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CALL FOR PAPERS

SUBMISSION DEADLINE: FEBRUARY 16, 2024

2024

M&M 2024
**MICROSCOPY &
MICROANALYSIS**
July 28-August 1 • Cleveland, OH



QUESTIONS?

TECHNICAL MEETING CONTENT:

2024 Program Chair

James LeBeau, Massachusetts Institute of Technology

MM2024ProgramChair@microscopy.org

EXHIBITS & EXHIBITORS:

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doreen@corcexpo.com

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Microscopy Society of America

Visit <http://microscopy.org> to join the Microscopy Society of America online, or for more information about the benefits of MSA membership.



Microanalysis Society

Visit <http://the-mas.org> to find out the benefits of MAS membership.



Visit <http://fieldemission.org> to learn more about the benefits of IFES membership.

COVER IMAGES

LEFT:

Jasper, by Bernardo Jasper, University of Padua, Padua, Italy

CENTER:

Cupric sulfate, by José Manuel Martínez López, Química Tech, Juárez, Mexico

RIGHT:

Bubbles, by Marek Miś, Marek Miś Photography, Suwalki, Poland

The Microscopy Society of America (MSA), the Microanalysis Society (MAS), and the International Field Emission Society (IFES) invite you to attend the Microscopy & Microanalysis (M&M) 2024 meeting in Cleveland, OH, from July 28 to August 1, 2024. Cleveland, Ohio is a vibrant and diverse destination city located in the northeastern part of the United States, along the southern shore of Lake Erie. Known for its rich industrial history, Cleveland has transformed into a dynamic urban center with a unique blend of cultural attractions, outdoor recreation, and a thriving culinary scene.



M&M 2024 will kick off with two fantastic plenary lectures by Prof. Edward Boyden from the Massachusetts Institute of Technology and Dr. Wren Carr from the National Ignition Facility at Lawrence Livermore National Laboratory. The plenary presentations will be followed by our main scientific program. The success of each M&M meeting owes to hundreds of symposium organizers who volunteer their time to identify trendy research directions and engage experts worldwide to present their work at our meetings.

For M&M 2024, more than 140 symposium organizers have assembled 11 symposia in the physical sciences, 11 in analytical sciences, 9 on biological sciences, as well as 7 cross-cutting symposia. We highly encourage you to support these symposia by submitting abstracts of your own research and contributing to the platform and poster presentations. Among the 38 scientific symposia that will be offered in the scientific program, two of them will be dedicated to two electron microscopy researchers who sadly passed away: Prof. Lena F. Kourkoutis (1979-2023) and Dr. Terence E. Mitchell (1937-2022). Both these outstanding scientists, mentors, educators, and leaders made landmark contributions to our field.

On behalf of MSA, MAS, IFES, and the M&M 2024 Executive Program Committee, the meeting management team, all the symposium organizers and countless volunteers, we look forward to greeting you in Minneapolis for an exciting and stimulating Microscopy & Microanalysis 2024.

James LeBeau

Massachusetts Institute of Technology (MIT)
M&M 2024 Program Chair



Analytical Sciences/Instrumentation Advances Symposia

A01 Advances in Cathodoluminescence Spectroscopy and Analysis

ORGANIZERS:

Colin MacRae, CSIRO Mineral Resources, Australia
Emma Bullock, Carnegie Institution of Science
Heather Lowers, U.S. Geological Survey

- Latest developments in CL systems and correlative techniques on a variety of platforms including SEMs, EPMA, and TEMs
- Advances in spectrometers and software to improve throughput and data analysis
- Novel applications of CL in the geological, biological, forensics, cultural, and green technology sectors
- Analytical challenges and solutions for beam sensitive samples and nanometer scale resolution

A02 Data Science and Atom Probe Tomography (IFES-Organized)

ORGANIZERS:

David Saxey, Curtin University, Australia
Markus Kühbach, Humboldt-Universität zu Berlin, Germany
Andrew London, UK Atomic Energy Authority, UK
David Reinhard, Cameca, UK

- Isotopic and chemical quantification
- Mass spectrometry in Atom Probe Tomography
- Machine Learning and Artificial intelligence algorithm for Atom Probe
- Modelling and reconstruction in APT
- APT software and management tools
- Data archiving and FAIR principles for APT

A03 Expanding Capabilities of Atom Probe Tomography (IFES-Organized)

ORGANIZERS:

Claudia Fleischman, IMEC, Belgium
Ann Chiamonti, NIST
Arun Devaraj, Pacific Northwest National Laboratory
François Vurpillot Université de Rouen, France

- New developments in field evaporation theories and mechanisms
- Advances in APT instrumentation, technique development and specimen preparation
- New concepts in APT design
- Reconstruction improvements and future directions
- Advanced application of APT in materials science

A04 Lens-less Microscopy and Related Techniques

ORGANIZERS:

Oleg Gradov, IEEE
Aydogan Ozcan, University of California-Los Angeles
C.Joo, Yonsei University, Korea

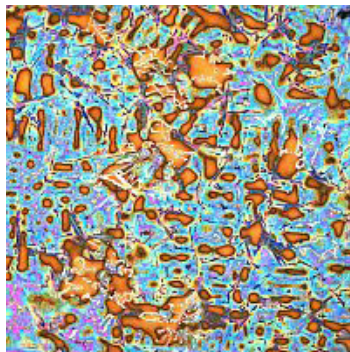
- Lens-less and optofluidic microscopy
- UV and X-ray lens-less microscopy
- Lens-less DIC and polariscopy
- Holographic and tomographic approaches in lens-less microscopy
- Applications: from biomedicine to industrial quality control
- Deep learning-enhanced lensless imaging

A05 Microscopy and Microanalysis in Cultural Heritage Studies

ORGANIZERS:

Jeffrey Pigott, Case Western Reserve University
Julianna Ly, The Cleveland Museum of Art
John Delaney, National Gallery of Art
Kathryn Dooley, National Gallery of Art

- Microscopy and microanalysis in art conservation and archaeological studies
- Cross-disciplinary research in cultural heritage
- Advances and challenges in sample preparation
- Advanced image processing and data analysis methods
- Development and implementation of novel imaging and spectroscopic instrumentation and methods for the collection of information at the microscopic scale (not exclusively collected with a microscope)



Foundry alloy, by Ondřej Ambrož, Institute of Scientific Instruments of the Czech Academy of Sciences, Borno, Czech Republic

A06 Electronic and Thermal Device Characterization with Electron Microscopy

ORGANIZERS:

B.C. Regan, University of California-Los Angeles
William Hubbard, NEI
Leopoldo Molina-Luna, Technische Universität Darmstadt, Germany

- Standard electron microscopy cannot easily distinguish between an insulator and a metal, or between a hot surface and a cold one
- Device functionality often depends on the distinction between an insulator and a metal, or between hot and cold
- Recent developments in, for instance, electron beam-induced current (EBIC) imaging, 4D scanning transmission electron microscopy (4D STEM), electron energy loss spectroscopy (EELS), and electron backscatter/transmission Kikuchi diffraction (EBSD/TKD) have enabled electronic and thermal structure mapping with high spatial resolution
- Relevant capabilities include the mapping of electrical conductivity, thermal conductivity, connectivity, electric fields, polarization, and/or temperature
- The symposium will discuss recent progress in methods (including sample preparation) and applications

A07 Triumphs, Trials, and Trepidations in Quantifying Low-Z Elements with Microanalytical Methods

ORGANIZERS:

Joseph Boro, Lawrence Livermore National Laboratory
Owen Neill, University of Michigan
Anette von der Handt, University of British Columbia, Canada
Samantha Rosenberg, Lockheed Martin

- Low-Z, or 'light' elements are challenging to quantify with microanalytical techniques
- Modern technological and computational advances have provided new avenues for these efforts
- This symposium encourages workers to highlight advancements they have made in the pursuit of microanalytical characterization of the light elements in solid-state materials

A08 New Opportunities in Material Science—Multi-Dimensional Imaging and Advanced Data Processing

ORGANIZERS:

Roland Brunner, Materials Center Leoben Forschung GmbH (MCL), Germany

Brian Patterson, Los Alamos National Laboratory

Debangshu Mukherjee, Oak Ridge National Laboratory

Steve Kelly, ZEISS

- Ex- and in-situ imaging methods for material science
- Hyperspectral mapping of material composition
- Correlative studies including multi-method/scale/structural-chemical information
- High resolution structural quantification, strain mapping, fluctuation electron microscopy, orientation analysis, electron ptychography, momentum-resolved EELS
- Multidimensional data acquisition and image analysis

A09 Automation in Microscopy from Image Acquisition to Image Analysis, Data Visualization, and Management

ORGANIZERS:

Ellen Keene, Dupont de Nemours Inc.

Daria Monaenkova, Dow Inc.

Maxim Ziatdinov, Oak Ridge National Laboratory

- Automated image analysis for real-time process feedback and control for high-throughput analysis
- Innovative and practical image analysis techniques and image processing tools including AI/ML
- Exploration of edge computing technologies and their integration into high-throughput environments for efficient and real-time decision-making
- Strategies and challenges for data handling, storage and data visualization, especially big data
- Strategies to report imaging methods and image analysis protocols

A10 Correlative Analysis and Multimodal Microscopy and Spectroscopy

ORGANIZERS:

Xiao-Ying Yu, Oak Ridge National Laboratory

Si Chen, Argonne National Laboratory

Ashwin J. Shahani, University of Michigan

- Correlative microscopy/spectroscopy instrumentation, methodology, and applications
- Cryogenic and in-situ sample preparation and handling for both materials and life sciences
- Data analysis pipelines to accelerate data fusion via ML/AI of data analytics
- Multimodal measurements of chemical/phase distributions, dislocation densities, and crystallographic orientations in two and three dimensions

A11 Perspectives from Complementary SEM Techniques: STEM-in-SEM Analytics and High-throughput Multi-beam Imaging

ORGANIZERS:

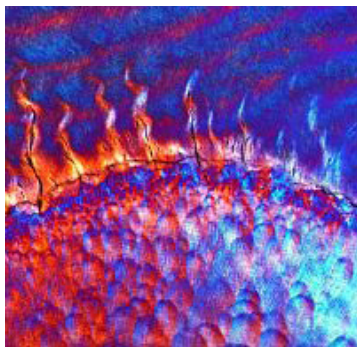
Jason Holm, National Institutes of Standards and Technology

Anna Lena Eberle, Carl Zeiss MultiSEM GmbH, Germany

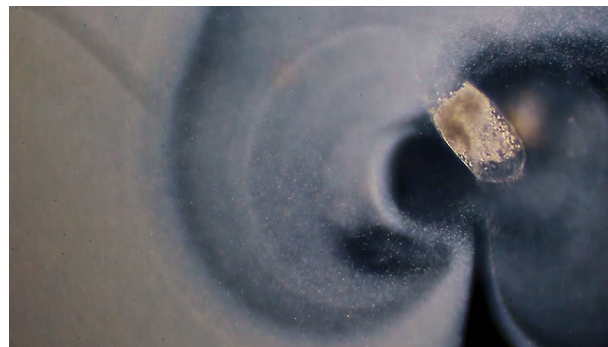
Hendrix Demers, Hydro-Québec, Canada

Milena Hugenschmidt, Fraunhofer Institute for Physical Measurement Techniques IPM, Germany

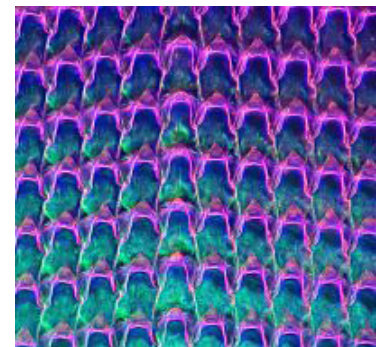
- Transmission imaging, diffraction, channeling, and spectroscopy in the SEM (all contrast mechanisms, t-EBSD/TKD, EDS, EELS, correlative imaging)
- Defect analysis in transmission mode
- 4D STEM-in-SEM applications (data acquisition, analysis, instrumentation, and control schemes)
- Combined FIB-SEM transmission methods for all-in-situ and high-throughput sample preparation and analysis
- Multi-beam scanning electron microscopy
- Strategies enabling high-throughput, automated imaging, and diffraction analysis for STEM-in-SEM and multi-beam configurations
- Preparation strategy and multi-signal characterization of biological materials
- Large dataset management and analysis strategies



Enamel, by Timothy Bromage, New York University College of Dentistry, New York, NY



Rotifer, by Tommy Gunn, New York, NY



Teeth, by Andrei Savitsky, Chernasky, Ukraine



Biological Sciences Symposia

B01 3D Structures: from Macromolecular Assemblies to Whole Cells (3DEM FIG)

ORGANIZERS:

Teresa Ruiz, University of Vermont
Melanie Ohi, University of Michigan
Cheri Hampton, AFRL/RXAS Wright-Patterson Air Force Base
Edward Eng, New York Structural Biology Center

Sponsored by the 3D-EM in the Biological Sciences Focused Interest Group

- Structure and function of macromolecular complexes in vitro and in vivo
- Single particle cryo-electron microscopy
- Cryo-electron tomography
- Molecular modeling

B02 Biological Applications of Quantitative Phase Imaging

ORGANIZERS:

Michael Model, Kent State University
Alexander Khmaladze, University at Albany

- Label-free imaging comprises several nondestructive techniques for the analysis of cells and tissues
- Label-free imaging provides unique information about cell structure and/or chemical composition
- New medical uses of label-free imaging are emerging

B03 Biomedical Research on Diseases in Humans, Plants and Animals using Electron and Light Microscopy

ORGANIZERS:

Marcela Redigolo, West Virginia University
Emily Benson, Cleveland Clinic
Claudia López, Oregon Health & Science University

Sponsored by the Diagnostic & Biomedical Microscopy Focused Interest Group

- Development of new techniques related to electron and light microscopies applied to diagnosis including correlative imaging techniques or hybrid imaging modalities
- Advances in plant research, from nutrition to medicine, promoting more accurate diagnosis and treatments
- Microscopic characterization of cellular and molecular structure in normal and diseased humans, animals and plants

B04 Electron Microscopy in Education

ORGANIZERS:

Claudia S. López, Oregon Health & Science University
Edward Eng, New York Structural Biology Center

- Curriculum development to train new practitioners
- Cryo-EM merit badges to standardize best practices and cross training
- Lowering barriers of access to cryoEM instrumentation
- Outreach to underserved communities and institutions

B05 Hyperspectral Imaging: A New Window into the Cell

ORGANIZERS:

Maria Cristina Ubach, Bayer Crop Science
Cristina Dalle Ore, Bayer Crop Science
Ce Yang, University of Minnesota

- Advantages of hyperspectral fluorescence confocal microscopy
- Impact of hyperspectral imaging in Agriculture: from the lab to the field
- Monitoring cell and plant health by remote sensing

B06 Imaging, Microscopy, and Micro/Nano-Analysis of Pharmaceutical, Biopharmaceutical, and Medical Health Products—Research, Development, Analysis, Regulation, and Commercialization

ORGANIZERS:

Jonathan Boyd, AstraZeneca
Somya Singh, Merck
Ce Yang, University of Minnesota

Sponsored by the Pharma Focused Interest Group

- Microscopy in the pharmaceutical industry
- R&D uses of microscopy
- Clinical uses of microscopy
- Artificial intelligence in imaging and image analysis
- Multidimensional high content imaging and pipeline analysis

B07 Microscopy Uncovering Biological and Technological Details Towards Biomimetics

ORGANIZERS:

Eduardo Favret, National Institute on Agricultural Technology (INTA), Argentina
Andres Lasagni, Technische Universität Dresden, Germany
Dagmar Voigt, Technische Universität Dresden, Germany
Christoph Neinhuis, Technische Universität Dresden, Germany

- Bioinspired surfaces
- Biomimetics
- Hierarchically structured materials
- Surface properties

B08 Spatial Omics Using Mass Spectrometry

ORGANIZERS:

Hua Tian, University of Pittsburgh
Haibo Jiang, Hong Kong University, Australia
Fershteh Zandkarimi, Columbia University

- Spatial omics is the new frontier of biological study
- Mass spectrometry imaging is the central player in spatial omics
- Technological advances enable spatial omics at single cell level
- Heterogeneous cellular landscape elucidates the new disease mechanism and treatment response

B09 Volume Electron Microscopy

ORGANIZERS:

Kedar Narayan, Frederick National Laboratory, National Cancer Institute, NIH
Kirk Czymmek, Donald Danforth Plant Science Center
Alice Liang, NYU Grossman School of Medicine
Camenzind G. Robinson, St. Jude Children's Research Hospital

- Sample and specimen preparation of biological samples for vEM
- High-resolution large-volume vEM techniques
- Combining and correlating vEM images with other imaging modalities
- Segmentation, visualization and quantification of features from vEM data
- Data handling, sharing, and community initiatives in vEM



Cross-Disciplinary Sciences Symposia

C01 Emerging 4D STEM Techniques in Materials and Biological Sciences

ORGANIZERS:

Emanuela Liberti, *The Rosalind Franklin Institute, UK*
 Laura Clark, *University of York, UK*
 Karen Bustillo, *Molecular Foundry (NCEM)*
 Shelly Conroy, *Imperial College London, UK*

Sponsored by the **Electron Diffraction Focused Interest Group**

- This symposium focuses on 4D-STEM computational and experimental developments for materials and biological science
- Phase retrieval and electron diffraction techniques, including DPC, ptychography and scanning electron diffraction are key tools for imaging at low dose
- Automation, live processing, and novel scan strategies of 4D STEM data as ways to improve experimental data collection
- Analysis strategies such as parallel processing, application of machine learning, novel data workflows, open-source code, novel ptychography algorithms, and denoising/ techniques, advanced filtering techniques of 4D STEM data

C02 Facilities Management: Crucial Skills and Strategies

ORGANIZERS:

Josefina Arellano, *The University of Texas-Dallas*
 Luisa Amelia Dempere, *University of Florida*
 Elizabeth Miller, *Michigan Technological University*

Sponsored by the **Facilities Operations Management Focused Interest Group**

- Skills and strategies involved in the operation of microscopy facilities.
- Management of multi-user and core facilities at different levels.
- Practical examples of best practices including administration, operations, fiscal compliance, etc.

C03 Interdisciplinary Analysis of Soft/Hybrid/Bio Materials Using Advanced Focused Ion Beam

ORGANIZERS:

Frances Allen, *University of California-Berkeley*
 Lawrence Drummy, *Air Force Research Laboratory*
 Stephan Krämer, *Harvard University*
 Robert Hovden, *University of Michigan*

- Advances in cryo-FIB, working with vitrified, beam-sensitive materials, charge neutralization, novel FIB sources

- Correlative approaches for site-specific sample preparation and analysis, including FIB lift-outs for TEM and APT, fiducial markers, novel genetic constructs
- Multimodal analytics, including 3D EDS/EBSD, EBIC, TKD, CL, Raman, fluorescence microscopy, X-ray tomography, TEM/STEM
- Innovations in automation, 3D imaging, and data processing via deep learning
- In-situ and in-operando experiments, air-free transfer
- Interface characterization with limited dose, data science challenges for low signal-to-noise images and spectra

C04 Machine Learning-driven Automated Microscopy for Materials Discovery and Semiconductor Manufacturing

ORGANIZERS:

Yongtao Liu, *Oak Ridge National Laboratory*
 Maxim Ziatdinov, *Oak Ridge National Laboratory*
 Tuyen K. Tran, *Intel Corporation*

- AI/ML-guided automated and autonomous microscopy
- Physics-driven workflow design, process-aware automation, edge computing
- Theory in the loop
- Beyond off-the-shelf AI/ML tools
- Software ecosystem(s) for autonomous experimentation

C05 Correlative Microscopy Using Light, Electron, and X-ray Microscopy

ORGANIZERS:

Jingshan Du, *Pacific Northwest National Laboratory*
 Kenneth Fahy, *Sirius XT Ltd.*
 Evan Krystofiak, *Vanderbilt University*
 Tony Fearn, *The Francis Crick Institute*

- Correlative light, electron, and x-ray microscopy (CLEM/CLEXM)
- In situ electron microscopy and tomography techniques

- Data collection, integration, and analysis workflows for correlative and multimodal imaging
- Soft and biological specimens and structures
- Materials formation and transformation

C06 Memorial Symposium: Lena Fitting Kourkoutis

ORGANIZERS:

Berit Goadge, *Max Planck Institute for Chemical Physics of Solids, Germany*

Michael Zachman, *Oak Ridge National Laboratory*
 Ismail El Baggari, *Harvard University*
 Robert Hovden, *University of Michigan-Ann Arbor*

- Atomic imaging of structure and valence in functional materials and across interfaces
- Chemical and electronic characterization via cutting-edge spectroscopic techniques
- Pioneering cryogenic and in situ STEM and STEM-EELS techniques
- Reaching new quantum phases and energy materials down to the atomic scale
- Enabling insights into biological and energy systems, including at hard-soft and solid-liquid interfaces

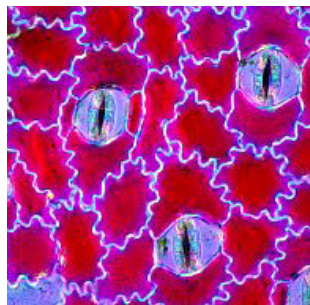
C07 Lens on Diversity in the Microscopy and Microanalysis Community*

ORGANIZERS:

Martha McCartney, *Arizona State University*
 Shery Chang, *University of New South Wales, Australia*
 Rhonda Stroud, *Arizona State University*
 Gail Celio, *University of Minnesota*

- Demographic studies of membership compared to STEM workforce in relevant specialties (biology, materials science, geosciences etc.). Who is underrepresented at what stage?
- Examples of successful programs and technologies that enable wider participation in microscopy and microanalysis
- Contributions that identify and address current obstacles to academic and professional advancement for women and minority microscopists
- Female and minority perspectives across all career stages concerning current advances in electron microscopy
- Biographical sketches and scientific contributions of hidden figures in M&M history

*Poster-only Symposium



Stomata, by Marek Miś,
 Marek Miś Photography, Suwalki, Poland



Physical Sciences Symposia

P01 Innovative Magnetic Imaging

ORGANIZERS:

Darius Pohl, Dresden Center for Nanoanalysis (DCN), Germany

Sebastian Schneider, Dresden Center for Nanoanalysis (DCN), Germany

Fehmi Yasin, CEMS, RIKEN, Japan

- Application of magnetic TEM techniques like Lorentz TEM, Differential phase-contrast (DPC), Lorentz 4D-STEM, Electron Holography and Electron energy-loss magnetic chiral dichroism (EMCD) for quantitative magnetic measurements
- New developments in quantitative magnetic characterization techniques in the TEM
- In- and ex situ correlation of TEM measurements with complementary magnetic characterization techniques
- Advances in simulation techniques including micromagnetic modeling and magnetic imaging (i.e., Lorentz (S)TEM, multislice, etc.) towards quantitative magnetic characterization

P02 Memorial Symposium: Terence E. Mitchell

ORGANIZERS:

Paul Kotula, Sandia National Laboratories

Jeremy Mitchell, Los Alamos National Laboratory

Amit Misra, University of Michigan-Ann Arbor

Kurt Sickafus, Los Alamos National Laboratory

- Memorial Symposium for Terence Mitchell
- Transmission electron microscopy in materials science
- Dislocations in FCC and BCC materials
- Dislocations in ceramics
- High-voltage electron microscopy

P03 Electron Microscopy of Advanced Functional Materials

ORGANIZERS:

Shize Yang, Arizona State University

Cong Su, Yale University

- Semiconductor materials characterization
- Catalysis materials characterization
- Battery materials characterization
- Quantum materials

P04 Science and Applications of High-Entropy Materials

ORGANIZERS:

Moon Kim, The University of Texas-Dallas

Babak Anasori, Indiana University-Purdue University

- Various bulk high-entropy materials (HEMs), including alloys, borides, carbides, nitrides, oxides, silicides, and chalcogenides
- 2D layered high-entropy materials, including 2D transition metal oxides, 2D carbides/carbonitrides/ nitrides (MXenes), 2D transition metal chalcogenides, and hydroxides
- Morphology, defects, interfaces, heterostructures
- Applications in electronics, energy, and other emerging devices

P05 Advanced Imaging and Spectroscopy Beyond Room Temperature

ORGANIZERS:

Juan Carlos Idrobo, University of Washington

Robert Klie, University of Illinois-Chicago

- Ultrafast and/or in-operando imaging, spectroscopy, and diffraction during electronic excitation
- Sample platforms and tools for in-situ electrical pulsing, optical excitation, and AC fields such as THz and microwave excitation
- Fast detectors, multimodal imaging, and simultaneous property measurements
- Ultrafast electron beam-induced dynamics, including beam damage and effects of temporal shaping
- Scientific advances in electronically driven phenomena (e.g. phase transformations, polarization switching, carrier dynamics)
- Advances in dynamic mechanisms important for microelectronics, energy storage and conversion, quantum materials, and quantum information science

P06 Visualizing Electrically Driven Dynamics Across Spatiotemporal Scales: From In-situ to Ultrafast

ORGANIZERS:

Daniel Durham, Argonne National Laboratory

Thomas Edward Gage, Argonne National Laboratory

Yimei Zhu, Brookhaven National Laboratory

John Cumings, University of Maryland

- Ultrafast imaging, spectroscopy, and diffraction of electrically driven dynamics
- In-operando real-time microscopy of electronic devices
- Sample platforms and tools for in-situ electrical biasing, pulsing, and AC fields such as THz and microwave excitation
- Fast detection equipment and schemes
- Correlated dynamic microscopy and property measurement
- Scientific discoveries of electric-induced phenomena and mechanisms

P07 Understanding Structure-Property Relationships in Quantum Materials with Emerging Electron Microscopy Methods

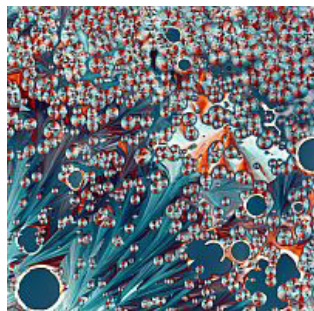
ORGANIZERS:

Yu-Tsun Shao, University of Southern California

Sandhya Susarla, Arizona State University

Y. Eren Suyolcu, Max Planck Institute for Solid State Research, Germany

- In situ TEM capabilities to study phase transitions in functional materials (heating, biasing, cooling, magnetic fields, mechanical testing)
- Applications of electron microscopy to characterize topological materials, ferroics, two-dimensional materials, superconductors
- Combination with advanced S/TEM techniques (phase related, spectroscopy, 4D-STEM)
- New development in imaging methods, instruments, and computational methods (including machine learning) for extracting functionality in quantum materials



Cupric sulfate, by José Manuel Martínez López, Quimica Tech, Juárez, Mexico

P08 Accelerating the Clean Energy Transition through Microscopy and Microanalysis of Complex Geologic Materials

ORGANIZERS:

Lori Hathon, University of Houston
 Lisa Van Loon, LISA CAN Analytical Solutions Inc.
 Neil Banerjee, Western University, Canada

- A stable supply of critical minerals is essential for the clean energy transition
- Coupling digital imaging techniques with rock properties measurements allows robust forward model development
- Advanced analytical approaches will provide transformational advances that secure domestic supplies for clean energy technologies
- Microscopy & microanalysis will inform responsible and sustainable practices by minimizing negative impacts throughout the value chain
- Novel and integrated use of microscopy & microanalysis helps unravel complex geological systems that host critical minerals, are reservoirs for seasonal hydrogen storage, act as receiving units and sealing lithologies for carbon sequestration, and safely store radioactive waste

P09 Advances in In Situ TEM Characterization of Dynamic Processes in Materials

ORGANIZERS:

Di Zhang, Los Alamos National Laboratory
 Eva Olsson, Chalmers University of Technology, Sweden
 Dongsheng Li, Pacific Northwest National Laboratory
 Wolfgang Jager, Christian-Albrechts-Universität zu Kiel, Germany

- In situ/operando S/TEM study of nucleation, crystallization, and particle self-assembly processes in solutions, melts, and vapors
- Chemical and electrochemical reactions
- Dynamic processes of energy materials such as batteries, solar cells, fuel cells, and thermoelectrics, etc.
- Low-energy and low-dose beam conditions for quantum and soft materials such as 2D materials, semiconductors, superconductors, topological insulators, magnetic materials etc.
- Advancement in specialized holders and electron microscopes and practical challenges for in situ microscopy of phase (trans)formation and chemical reactions (including corrosion)
- Artificial intelligence/machine learning aided automated in situ S/TEM experiments

P10 In Situ and Cryogenic Electron Microscopy and Spectroscopy for Energy Materials

ORGANIZERS:

Yaobin Xu, Pacific Northwest National Laboratory
 Reza Shahbazian-Yassar, University of Illinois-Chicago
 Chongmin Wang, Pacific Northwest National Laboratory
 Kai He, University of California-Irvine

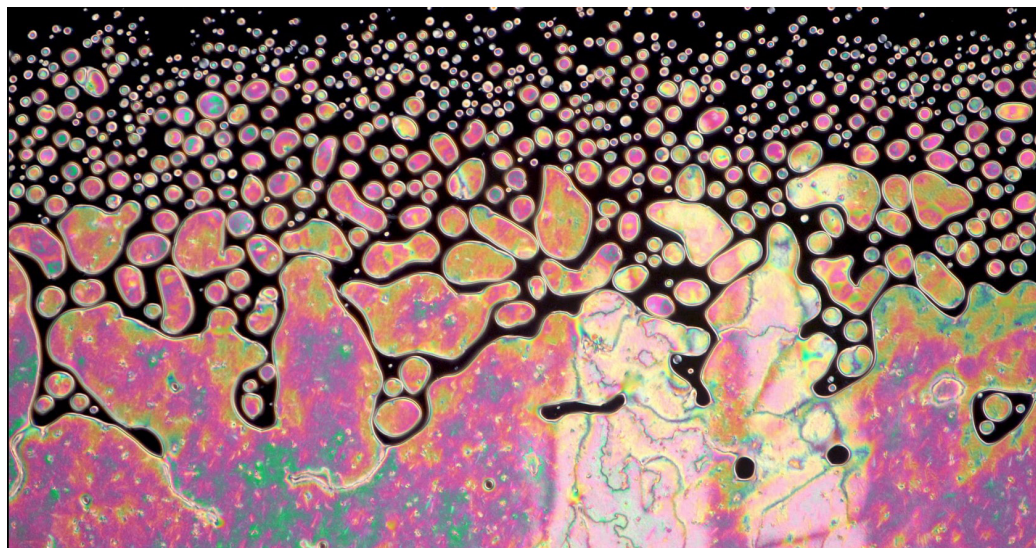
- Multi-scale to atomic-resolution imaging and spectroscopy of energy materials
- In-situ and operando imaging and spectroscopy of materials/devices under working conditions
- Cryo-TEM and 4D-STEM
- Automation and data driven microscope
- Advances in ultrafast imaging and spectroscopy data collection and interpretation

P11 Chasing Higher Resolution in Electron Tomography

ORGANIZERS:

Yao Yang, Westlake University
 Peter Ercius, Lawrence Berkeley National Laboratory
 Jianwei (John) Miao, University of California-Los Angeles

- Advances in methods for electron tomography at atomic resolution by S/TEM and liquid cell TEM
- Advances in sample preparation and data acquisition for higher resolution in single particle analysis and cryo-ET
- Development of algorithms to determine 3D structures with higher resolution at lower doses
- Structure-property relations with better resolution in all fields



Liquid crystal, by Karl Gaff, Karl Gaff Photography, Dublin, Ireland



Outreach Sessions

X90 Exploring Microscopy in Educational Settings

ORGANIZERS:

Josh Silverstein, Pacific Northwest National Laboratory
Abinash Kumar, Nanospective Inc.

In the realm of scientific exploration, the microscope stands as an indispensable interdisciplinary tool, enabling students to peer into the realms of the unknown while establishing vital connections between structure and function. The Education Outreach Committee of MSA is dedicated to forging connections between individuals and institutions, ensuring that the paths to careers and education in microscopy are not only clear but also thrilling and captivating.

During the X90 Symposium, we will delve into the following key topics:

1. Implementing Microscopy in K-12 and Post-Secondary Classrooms and Curricula: Discover best practices for seamlessly integrating microscopy into educational settings, from primary to higher education.
2. Promoting STEM Education and Outreach at Local and National Levels: Explore local and national initiatives that emphasize the importance of science, technology, engineering, and mathematics (STEM) education and outreach.
3. Creating Engaging Microscopy Experiences: Uncover innovative methods to introduce students to microscopy in a manner that is both fun and impactful, igniting their passion for scientific exploration.

X91 Microscopy Adventures for Families and Children of All Ages

ORGANIZERS:

Josh Silverstein, Pacific Northwest National Laboratory
Abinash Kumar, Nanospective Inc.

Prepare for a delightful journey of scientific discovery and exploration suitable for families and children of all ages! The X91 Microscopy Adventures session, formerly known as "Family Affair," offers an engaging and interactive experience that introduces the fascinating world of microscopy to both the young and the young at heart. This event is designed to spark curiosity, nurture a love for science, and inspire the next generation of scientists.

X92 Project MICRO - Empowering Microscopy Outreach

ORGANIZERS:

Josh Silverstein, Pacific Northwest National Laboratory
Abinash Kumar, Nanospective Inc.

Join us at the Outreach booth, an integral part of the MSA Megatooth, available every day the exhibit hall is open. Discover how to set up engaging educational stations in your classroom and share your exciting experiences with microscopy outreach. Witness diverse microscope systems in action, tailored for classroom use, explore a curated selection of books suitable for elementary school-age children, and participate in our daily door prize draw. This event is open to all, including delegates, their families, and friends. Come and be a part of Project MICRO, where the power of microscopy outreach comes to life!

X93 Cultivating STEM Networks - A Workshop for Local Leaders, Students, and Educators

ORGANIZERS:

Josh Silverstein, Pacific Northwest National Laboratory
Abinash Kumar, Nanospective Inc.

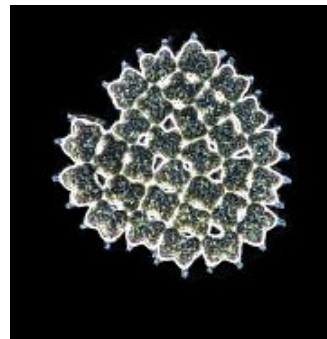
X93 is a two-day initiative leveraging the M&M hosting city to establish a National Microscopy Education Alliance. It brings together local STEM leaders, students, and educators for immersive experiences in advanced microscopy techniques on Day 1. On Day 2, participants dive into the M&M National Conference to connect with professionals and explore research projects. X93 is your opportunity to build local STEM networks and contribute to a national alliance, shaping the future of STEM education and outreach, all within the dynamic atmosphere of the hosting city. Join us to make a lasting impact in the world of microscopy education.

X94 STEM Roundtable: Building Skills for the Future

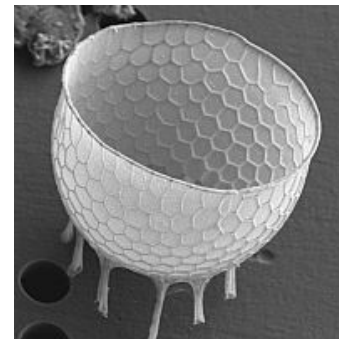
ORGANIZERS:

Lori Harvey, Hitachi High Technologies America
Summer Hamilton, Hitachi High Technologies America
Troy Hall, Hitachi High Technologies America

We will explore how to integrate varied resources to have broader, sustainable impacts in STEM education, including bridging K-12 outreach with undergraduate and graduate education, and emphasizing the importance of diversity and inclusion which will lead to a stronger workforce for everyone. In response to education changes in 2020 & 2021, The HTA Inspire STEM Education Outreach Program has put forth a plan to provide an opportunity to make quality in-person and virtual experiences easily accessible to teachers as they create the classrooms of tomorrow now. The program is continuing its work with local, national, and international partners to provide flexible access to easy-to-use content and technology that can be used in the following learning scenarios.



Algae, by MacKenzie Freeze, Frostburg State University, Frostburg, MD



Diatom, by Mark Webber, Galiano Island, Canada



Tech Forum

X30 Technologists' Forum Symposia: Exploring New Methods in Volume Electron Microscopy (vEM) [Partnering with B09]

ORGANIZERS:

D. Page Baluch, Arizona State University
Alice Liang, NYU Grossman School of Medicine

Advancements in volume electron microscopy are improving high resolution visualization of 3D cellular structures at a nanometer scale. Efforts to optimize and improve this data relies on optimal sample preparation and high-level image analysis. This year the Technologists' Forum is partnering with the organizers of the Volume electron Microscopy [B09] symposium to provide a series of presentations that will focus on the development of new protocols to optimize sample preparation and analysis obtained from various imaging platforms.

- Biological sample preparation for vEM.
- Exploring multimodal imaging techniques.
- Large data management and analysis.

X31 Technologists' Forum Symposium: SubAngstrom Room Design and Lab Space Optimization

ORGANIZERS:

John L. Grazul, Cornell University
D. Page Baluch, Arizona State University

Within the past few years there has been a rapid development of new technologies that are transforming the field of microscopy. The development of new systems with greater resolution requires optimal environmental conditions to avoid issues related to vibration, temperature fluctuations and magnetic field interference. In addition to room design considerations, these advanced systems also have improved detection systems that capture large amounts of data in a short time frame which introduces data management issues. This symposium will focus on SubAngstrom room design and other ways to optimize your EM lab space.

- How to design a SubAngstrom lab space.
- Large data management.

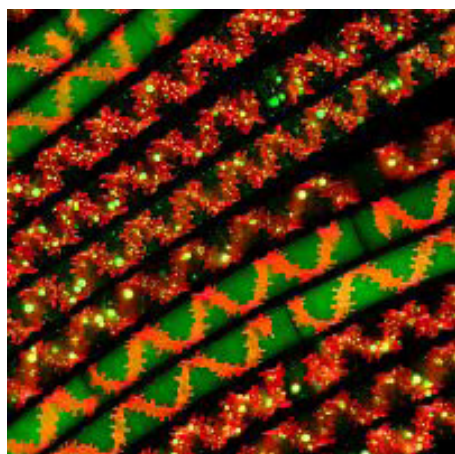
X32 Technologists' Forum Roundtable: Tips for Managing an EM Lab

ORGANIZERS:

John L. Grazul, Cornell University
D. Page Baluch, Arizona State University

Electron Microscopy laboratories rely on optimized lab management by well-trained managers and technologists. This symposium will focus on key areas that help improve lab proficiency and image quality by reviewing many common lab protocols that are essential to a productive lab.

- Lab safety and standardizing SOPs.
- Sample prep and realistic expectations for CLEM.
- Avoiding TEM/SEM contamination.
- Hazardous waste management.
- Guidelines for training new users.



Chloroplasts, by Håkan Kvarnström, , Bromma, Sweden



Meeting Awards

How to Apply For an M&M Meeting Award:

- Apply for M&M meeting awards during the online paper submission process. Applicants must check the box during submission to have their paper considered for an award. **Only one paper may be designated per applicant.**
- The applicant must appear as first author and presenter of the paper submitted for award.
- The applicant must provide the name, title, institution, and e-mail address of their **supervisor**, who will be contacted to provide a **supporting letter and confirmation of applicability** for the indicated award category (e.g. student, post-doc, or technical staff).

GENERAL CONSIDERATIONS:

Award applicants will automatically be considered for memorial scholarships, conferred by MSA based on the generous support of society sponsors. Applicants who have previously received an M&M Meeting Award will not be considered for a second award in the same category.

STUDENTS:

All students in good standing enrolled at accredited academic institutions are eligible. High school, undergraduate, and graduate students are encouraged to apply. Applicants are not required to be members of the sponsoring society. If an applicant is not a full-time student, their submitted work ***MUST*** have been done at their academic institution in their role as student. Student applicants are required to provide their advisor's name and email address during the application process.

POSTDOCTORAL RESEARCHERS:

All postdoctoral researchers are eligible. Applicants are not required to be members of the sponsoring society. If an applicant is not a full-time researcher, their submitted work ***MUST*** have been done at their institution in their role as post-doc researcher. Postdoctoral researchers are required to provide their advisor's name and email address during the application process.

PROFESSIONAL TECHNICAL STAFF MEMBERS:

Full-time technologists/technicians are eligible. In addition, the applicant must be a member of the sponsoring society, current in their dues for the year of the meeting.

AMOUNT OF AWARD:

M&M Meeting Awards and memorial awards consist of full meeting registration and up to \$1,000 for travel-related expenses. Original receipts must be provided to receive travel reimbursement. All award winners also receive an invitation to the Presidents' Reception, held on the Tuesday evening of the meeting.

NOTIFICATION OF AWARD:

All award applicants will be notified of their award status approximately eight weeks following the Call for Submissions deadline. Unsuccessful applicants will be permitted to withdraw their papers, should their ability to attend the meeting be contingent on the award, within one week following notification.

REQUIREMENTS OF AWARD:

All award winners must present their paper **in-person** at the M&M meeting in order to receive their award. Awardees are expected to attend and participate in the entire meeting, which runs from Sunday evening's opening reception through late Thursday afternoon. Awardees are required to attend the Monday morning plenary session, at which their award will be conferred. Awards or award monies are non-transferable.

ONSITE AWARDS

The M&M meeting's co-sponsoring societies confer competitively judged awards at the meeting.

MSA Student Poster Awards

We believe poster presentations are an excellent format for all participants to engage in intensive discussion with other researchers in the field. To especially encourage students to take advantage of this opportunity and submit papers for poster presentation, MSA provides cash awards to the most outstanding student posters (first author) each day (up to one in each of three categories—physical, analytical, and biological).



Ultramicrotomy Awards

Posters that wish to be considered for the Ultramicrotomy awards should indicate this in their online paper submission. Ultramicrotomy awards consist of a trip to Switzerland from first place and a Swiss watch for second place. These awards are sponsored by Diatome US.

MAS Best Paper Awards

MAS annually confers awards for papers presented at the M&M meeting deemed to be best in four categories. Each comes with a cash award generously provided by MAS Sustaining Members.



Microscopy Today Micrograph Awards

Scientifically significant micrographs:



Published category (images published in 2022)

Open category (unpublished images)

Video category (movies and 3-D reconstructions)

Deadline for submission is February 16, 2024

Prizes awarded at M&M 2024 in Cleveland, OH



Plenary Speakers

Ed Boyden

Professor, Departments of Brain and Cognitive Sciences, Media Arts and Sciences, and Biological Engineering, Y. Eva Tan Professor in Neurotechnology, McGovern Institute and HHMI

Ed Boyden is Y. Eva Tan Professor in Neurotechnology at MIT, an investigator of the Howard Hughes Medical Institute and the MIT McGovern Institute, and professor of Brain and Cognitive Sciences, Media Arts and Sciences, and Biological Engineering at MIT. He leads the Synthetic Neurobiology Group, which develops tools for analyzing and repairing complex biological systems, such as the brain, and applies them systematically to reveal ground truth principles of biological function and to repair these systems. These inventions include optogenetic tools,

which enable control of neural activity with light; expansion microscopy, which enables ordinary microscopes to do nanoimaging; new tools for high-speed imaging of living biological signals and networks; noninvasive brain stimulation strategies that may help with conditions ranging from Alzheimer's to blindness; and new strategies for inexpensively creating 3-D nanotechnology. He co-directs the MIT Center for Neurobiological Engineering, which aims to develop new tools to accelerate neuroscience progress, and is a faculty member of the MIT Center for Environmental Health Sciences, Computational & Systems Biology Initiative, and Koch Institute.

Amongst other recognitions, he has received the Wilhelm Exner Medal (2020), the Croonian Medal (2019), the Lennart Nilsson Award (2019), the Warren Alpert Foundation Prize (2019), the Rumford Prize (2019), the Canada Gairdner International Award (2018), the Breakthrough Prize in Life Sciences (2016), the BBVA Foundation Frontiers of Knowledge Award (2015), the Carnegie Prize in Mind and Brain Sciences (2015), the Jacob Heskel Gabbay Award (2013), the Grete Lundbeck Brain Prize (2013), the NIH Director's Pioneer Award (2013), and the Perl/UNC Neuroscience Prize (2011). He was named to the World Economic Forum Young Scientist list (2013) and the Technology Review World's "Top 35 Innovators under Age 35" list (2006), and is an elected member of the National Academy of Sciences (2019), the American Academy of Arts and Sciences (2017), the National Academy of Inventors (2017), and the American Institute for Medical and Biological Engineering (2018). His group has hosted hundreds of visitors to learn how to use new biotechnologies, and he also regularly teaches at summer courses and workshops in neuroscience, and delivers lectures to the broader public (e.g., TED (2011), TED Summit (2016), World Economic Forum (2012, 2013, 2016)).

Ed received his Ph.D. in neurosciences from Stanford University as a Hertz Fellow, working in the labs of Jennifer Raymond and Richard Tsien, where he discovered that the molecular mechanisms used to store a memory are determined by the content to be learned. In parallel to his PhD, as an independent side project, he co-invented optogenetic control of neurons, which is now used throughout neuroscience. Previously, he studied chemistry at the Texas Academy of Math and Science at the University of North Texas, starting college at age 14, where he worked in Paul Braterman's group on origins of life chemistry. He went on to earn three degrees in electrical engineering and computer science, and physics, from MIT, graduating at age 19, while working on quantum computing in Neil Gershenfeld's group. Long-term, he hopes that understanding how the brain generates the mind will help provide a deeper understanding of the human condition, and help humanity achieve a more enlightened state.



Dr. Christopher (Wren) Carr

Lawrence Livermore National Laboratory

Dr. Christopher (Wren) Carr is an experimental physicist with a specialty in ns laser-induced damage in optical materials. He earned his Ph.D. in a collaboration UC Davis and LLNL in 2003. After graduation Wren became a permanent member of the scientific staff at Lawrence Livermore National Laboratory (LLNL). Wren has studied laser-induced damage and growth in all the major components of the NIF laser including the final optics, amplifiers, and laser mirrors. He has published 120 manuscripts in the field of laser-induced damage and is one of the current chairs of the SPIE Laser Damage international conference on laser-induced damage.

Wren currently leads the OMST Damage and Mitigation Science and Technology group who focus on understanding laser-induced damage on laser systems in general, and NIF in particular, and developing and mitigating technologies.





Short Courses

X10 Guidelines for Performing 4D-STEM Characterization from the Atomic to Micrometer Scales: Experimental Considerations, Data Analysis

LEAD INSTRUCTORS:

Colin Ophus, Lawrence Berkeley National Laboratory

David Muller, Cornell University

- Electron detector technology suitable for 4D-STEM experiments
- List of possible 4D-STEM experimental configurations and references
- Analysis software for characterizing large numbers of STEM diffraction pattern images and visualization of the results
- Software and tutorial for simulating 4D-STEM datasets

X11 Cryo-EM for Materials Sciences: Hardware, Applications and Data Acquisition

LEAD INSTRUCTORS:

Ismail El Baggari, Harvard University

Myung-Geun Han, Brookhaven National Laboratory

Michael Zachman, Oak Ridge National Laboratory

While cryogenic TEM has revolutionized the research in biological science, its applications in materials sciences have been relatively limited. The major challenges lie in realizing reliable cryogenic specimen preparation, and atomic-scale imaging and spectroscopy at a wide range of cryogenic temperatures. Though still in its infancy, recent advancements in cryo-EM, especially in cryo-FIB and new TEM stages, have brought us the promises.

This short course will focus on the fundamentals of cryo-EM and primarily benefit those new to the field. We will highlight historical developments, current state, and future perspectives of cryo-EM for materials science. We will cover critical steps involved in a successful cryogenic microscopy study, including specimen preparation, specimen transfer, cryogenic FIB, new cryo-TEM stages, imaging, spectroscopy at low temperatures, and data analysis methods that can potentially be used to assist cryo-EM data acquisition and data analysis.

X12 Transmission Electron Microscopy and Spectroscopy from First Principles

LEAD INSTRUCTORS:

Toma Susi, University of Vienna, Austria

Jacob Madsen, University of Vienna, Austria

Jan Rusz or Paul Zeiger, Uppsala University, Sweden

Rebecca Nicholls, University of Oxford, UK

Simulations of transmission electron microscopy images and electron energy-loss spectra can not only be vital for correctly interpreting and understanding measured data, but may also be used to design experiments or even instrumentation. With modern open source tools, simulations of all kinds of image signals including HRTEM, ED, DPC and 4D-STEM are easy to learn and tractable on a personal computer. Computational exercises are performed using the open-source Python package abTEM. Simulation of electron energy-loss spectra is more demanding, and requires specialized expertise and high-performance computing resources. Different approaches to model phonon, plasmon and core-loss spectra are introduced, including a limited exercise.

- (Scanning) transmission electron microscopy image simulations
- Introduction to open-source TEM simulation software
- Computational exercises for modeling common imaging modes
- First-principles simulation of electron energy-loss spectroscopy
- Introduction to principles of phonon, low-loss and core-loss modeling

X13 Automated Experiments in Electron Microscopy

LEAD INSTRUCTORS:

Sergei Kalinin, University of Tennessee, Knoxville

Maxim Ziatdinov, Oak Ridge National Lab

Kevin Roccapriore, Oak Ridge National Lab

- Machine learning driven design of workflows in electron microscopy and spectroscopy based on the chosen experimental objective
- Myopic and non-myopic workflows: rewards, policies, and value functions—neural networks for real time data analysis in EM
- Structured Gaussian Processes and deep kernel learning: co-discovery of physical mechanisms and optimization—from myopic optimization to reinforcement learning

- Automated experiment forensics and human in the loop AE

X14 From Obscure to Clear: A Dive into Tissue Clearing and Expansion Microscopy

LEAD INSTRUCTORS:

Yongxin (Leon) Zhao, Carnegie Mellon

Alan Watson, University of Pittsburgh

Adam Glaser, Allen Institute

Aleksandra Klimas, Carnegie Mellon

- Foundations of Tissue Clearing: Understanding the basics and significance.
- Tissue Clearing Methods: Exploring popular techniques and essential reagents.
- Expansion Microscopy and variants: Delving into principles, different variants and applications.
- Imaging and Analysis: Best practices for capturing and interpreting results.
- Challenges & Limitations: Recognizing potential pitfalls and ways to overcome them.
- Future Prospects: Where next for tissue clearing and expansion microscopy?

X15 Automation for the Microscopy Workflow—Serial Sectioning of Materials at the Meso-scale

LEAD INSTRUCTORS:

Lucille Gianuzzi, EXpressLO, LLC

Joseph Michael, Sandia National Laboratory (ret.)

The use of FIB instruments in materials- and biological-science laboratories is growing rapidly. The versatility and capabilities of these tools are also rapidly improving. This course will first cover ion/solid interactions, which must be understood for successful application of these tools. The attendees will learn of the variety of commercial ion sources and ion species available in FIB instruments, and explore their benefits for a range of applications. Applications of femtosecond laser micromachining in conjunction with FIB will be discussed. Techniques of sample preparation for SEM and TEM, 3D applications, micro- and nano-fabrication and cryo-methods will be presented.

- Theory of ion-solid interactions
- A review of ion sources: LMIS (Ga and others), PFIB (Xe and others), and other commercial ion sources.
- 2D and 3D (FIB SEM tomography) sample preparation
- TEM and APT specimen preparation
- Cryo FIB TEM specimen preparation
- Micro and nano-fabrication using ion beams



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