://buffalorosegolden.com/

The workshop on Laser Patterning and Surface Modification for Bioengineering, Energy, and Optoelectronics Applications will be held at the Rose Event Center. In addition to all presentations, a welcome reception, breakfast and lunch will be held onsite at the Rose. The Rose has a concert-quality sound system, a theater-quality video projection system, and an elevated stage enabling a state-of-the-art workshop experience.

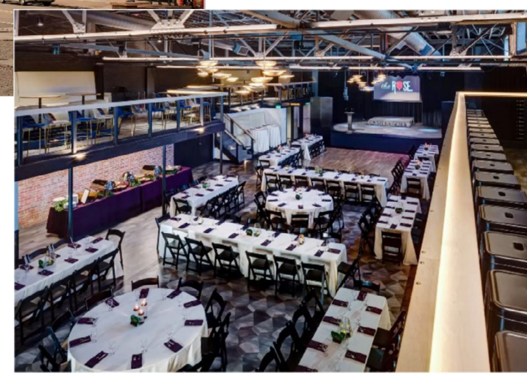


Table Mountain Inn

1310 Washington Ave., Golden, CO 80401
Reservations: (303) 325-3995
General Hotel Questions: (303) 277-9898
hotel@tablemountaininn.com
www.tablemountaininn.com

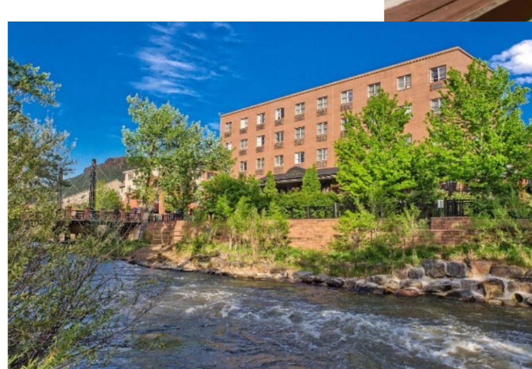
Table Mountain Inn is one of the two hotels in close proximity to the workshop venue.

Table Mountain Inn

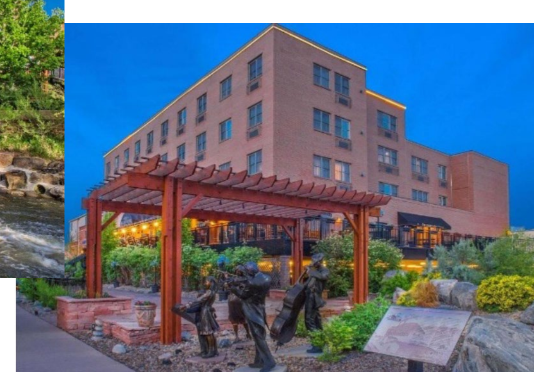
The Golden Hotel

800 Eleventh Street, Golden, Colorado 80401
Telephone: (303) 279-0100 | (800) 233-7214
https://www.thegoldenhotel.com/

Overlooking scenic Clear Creek and the Rocky Mountain Foothills, it is conveniently located in the heart of the historic downtown Golden, Colorado.



The Golden Hotel



Tours

Coors Brewery, also known as the Molson Coors Brewery, is a major American brewery located in Golden, Colorado. It was founded in 1873 by Adolph Coors and is one of the largest craft breweries in the United States. The brewery is situated at the foothills of the Rocky Mountains and is known for its iconic beer brands such as Coors Banquet, Coors Light, and Blue Moon. Visitors can take a tour of the brewery, which includes a tasting room, a beer garden, and a gift shop. The brewery is also a popular destination for beer enthusiasts and history buffs.

CoorsTek, Inc. is a privately owned manufacturer of technical ceramics for aerospace, automotive, chemical, electronics, medical, metallurgical, oil and gas, semiconductor and many other industries. CoorsTek headquarters and primary factories are located in Golden, Colorado.

The Colorado School of Mines (CSM) is a public research university located in Golden, Colorado. Established in 1873, CSM is known for its strong STEM programs. The Colorado School of Mines is home of the Alliance for the Development of Additive Processing Technology laboratory, focusing on materials development and characterization, processing-structure-property relationships, AM process control and part qualification, machine learning and big data mining, and data informatics.

The National Renewable Energy Laboratory (NREL) in Golden, Colorado specializes in the research and development of renewable energy, energy efficiency, energy systems integration, and sustainable transportation. NREL researchers are recognized for development of advanced, high-throughput laser fabrication and materials synthesis processes.

For more information, contact Christopher Muratore, *IUVSTA SED Chair:* cmuratore1@udayton.edu

SVC Workshop Partner

106th IUVSTA Workshop on Laser Patterning and Surface Modification for Bioengineering, Energy, and Optoelectronics Applications

February 17 – 20, 2025
The Rose Event Center – 1119 Washington Ave., Golden, CO USA 80401

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Full payment by credit card or company check is required.
Form can be sent by fax to 866-577-2407 or by Email to jacque.matanis@svc.org.
Mail checks to SVC, PO Box 10628, Albuquerque, NM 87184-0628 USA

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CLICK HERE to submit an abstract to 2025 Workshop on Laser Patterning and Surface Modification for Bioengineering, Energy, and Optoelectronics Applications