Abstracts for MMMS 2017

Sponsors

Exhibitors

Keynote Speakers

Using cryo-electron microscopy to visualize the function of PMP22, a major cause of Charcot-Marie-Tooth disease (CMTD)

Professor Melanie Ohi
Life Sciences Institute, University of Michigan

Peripheral myelin protein 22 (PMP22) is highly expressed in myelinating Schwann cells of the peripheral nervous system (PNS). *PMP22* genetic alterations cause the most common forms of Charcot-Marie-Tooth disease (CMTD), which is characterized by severe dysmyelination in the peripheral nerves. However, the functions of PMP22 in Schwann cell membranes remain unclear. Using cryo-electron tomography (cryo-ET) we demonstrate that reconstitution of purified PMP22 into lipid vesicles results in the formation of compressed and cylindrically wrapped protein-lipid vesicles that share common organizational traits with compact myelin of peripheral nerves *in vivo*.

Ultrasonic Fatigue and its role in Materials Centric Design

Dr. Jason W. Carroll
Presenting Author Email: JasonWCarroll@eaton.com
Presenting Author Affiliation: Eaton Corporation
Presenting Author Department: Global Technology

21st century product design is rapidly moving towards a "**Material Centric Design**" methodology that will radically alter the geometric based design processes that defined the past century. The small amount of metal alloy options developed during the past two-hundred years of manufacturing are being replaced by options limited only by the imagination of engineers and the periodic table. Matched with material minimization routines, material centric design will help modernize US manufacturing. To make this transformation possible, and to fully appreciate it's benefits, there needs to be a revolutionary shift in how materials and designs are rapidly characterized and validated for volume production to acceptable quality and performance levels.

As part of the solution, we propose to grow the use of ultrasonic fatigue testing at 20kHz versus traditional fatigue testing at 20-40 Hz. Ultrasonic fatigue began in the 1950's with the work of Warren Mason at Bell Labs and has since been used to rapidly characterize most major metal alloys and even some polymer composites. Coupled with new fracture mechanics models, this method provides a platform to rapidly understand novel material designs.

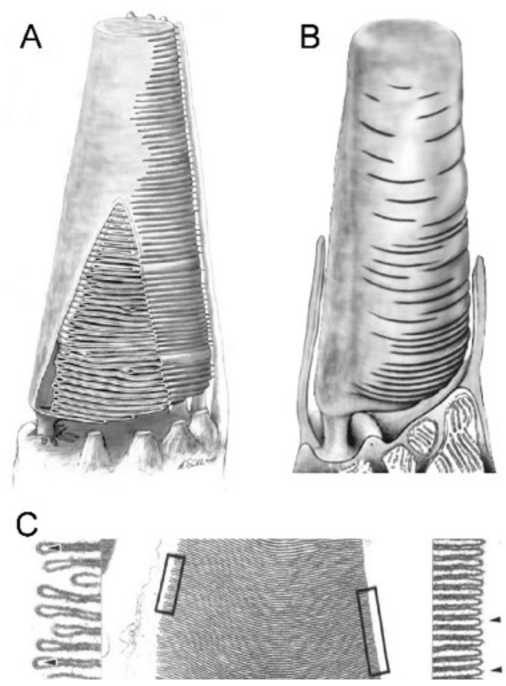
In this presentation, we will explore the history of ultrasonic fatigue: discussing it strengths and limitations, and where it can take us in a Material Centric Design future.

Shaping (and reshaping) biological membrane architecture for vertebrate photoreceptor health (and disease)

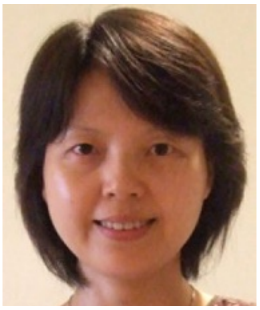
Associate Professor Andrew Goldberg

Presenting Author Email: goldberg@oakland.edu
Presenting Author Affiliation: Oakland University
Presenting Author Department: Eye Research Institute and Department of Biological Sciences

Vertebrate retinal photoreceptors are sensory neurons specialized to detect light and initiate the biological process of vision. They possess a dedicated and distinctive photosensory organelle evolutionarily derived from a non-motile cilium, referred to as an outer segment (OS). The ciliary basis of vertebrate vision spurred intense interest during the original development and widespread application of biological transmission electron microscopy, and numerous elegant studies detailed the highly membranous and dynamic nature of rod and cone (A, B) photoreceptor OSs. These investigations revealed that the hundreds of precisely stacked membranous disks comprising these organelles are renewed by opposed processes of disk morphogenesis and disk shedding, and that a significant fraction of the disks (up to ~10%) must be replaced on a daily basis, which poses a challenge for maintaining OS organization and photoreceptor metabolism. OS organelle architecture more recently became a subject of renewed attention, when it was discovered that humans suffer from a variety of inherited "ciliopathies" - syndromic diseases that often include problems with vision. In addition, numerous environmental insults and other genetic defects can disrupt OS morphology to impair photoreceptor function and viability, and generate a broad range of debilitating retinal diseases. Our laboratory uses in vitro, in cellulo, and engineered vertebrate models to investigate the molecular basis for photoreceptor OS membrane architecture, and has discovered that a retinal-specific tetraspanin protein, peripherin-2/rds, plays a key role for generating the membrane curvature (C) needed for the structure of normal OS organelles. Because tetraspanins are increasingly viewed as potential therapeutic targets in other tissues, the lessons learned may prove useful for understanding the roles tetraspanins play in cell biology and human disease more generally.

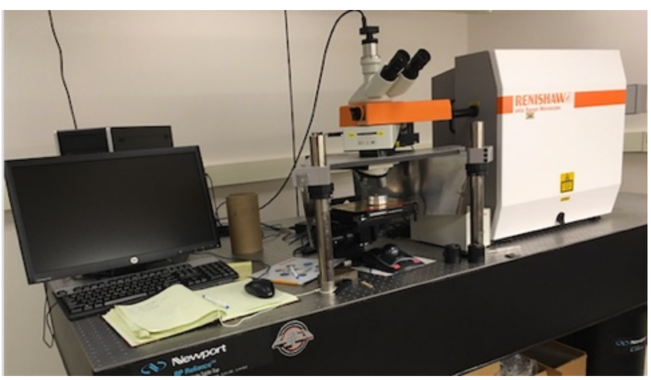


Micro-Raman analyses of Earth and planetary materials: Advantages and challenges



Prof. Jie (Jackie) Li
Presenting Author Email: jackieli@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Earth and Environmental Sciences

Micro-Raman spectroscopy and imaging are widely used for studying Earth and planetary materials at ambient conditions and extreme environments. In this presentation, I will compare Raman spectroscopy with polarizing optical microscopy, x-ray diffraction, and energy dispersive x-ray spectroscopy as tools for phase identification. I will share my experience in selecting a Raman microscope for analyzing natural multi-component specimens, characterizing experimental products, and monitoring phase transitions and chemical reactions at high pressures and high temperatures in diamond-anvil cells. The presentation will showcase successful applications of Raman spectroscopy in analyzing meteorites to infer the climate history of Mars, facilitating syntheses of high-pressure phases for research on the origin of Earth's Moon, and detecting polymorphic phase transition for understanding Earth's deep carbon cycle (Fig. 1). I will also discuss challenges we encountered in our attempts to detect hydrogen gas in basaltic glass, measure thin film of olivine, and quantify water in hydrous minerals.



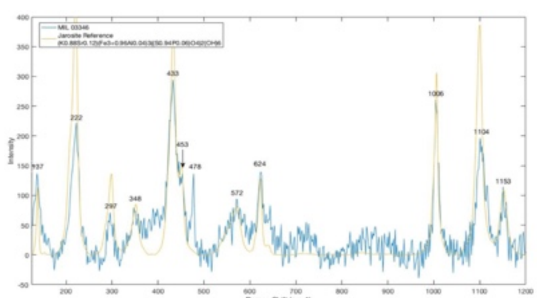


Fig. 1. Left: Renishaw confocal Raman microscope in C.C. Little Bldg, Right: Raman spectrum of jarosite in Martian meteorite MIL 03346, 171 (blue) and reference spectrum R060113 of jarosite from U. Arizona Mineral Museum 9868 (yellow) and a Raman map of a $CaCO_3$ sample recovered from 8.5 GPa and nearly 2000 K, showing aragonite phase (red) with cavities (black).

Probing Atomic Structure across Scale and Dimensions with Highly Convergent Electron Beams

Assistant Professor Robert Hovden
Presenting Author Email: hovden@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Materials Science and Engineering

Modern materials are designed atomic layer by atomic layer with architectural complexity extending into the third dimension. Probing atomic structure across sub-Angstrom to micron scales in both two and three dimensions is therefore integral to the hierarchical engineering and design of future materials.

In 2D-materials—such as graphene, MoS_2, and TaS_2—reduced dimensionality leads to unique properties that could transform the future of electronic devices. Local atomic structure of 2D materials dictates local topology which greatly influences electronic properties and implementation in actual devices. Using a modern electron microscope we can count the atoms across grain boundaries, identify stacking structure, and locate individual defects and dopants. Concurrently, diffraction techniques provide an understanding of structure across billions of atoms at larger length scales. In combination, we can obtain a complete description of the structure of 2D materials and correlate them with macroscopic properties. In multilayer graphene we use these methods to elucidate the rich structure of grain boundaries and stacking faults across length scales, a result which prompted the discovery that stacking order and twin boundaries dominate bulk transport behavior. In TaS_2 we show the persistence and control of charge density waves (CDW) down to the ultrathin limit using cryogenic scanning transmission electron microscopy.

Three-dimensional characterization at the nano- and meso-scale in high resolution electron microscopes provides vital insights into a wide array of 3D nanomaterials, including hydrogen fuel cells, block-copolymer networks, and semiconductor devices. However achieving sub-nanometer resolution in three-dimensional reconstructions has not been possible due to a restriction known as the Crowther criterion, which forces a tradeoff between object size and resolution. Here we demonstrate a three-dimensional imaging method that overcomes this limit by combining through-focal depth sectioning and traditional tilt-series tomography to reconstruct extended objects, with sub-nanometer resolution, in all three dimensions.

Sponsor Speakers

Thermo Fisher Presentation

Thermo Author

Presenting Author Email:
Presenting Author Title:
Presenting Author Affiliation:

Low dose spectroscopy by direct detection.

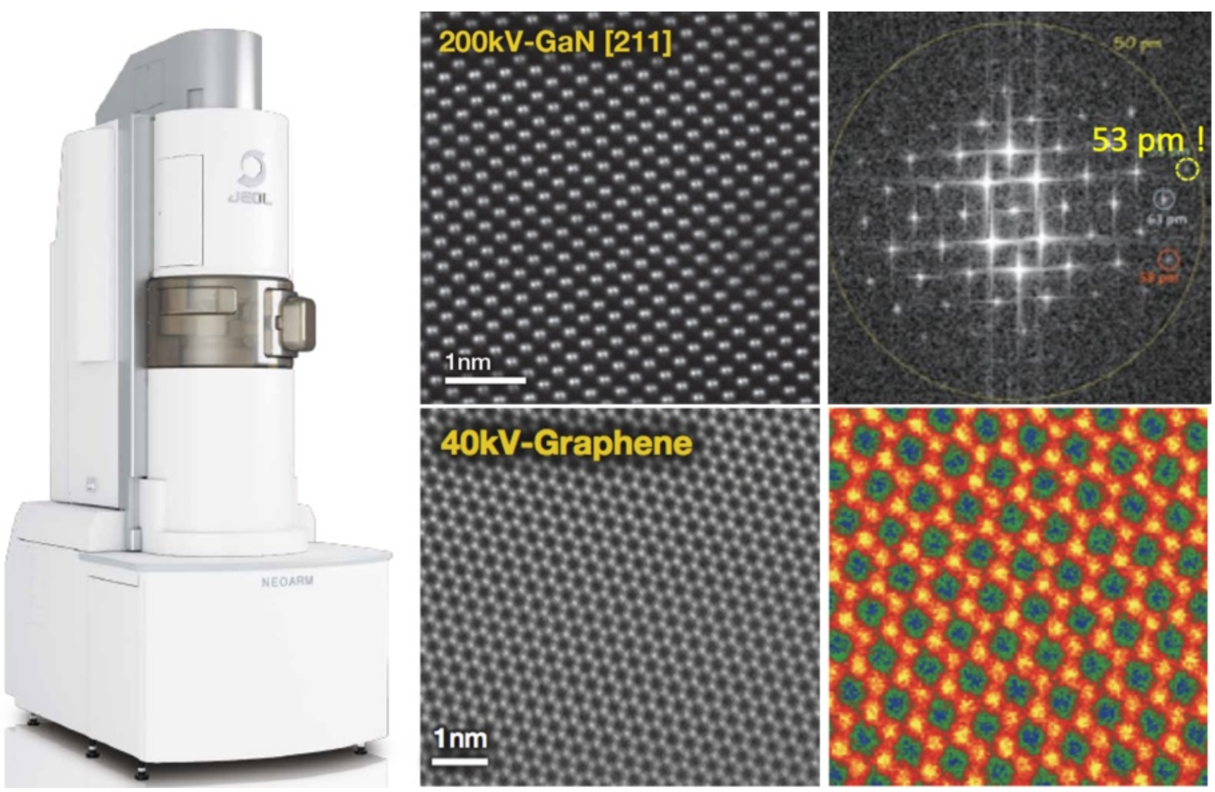
Paolo Longo
Gatan, Inc.

Advanced Aberration-Corrected STEM: Low kV and High Speed

Patrick J Phillips

Presenting Author Email: pphillips@jeol.com
Presenting Author Affiliation: JEOL USA Inc.
Presenting Author Department: TEM Applications Group

Aberration-corrected scanning transmission electron microscopy (STEM) continues to play an essential role in the analysis of a multitude of relevant materials systems. By combining high-resolution imaging, X-ray and electron energy loss spectroscopy, and fine structure analysis, one can fully characterize a material's structure, chemical composition, and electronic properties. The present contribution will focus on the latest aberration-corrected STEM instrument from JEOL, the 30—200 kV NEOARM, while discussing both low voltage and high speed applications. For example, the acquisition of atomic-resolution STEM images at 30 kV, while simultaneously retaining the ability to perform both chemical and electronic fine structure analysis.



Knowing All The Angles

Mark S. Kelsey

Presenting Author Email: Mark.Kelsey@bruker.com
Presenting Author Affiliation: Bruker AXS
Presenting Author Department: Microanalysis

With the advent of large area Silicon Drift Detectors (SDD) solid angle is most often used to describe the performance of the system. While it is true for flat samples and working at the standard working distance of the SEM this is the only angle of importance, in this "year of the eclipse" we have earned about other angles and shadowing. These factors come into play in microscopy as well. This talk will explore these factors and the effect they have on the success or failure of an analysis.

3D Bench Top Manufacturing Application in AFM in-Situ Research in Electrochemistry

Song Xu

Presenting Author Email: Mark.Kelsey@bruker.com
Presenting Author Affiliation: Park AFM Systems, Inc.
Presenting Author Department: Applications

Atomic force microscopy uses a microfabricated probe to detect surface topography with molecular resolution. There are many commercially available instruments that allows user to obtain high resolution with smart algorithms. However, when trying to adapt the instrument for their own research, users often find it is not adequate to use the existing instrumentation hardware. Scientists often find problems that can only be solved by modifying the existing equipment and fabricating custom designed accessories. However, research groups often find graduate students' knowledge and training in chemistry, material science and biology does not cover this very useful know how. 3D Bench top manufacturing is often not part of the science education. This presentation will discuss the application of 3D benchtop manufacturing techniques and designs in developing a wide range of custom sample holding solutions, experimental accessories and instrument modification ideas in atomic force microscopy. We will specifically present an example of the observation of surface morphology evolution of an electrochemistry reaction and its application in lithium battery research.

High Speed EDS Analysis: Pitfalls of fast data collection and techniques to ensure accurate data analysis

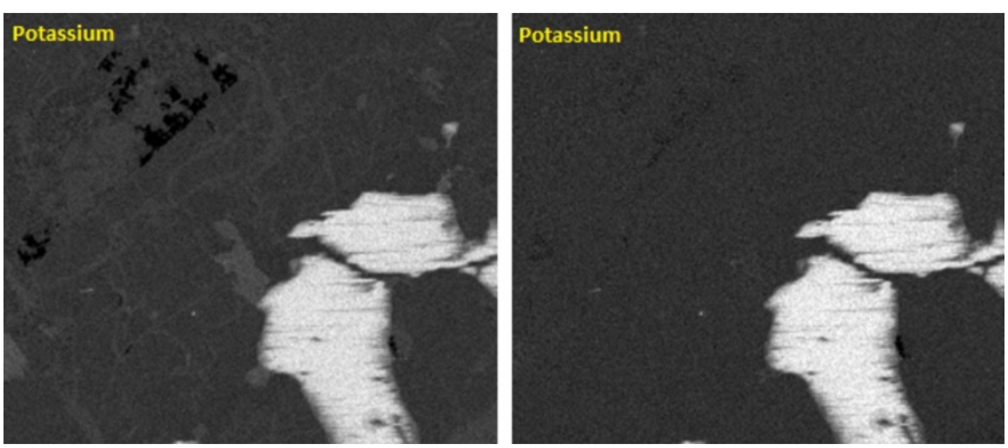
Richard McLaughlin

Presenting Author Email: richard.mclaughlin@oxinst.com
Presenting Author Affiliation: Oxford Instruments NanoAnalysis
Presenting Author Department: Applications

Energy dispersive spectrometry (EDS) on the scanning electron microscope (SEM) has been an important analytical tool for many decades and with recent advancements in EDS technology, it has become a fast and easy form of chemical characterization. The advent of large area Silicon Drift Detectors now allows the analyst to acquire X-ray data 10 times faster than what was possible using its predecessor, the Si(Li) detector. This certainly has improved the productivity of the analyst, but the higher acquisition rate has also introduced new challenges for the analyst and EDS manufacturer. Artifacts such as pile-up may reduce the fidelity of spectra, the interpretation of element maps, and the accuracy of quantitative analysis.

Pile-up is due to the corruption of the energy measurement when the system electronics cannot resolve two or more concurrent X-ray events. The severity is related not only to the input count rate, but also the composition of the sample as the resolving time is significantly better for higher energy photons. Most modern EDS systems have implemented software algorithms to correct for pile-up with various degrees of success, however all will show some limitations at extreme count rates or when analyzing challenging samples.

The analyst needs to recognize these artifacts, the conditions in which they occur, and be familiar with the software tools available to reduce or eliminate these problems. The talk will include application examples as well as techniques to ensure data collection is truly representative of the sample.



X-ray map of a geological sample showing potassium distribution before pile-up correction (left) and after pile-up correction (right).

Multiple Approaches Applied for the Microscopic Characterization of Atmospheric Particles Show Sulfates with Unique Morphology in the Arctic

Rachel Kirpes, Matthew Gunsch, Matthew Fraund, Ryan Moffet, Rachel Merzel, Mark Banazak-Holl, Swarup China, Alexander Laskin, Andrew Ault, Kerri Pratt

Presenting Author Email: rmkirpes@umich.edu
Presenting Author Affiliation: University of Michigan, University of the Pacific, Pacific Northwest National Laboratory, Purdue University
Presenting Author Department: Department of Chemistry

Electron microscopy and vibrational spectroscopy techniques were used to characterize atmospheric particles collected at a remote Arctic site. Computer-controlled scanning electron microscopy with energy-dispersive X-ray spectroscopy (CCSEM-EDX), combined with a neural networking clustering algorithm, were used to identify particles based on their elemental composition, size, and morphology.

Particle types classified included sea salt, organic rich particles, sulfur rich particles,mineral dust, and soot. A sulfur-rich particle type with a unique morphology, consisting of spherical particles with small cubic protrusions, was further characterized using scanning transmission X-ray microscopy with near-edge X-ray absorption fine structure spectroscopy (STXM-NEXAFS) and atomic force microscopy coupled with infrared spectroscopy

(AFM-IR). STXM-NEXAFS over the sulfur k-edge determined S(VI), indicative of sulfate, was present in the particles. Despite the unique morphology, no intraparticle chemical differences were observed. AFM-IR confirmed the presence of sulfate and also identified ammonium modes in the particles and weak organic modes, suggesting the particles are mainly inorganic ammonium sulfate in addition to a small organic component. Characterization of the composition and morphology of atmospheric particles is crucial to determine their sources and constrain their impacts on climate under changing conditions.

Iron Sulfide Supraparticles as Artificial Viruses for Gene and Gene Editing Therapies

Emine S. Turali-Emre, Ahmet E. Emre, Nicholas Kotov

Presenting Author Email: esumeyra@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Biomedical Engineering

Gene and gene editing therapies have been widely investigated for treatment of inherited or acquired genetic diseases. Efficient delivery of therapeutic agents has become a significant barrier in clinical applications due to the toxicity and instability of the vectors in the complex intracellular environment. Among non-viral vectors, individual inorganic nanoparticles (NPs) have become a popular strategy for nucleic acid delivery. However, the nanoshell geometry of viruses is advantageous for the gene/CRISP cargo protection. Therefore, we synthetized L-cysteine stabilized iron-based inorganic nanoparticles which self-assemble into supraparticles with nanoshell geometry. Transmission electron microscopy (TEM), STEM tomography, scanning electron microscopy (SEM), and dynamic light scattering (DLS) were used to characterize the virus-like supraparticles size, shape, and charge. Our results indicate that virus-like supraparticles contain continuous compartments, are positively charged (25±7.2 mV) and 74±21 nm in diameter. We loaded the DNA in the compartments during the formation of supraparticles. We tested these complexes in circular dichroism, UV-Vis spectroscopy, electrophoretic mobility shift and protection assays. Since iron sulfide is a natural material, it presumably has low cytotoxicity and high biocompatibility. Supraparticles can condense DNA, protect it against degradation, penetrate through cellular membranes and facilitate endolysosomal escape in gene therapy. Therefore, development of these particles can be used as an effective cargo delivery tool for gene and gene editing therapies.

Use of transmission electron microscopy to investigate lens αA-crystallin amyloid fibril formation

Anbarasu Kumarasamy, Sivakumar Jeyarajan, Anthony Premceski, Eric Seidel, Jonathan Cheon, Victoria Kimler and Frank Giblin

Presenting Author Email: akumarasamy@oakland.edu
Presenting Author Title: Research Associate / Assistant Professor
Presenting Author Affiliation: Eye Research Institute, Oakland University, Michigan & Department of Marine Biotechnology, Bharathidasan University, TN, India.

αA-crystallin, a major protein present in both the human and guinea pig lens, plays an important role in maintaining lens transparency. The protein exists as large multimers of 20 kDa subunits. Since there is no turnover of protein in the center of the lens, αA-crystallin can remain for many years, eventually degrading into fragments such as αA-(66-80) peptide. This peptide can bind to intact αA-crystallin to form “hydrophobic patches”, resulting in formation of insoluble aggregates called as nuclear cataract. The peptide has beta-amyloid characteristics and forms amyloid fibrils when incubated alone. Here, we investigated in vitro binding of αA-(66-80) peptide to recombinant human and guinea pig αA-crystallin, and subsequent aggregate formation, using transmission electron microscopy (TEM). Proteins (0.5 mg/ml) were incubated with peptide (0.1 mg/ml) for 24 hrs at 37o C, and analyzed by TEM. With human αA-crystallin, the peptide induced formation of large clusters of aggregates of αA-crystallin multimers. In contrast, for guinea pig αA-crystallin, long, linear amyloid fibrils containing multimers of αA-crystallin were formed. Here, it appeared that the peptide first formed long amyloid fibrils, followed by binding of αA-crystallin multimers to produce large aggregates. Sequences of human and guinea pig αA-crystallin differ by only 8 out of 173 amino acids. Studies are underway to determine the amino acid that is critical for formation of fibrils. Nuclear cataract and certain neurodegenerative diseases are known as “protein aggregation diseases”. A better understanding of αA-crystallin amyloid fibril formation may lead to therapies for both nuclear cataract and neurodegenerative diseases.

Machine Learning Data Analysis for Microscope Images and Spectral Maps

Tommaso Costanzo and Gabriel Caruntu

Presenting Author Email: costa1t@cmich.edu
Presenting Author Affiliation: Science of Advanced Materials, Central Michigan University, 48858, Mount Pleasant (MI)
Presenting Author Department: Department of Chemistry and Biochemistry

The recent developments in microscopy have allowed faster collection of images, spectroscopic data, and diffraction patterns. Consequently, a higher volume of data can be collected, and in many cases the dataset captured has a multidimensional nature(e.g. energy dispersive X-Ray spectroscopy maps, where the full dataset D is three dimensional: D(x,y,E)). These multidimensional data are difficult, if not impossible, to be directly visualized. Therefore, the data analysis/reduction employed is crucial. The principal components analysis (PCA) is a common technique used for dimensionality reduction that can extract and order the principal components of a dataset based on their variance. It is very fast and allows the visualization of the main components of a multidimensional dataset, however, since the data are transformed in unit of variance the physical information is completely lost. To overcome this difficulty, semi-supervised machine learning algorithm(s) can be used in order to keep the physical information but also to allow a quantitative analysis of the components. Here we will present how this analysis can be carried out and what information can be obtained when this is applied to microscopy data. To demonstrate its versatility, the analysis of two different types of data will be shown. The first one will be the local analysis of lattice fringes from high resolution transmission electron microscopy (HRTEM) images, while the second one will be based on the analysis of spectroscopic maps obtained from a scanning probe microscope (SPM).

Auger nanoprobe for very small feature analysis

Zhongrui Li and Owen K. Neill

Presenting Author Email: zhongrui@umich.edu
Presenting Author Affiliation: Electron Microbeam Analysis Laboratory University of Michigan, Ann Arbor
Presenting Author Department: School of Earth and Environmental Sciences

The rapid advance in nanoscience and nanotechnology demands a powerful tool which can provides elemental and chemical state information from sample surfaces and nano-scale features, thin films, and interfaces. The superior imaging performance, spatial resolution, sensitivity, and the spectral energy resolution are needed to address the most demanding applications such as the design of new materials, facilitating manufacturing processes, and increasing product quality/yield. Optical methods and EDX analysis have found their limitations in detecting the continued shrinking of device size and critical defect size, while Auger nanoprobe exhibits its irreplaceable advantages in such application. As a sophisticated surface analysis tool, Auger nanoprobe can provide comprehensive information as one can get from both XPS and SEM. Among surface analysis methods, Auger electron spectroscopy stands out in its excellent spatial resolution (~10 nm), amazing surface sensitivity (~2 nm in depth), and highly efficient detection of light elements. As far as the surface sensitivity is concerned, Auger nanoprobe provides the smallest analysis volume, which is second to none. The availability of various modes of operation is a plus, including survey, multiplex, line, profile, and elemental mapping. Therefore, this technique is ideal for analyzing compositions, identifying chemical states, detecting elemental distribution and mapping depth profile of particulates, interfaces, and second phases. More wide applications of Auger nanoprobe, include but not limited to, materials characterization, thin film analysis, corrosion product chemistry, failure analysis, particle identification for semiconductor and thin film head manufacturing, and mineral chemistry.

3D Nano-Metallic Thin Films by Design

Benjamin Derby, Yuchi Cui, Jon Kevin Baldwin and Amit Misra

Presenting Author Email: benderby@umich.edu
Presenting Author Affiliation: University of Michigan, Ann Arbor
Presenting Author Department: Materials Science and Engineering

Nanostructures, self-organized into periodic concentration modulations, have been reported with radically different two-phase morphologies, including vertical and lateral striations. In order to understand the origin of these morphologies, we study the organizing mechanisms of these architectures via phase decomposition during elevated temperature co-sputtering of immiscible metals using analytical electron microscopy. Based on structural and chemical analysis results, an evolution in self-organized, nano-metallic morphologies was observed according to the direction of phase separation. This was the result of the phase separation kinetics relative to the deposition rate during growth. Depending on the comparison between the rate of phase separation and the deposition rate, lateral, vertical, and randomly oriented concentration modulations in three-dimensions were obtained. A predictive capability over these self-organizing nano-metallic thin films will allow for unique designs needed for the advanced functionalities of the future.

Improvements in Electron Microprobe Measurements of Minor and Trace Elements in Rutile

Owen Neill, Chris Mattinson, John Donovan, David Hernández Uribe, Alex Sains

Presenting Author Email: okneill@umich.edu
Presenting Author Affiliation: Electron Microbeam Analysis Laboratory University of Michigan, Ann Arbor
Presenting Author Department: School of Earth and Environmental Sciences

Electron microprobe measurements of minor and trace elements in rutile, an important accessory mineral found in a variety of geologic settings, require long X-ray counting times to achieve acceptable precision, and highly accurate measurements of continuum intensity to eliminate systematic over- or under-estimates of peak count rates. Use of Mean Atomic Number (MAN; Donovan and Tingle, 1996) backgrounds obviates the need for direct off-peak measurements of continuum intensity, reducing the time per point necessary to achieve acceptable counting precision by half. Furthermore, use of a "blank" intensity correction (Donovan et al., 2011) improves accuracy by eliminating systematic errors in background measurements. Data collected and re-processed using MAN and traditional off-peak background measurements show minimal systematic differences between the two methods for Fe, Cr, Nb, and Zr. This suggests that, provided the operator avoids measurements adjacent to other phases that can contribute to continuum fluorescence artifacts, measurements of these elements in rutile can be performed much faster than previously, with no reduction in data quality. These measurements have been used to interpret the metamorphic history of rocks from the North Qaidam terrane, Northwest China.

References:

J.J. Donovan and T.N Tingle (1996) J. Microscopy, 2(1), 1-7
J.J. Donovan, H.A. Lowers, and B.G. Rusk (2011) Am. Mineral., 96, 274282

Compression Testing of Micropillars Fabricated by Fully Automated Focused Ion Beam Script

Haiping Sun, Allen H. Hunter and Bobby Kerns

Presenting Author Email: haipings@umich.edu
Presenting Author Affiliation: University of Michigan, Ann Arbor
Presenting Author Department: Michigan Center for Materials Characterization

Micropillar compression testing is a method to study mechanical properties such as stiffness, elasticity and plasticity of a variety of different materials such as metals, ceramics and semiconductors. In this study, we demonstrate the use of our fully automated script on the focused ion beam (FIB) to fabricate Si pillars followed by compression testing to reveal the failure of the pillar due to slip until final fracture.

The FIB system used is an FEI (Now ThermoFisher Scientific) Helios 650 Nanolab. The automated script was created using the iFast program version 1.3.2 (FEI). Key components of the automated script include a reference fiducial located adjacent to the pillar to allow for sub- µm pattern placement, the ability to specify independent pillar diameter and height, and the option to use rotational side cutting to improve pillar shape compared to top-down milling. The script allows pillar fabrication with improved repeatability and speed compared with manual operation.

A Hysitron TI950 Triboindenter with a 50 µm 60° conical probe was used to perform the compression testing of the pillars. Displacement feedback control was used for each test, and the onset of the slip of Si {111} plane is revealed from a short, sharp drop on the loading curve. Further displacement of the indenter resulted in catastrophic fracture of the micropillar. Post-slip analysis of each pillar was conducted by imaging with a scanning electron microscope.

In summary, programed fabrication of micropillars using FIB and followed by compression testing using the Triboindenter are available in Michigan Center for Materials Characterization. We use Si as an example to outline the whole procedure and to show the results obtained.

A MetalMUMPs DC Switch with Reliable Contact Enabled by Symmetric Latches

Xun Zhang, Yuzan Xiong, Jay Khazaai, Peng Qu and Hongwei Qu

Presenting Author Email: xunzhang@oakland.edu
Presenting Author Affiliation: Oakland University
Presenting Author Department: Department: Electrical and Computer Engineering

In a DC MEMS switch, reliable mechanical contacts with small electrical contact resistance are required. Previous efforts have been focused on polysilicon switches and contact structures because of the availability of polysilicon surface processes. In many applications, actuators with larger force generating ability is desired. A metallic micro-electro-mechanical system (MEMS) DC switch with reliable contacts enabled by a special latching mechanism is reported in this abstract. The device is fabricated using MetalMUMPs (Metal Multiply User MEMS Process) technology in which electroplated nickel with 20 μm thickness is used as structural material. Compared with the typical polysilicon switches, the switch features easy actuation for mode switching and improved mechanical and electrical performance, thanks to the lower electrical resistivity and higher Young's Modulus of nickel. The demonstrated unique latching mechanism enables zero power consumption in a latched "ON" mode, which demonstrates a contact resistance less than 1.5 Ohms. Due to the symmetric design of the contact beams, the switch also features great contact force and minimized out-of-plane displacement that is necessary for reliable engagement. In addition to electrical measurements, surface morphology of the actuator and contacts have been characterized using SEM and surface profilometer.

Synthesis, Characterization and Fabrication of Functional Electronic Devices using $BaTiO_3$ Nanocubes

Benard Kavey and Gabriel Caruntu

Presenting Author Email: Kavey1bd@cmich.edu
Presenting Author Affiliation: Central Michigan University
Presenting Author Department: Science of Advanced Materials, Chemistry & Biochemistry

Titanium-based perovskites such as BaTiO3 exhibit unique optical, ferroelectric, dielectric and catalytic properties that are exploited in data storage, energy conversion/ storage, cellular imaging, thin film technologies, water splitting and hydrogen generation and other cutting-edge technologies. As the properties of nanoparticles are substantially influenced by their crystal structure, size/shape and surface properties, it is critically important to understand the surface functionalities and particle morphologies at the atomic scale. In this study, we report on the synthesis and characterization of BaTiO3 nanocubes of various sizes and their use in functional devices, for example transistors and capacitors. With variation in the reaction temperature, time and solvent properties, BaTiO3 nanocubes of 8, 10, 15, 46, 75 and 85 nm have been synthesized. New insights into the growth and self-organization of BaTiO3 nanoparticles on substrates have been gained by various microscopy techniques such as, transmission electron microscopy, high- resolution transmission electron microscopy and scanning probe microscopy. The as-synthesized nanocubes have been subsequently formulated into nanoparticle-inks and spin coated to form thin films with controllable thickness for capacitor and transistor device fabrication. Also, with the use of an atomic force microscopy, a detailed description of the surface topography of the thin films have been studied. The thin films have been subsequently incorporated into functional electronic device such as capacitors and transistors. High capacitance values in the order 100 pF were observed for thin films that exhibit uniform topography and minimal air voids.

Alpha A Crystallin (66-80) Peptide Enters Cultured Human Lens Epithelial Cells, Binds to Alpha A Crystallin, and Generates H_2O_2

Maria Donovan, Anbarasu Kumarasamy, Sivakumar Jeyarajan, Annika Grupp, Caroline Cencer and Frank J. Giblin

Presenting Author Email: mgdonovan@oakland.edu
Presenting Author Affiliation:Oakland University
Presenting Author Department: Eye Research Institute, Biology

Alpha A crystallin is a major protein in the lens that is vital for maintaining transparency of the tissue. With age, the protein degrades in the center of the lens to form alpha A (66-80) crystallin peptides, which are believed to bind to alpha A crystallin causing aggregation of the crystallin and eventually nuclear cataract. The purpose of this study was to determine (1) whether alpha A (66-80) peptide present in culture medium would be taken up by cultured human lens epithelial cells (LECs) and bind to alpha A crystallin within the cells to form aggregates, and (2) whether this binding of the peptide would result in the generation of H2O2 within the cells. Cultured human SRA 01/04 LECs were exposed to fluorescently-labeled alpha A (66-80) peptide for one hour and then incubated normally for 24 hours. Immunocytochemistry, using a fluorescently-labeled alpha A crystallin antibody, was employed to stain the protein within the cells, and images were taken with a fluorescence microscope. Evidence of peptide binding was visualized through co-localization of the peptide and alpha A crystallin fluorescent stains. Levels of H2O2 were measured in the culture medium. The results showed for the first time that alpha A (66-80) peptide can enter cultured human LECs and bind to alpha A crystallin to form aggregates, resulting in the generation of H2O2. These data provide evidence for a possible role for this peptide in causing human nuclear cataract, and may help in developing therapies for preventing or delaying this type of lens opacity.

Identification of Toxic Cyanobacteria Collected in Palacios Texas (USA), and Pueblo Nuevo (Columbia), using Light and Scanning Electron Microscopy

Brandyn Braswell

Presenting Author Email: brasw1bg@cmich.edu
Presenting Author Affiliation:Central Michigan University
Presenting Author Department: Biology

Cyanobacteria are photosynthetic bacteria that inhabit aquatic environments, both marine and freshwater. Under stress cyanobacteria produce toxins, i.e. cyanotoxins, to reduce competition with the surrounding bacteria. Cyanobacteria, because of these and other adaptions, have diversified through evolution allowing numerous species to inhabit different areas. Morphology of cyanobacteria, while limited, plays an important role in their identification and classification. This study uses light and scanning electron microscopy to examine the morphology of two unknown cyanobacteria specimens in the attempt to classify each one. These two cyanobacteria specimens were “Lone Star” collected from a redfish farm in Palacios Texas (USA), and “Columbia” collected from a shrimp farm in Pueblo Nuevo (Columbia). Data on each species size, shape, colony, and mucilage forming ability was collected. This data will be combined with TEM studies, DNA sequence and fatty acid analysis to determine whether each is a known or new to science species

ZnO-CuO nanoparticles anchored reduced graphene oxide sheets for supercapacitance studies

Hassnain Asgar and Waseem Haider

Presenting Author Email: asgar1h@cmich.edu
Presenting Author Affiliation:Central Michigan University
Presenting Author Department: School of Engineering and Technology

30Supercapacitors are increasingly being adopted for a variety of energy storage applications. Besides their high rates of charge and discharge, the limited amount of energy stored in the currently available electrode materials restricts their large-scale use. Thus, there has been a significant interest in the research to develop electrode materials with higher capacity and improved performance. Briefly, in this work, ZnO-CuO nanoparticles were attached to reduced graphene oxide (rGO) sheets via a facile synthesis route. For comparison, ZnO and CuO were separately decorated on rGO as well. The formation of nanocomposites was validated using XRD, IR, SEM, EDS, and TEM. Cyclic voltammetry, galvanostatic charge/discharge, and electrochemical impedance spectroscopy techniques were employed, in both two and three electrode cell setups, to evaluate the electrochemical response of the electrodes. The higher specific capacitance values and stability in charge/discharge cycles were exhibited by ZnO- CuO-rGO electrodes, making them the best choice for the supercapacitor applications..

How UV-irradiation and metallation affect aggregation of crystallin peptide?

Iva Ziu, Katelyn Silva, Saba Anwar, and Sanela Martic

Presenting Author Email: iziu@oakland.edu
Presenting Author Affiliation: Oakland University
Presenting Author Department: Chemistry

The αA-crystallin protein, commonly found in the eye lens, acts as a chaperone protein by preventing protein aggregation. Protein aggregation may lead to clouding of the eye lens, causing degeneration or cataracts. The eye lens degeneration may be associated to degradation of αA-crystallin protein and compromised chaperone activity. The αA-crystallin degradation may be ascribed to the formation of reactive oxygen species (ROS), which may be induced by UV-irradiation or metal-catalysis. Thus, understanding how UV-irradiation and metal ions influence αA-crystallin protein structure and function will provide an insight into the relevance of ROS to eye diseases. The role of UV-irradiation and metal ions such as copper (II), zinc (II), iron (II), and iron (III), were evaluated on the aggregation of αA66-80 crystallin peptide (79His), commonly found in cataracts eye lenses, and its mutant (79Ala). The aggregate morphologies were characterized by Transmission Electron Microscopy (TEM).

Effect of calcium flux on filopodia production in epithelial cells

Omolade M. Ademuyiwa and Carol Heckman

Presenting Author Email: omolada@bgsu.edu
Presenting Author Affiliation: Bowling Green State University
Presenting Author Department: Department: Biological Sciences

Filopodia are the sensors of a cell and are important for directing motility. They act like "antennae," collecting signals from both soluble ligands in the environment and those on the substrate. In nerve cell protrusions (axons), these two aspects of signaling are integrated so that chemotactic signaling is modulated according to the composition of the substrate. Although epithelial cells differ greatly from nerve cells in their organization, the same second messengers mediate the filopodia's sensory function. Activation of PKC (protein kinase C) disassembles them. Previous reports showed that another important second messenger, calcium, had a positive or negative effect on filopodia production in the axon. Here, we investigate whether the dynamics overall are driven by calcium. The variables measured were percentage of the cell periphery covered with filopodia and percentage of cells in a population showing filopodia. Because there is an inhibitor of filopodia in culture media, replacing the medium with a buffer increased filopodia production. The trend was not affected by the calcium concentration of the buffer. Even with cells in culture medium, however, filopodia display was depressed by inhibiting calcium transport. With cells in Ca++-free buffer, cyclopiazonic acid (CPA) blocks transport into the cell's internal storage compartment. This favored outward transport of calcium and enhanced filopodia. Restoring calcium in the external buffer, however, also enhanced filopodia production. We conclude that filopodia display was sensitive to calcium flux but not to levels of calcium that are physiologically relevant. It remains to be determined how calcium flux is detected in the system.

Pulsed laser deposition of In_2O_3-SnO_2: from films to nano-wires

Del Gaudio, D., Reese, C., Boone, C., Yarlagadda, S., Heron, J. T., Shalish, I., and Goldman, R. S.
Presenting Author Email: ddelgaud@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Materials Science and Engineering

As micrometer sized device structures approach their limits in performance, nano-structures, such as nano-wires (NW) are being considered for high efficiency energy conversion and storage devices [1.] Metal oxides have been identified as promising materials for lithium ion batteries[2] and UV lasers [2]. Furthermore, metal-oxide NWs have been embedded in field-effect transistors, lasers, solar cells, and various chemical sensors [4]. Typically, metal-oxide NW are prepared by vapor deposition [3] or thermal evaporation [5]. Pulsed-laser deposition (PLD) [6],[7],[8] has emerged as a promising approach for the fabrication of tin-doped indium oxide (ITO), with film or NW growth determined by the choice of a reactive (O_2) or inert (N_2) atmosphere [6]. To date, cubic NW with ≤10 % Sn incorporated into In_2O_3 have been reported. However, a mechanistic understanding of the influence of growth parameters and substrates on the morphology, composition, and crystal structure of the deposited film is needed. Additionally, PLD of various In_2O_3-SnO_2 mixtures has yet to be considered. We report on PLD of various In_2O_3-SnO_2 mixtures, onto c-plane sapphire and Inconel substrates. Using an inert atmosphere, we have identified parameters to obtain smooth films; pyramid-shaped nano-scale clusters; sparse, tapered nano-rods; and high density, vertically oriented NWs, with and without catalyst spheres. We will present high-resolution transmission electron microscopy (HRTEM) images and selective-area electron diffraction (SAED) patterns illustrating the structure and composition of the films, nanowires, and catalyst. The photoluminescence emission from NWs and films, the electronic transport properties of individual NWs will also be discussed.

References

[1] Guo, Y.-G., Hu, J.-S., & Wan, L.-J. (2008) Advanced Materials, 20(15), 2878–2887
[2] Poizot, P., Laruelle, S., Grugeon, S., Dupont, L., & Tarascon, J.-M. (2000) Nature, 407(6803), 496–499
[3] Kong, Y. C. and Yu, D. P. and Zhang, B. and Fang, W. and Feng, S. Q. (2001) Applied Physics Letters, 78, 407-409
[4] Shen, G., Chen, P.-C., Ryu, K., & Zhou, C. (2009) J. Mater. Chem., 19(7), 828–839
[5] Yao, B. D. and Chan, Y. F. and Wang, N. (2002) Applied Physics Letters, 81, 757-759
[6] Khan, G. G., Ghosh, S., Sarkar, A., et. al. (2015) Journal of Applied Physics, 118(7), 074303
[7] Kee, Y. Y., Tan, S. S., Yong, T. K., et. al. (2012) Nanotechnology, 23(2), 025706
Savu, R., & Joanni, E. (2006) Scripta Materialia, 55(11), 979–981

Influence of surface reconstruction on GaAsNBi alloy formation

J. Occena,T. Jen, A. G Norman, R. S. Goldman
Presenting Author Email: joccena@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Materials Science and Engineering

Due to the significant bandgap narrowing induced by dilute fractions of N and Bi in GaAs, quaternary GaAsNBi alloys are attractive for a variety of applications, including long-wavelength lasers and detectors, ultra-high efficiency solar cells, and high performance heterojunction bipolar transistors. However, the formation of GaAsNBi films and heterostructures is complicated by the interactions of N, As, and Bi during epitaxy. Here, we examine the role of surface reconstruction on N and Bi solute incorporation into GaAs, and its influence on atomic ordering and phase separation in quaternary GaAsNBi alloys.

We discuss the role of surface reconstruction on atomic ordering and phase separation in GaAsNBi alloys. We identify a threshold substrate temperature for which the surface reconstruction transitions from (1x3) or (1x1) to (2x1) and CuPt atomic ordering on the group V sublattice emerges. The emergence of Group V ordering on the (2x1) GaAsNBi surface is consistent with an ordering mechanism based upon a high fraction of [-110] oriented dimers, which are able to preferentially accommodate the smaller and larger solute atoms beneath and between the dimers, respectively. As the temperature is further increased above the threshold temperature, the ordering is strengthened. We will discuss the influence of dimer type (As-As, Bi-Bi, or As-Bi) on the development of CuPt ordering and alloy phase separation in GaAsNBi alloys.

Enhancing p-type Doping of GaN for Power Electronics: A Combined Computational-Experimental Approach

James Delaney and Timothy Johnson
Presenting Author Email: deljm@umich.edu
Presenting Author Affiliation: University of Michigan
Presenting Author Department: Materials Science and Engineering, Physics, Engineering Physics

Although silicon-based electronics are used to power light-emitting diodes and electric vehicles, their utility in high power applications is limited by a low breakdown voltage. Wide-bandgap semiconductors, such as gallium nitride and related alloys have been proposed as alternatives, but the effective p-type doping at high concentrations remains elusive. For example, Mg dopant activation following ion implantation, selective diffusion, and metal-organic vapor deposition requires high temperature annealing which may disrupt the active device structure. In the case of molecular-beam epitaxy, surfactants and co-dopants such as O and Si have been explored, but the concentration of substitutional Mg is often limited, leading to limited p-type doping efficiency. Here, we are developing a novel approach to enhance the p-type doping of GaN and related alloys. We describe a combined computational-experimental approach consisting focused-ion-beam (FIB) nano-implantation of Mg in GaN during molecular-beam epitaxy (MBE), followed by computational and experimental ion channeling studies of the Mg incorporation mechanisms. This approach is likely to result in p-type doping at ultra-high concentrations, without the need for subsequent high temperature annealing. In this poster, we will discuss the development of a modified Mg-Ga alloy source for nano-implantation and our progress towards its implementation in a modular MBE-FIB system. We will also present our Monte Carlo-Molecular Dynamics simulations of ion channeling in wurtzite GaN crystals, and discuss our progress towards quantifying the influence of growth and annealing sequences on Ga and/or N vacancy formation and the result substitutional vs. interstitial incorporation of Mg in GaN.