Facilities Days Open House 2017
featuring
College of Engineering Shared Facilities
Department of Geoscience Research Facilities

Tuesday, February 21, 2017
Varsity Hall 3, Union South

Students learn about new instrumentation, win poster prizes, network with peers, tour facilities

Faculty learn about new instrumentation, discuss specs with vendors, demo your materials

Industry learn about new instrumentation, network with students, faculty, and staff, tour facilities

Focused Ion Beam-SEM
Electron Beam Lithography
Time-of-flight Secondary Ion Mass Spectrometry

Electron Probe Microanalysis
TEM Orientation Imaging

The Facilities Days Open House 2017 is hosted by
The College of Engineering Shared Facilities | The Department of Geosciences Research Facilities
Office of the Vice Chancellor for Research and Graduate Education (OVCRGE)

FDOH 2017 is organized by the Advanced Materials Industrial Consortium (AMIC), part of the Wisconsin Materials Research Science and Engineering Center (MRSEC)
Welcome!

We would like to thank you for your participation in the 3rd annual Facilities Days Open House co-hosted by the Materials Research Science and Engineering Center (MRSEC), College of Engineering Shared Facilities, Department of Geoscience Research Facilities, and the Office of the Vice-Chancellor for Research & Graduate Education (OVCRGE), and organized by the Advanced Materials Industrial Consortium (AMIC), part of the MRSEC.

This event showcases core facilities within the University of Wisconsin-Madison campus with a focus on instrumentation and resources for materials research. This year, in addition to the College of Engineering, facilities are featured from the Department of Geoscience, Physical Sciences Lab (PSL), Paul Bender Chemical Instrumentation Center (PBCIC), and the National Magnetic Resonance Facility at Madison (NMRFAM), and others. We hope you will leave this event knowing more about the instrumentation and resources available to you.

Campus core facilities serve hundreds of researchers from UW-Madison, other academic institutions, industry partners and national labs. We invite you to take a tour of our shared instrument facilities (see Facilities contacts) and talk with staff and colleagues to see if these powerful resources can help you answer your research question!

We would like to thank our sponsors: Physical Electronics, Cameca, NanoMEGAS, Thermo Fisher Scientific/FEI, Horiba, KLA Tencor, Elionix, MRSEC/AMIC and OVCRGE. This event would not be possible without their support.

In this booklet, you will find the agenda, maps, and speaker information, as well as links to useful websites, and contacts.

We also welcome any feedback you may have to make future meetings more tailored to your interests and priorities. We are here to help research succeed.

Best regards,

Jerry Hunter
Director, MRSEC/CoE Shared Facilities
ejerry.hunter@wisc.edu

John Valley
Charles R. Van Hise Professor of Geology
valley@geology.wisc.edu

Isabelle Girard
Director, Office of Campus Research Cores
isabelle.girard@wisc.edu
AGENDA

8:30 – 9:15am  Registration and Networking; coffee & light breakfast will be provided
9:15 – 9:30am  Welcome: MRSEC/AMIC, Campus Core Facilities, Felix Lu, Erin Gill, Isabelle Girard
9:30 – 9:45am  Core Facilities Brief Overviews:
                  Paul Bender Chemical Instrumentation Center, Charlie Fry
                  National Magnetic Resonance Facility at Madison, John Markley
                  Physical Sciences Lab, Bob Paulos
9:45 – 10:05am Geosciences Research Facilities, John Valley
10:10 – 10:30am College of Engineering Core Facilities, Jerry Hunter
10:30 – 10:50am Vendor Presentation #1: Plasma FIB for New Applications, Ron Kelley, Thermo Fisher Scientific/FEI
10:50 – 11:00am Break
11:10 – 11:30am Vendor Presentation #2: Electron Beam Lithography w/ Elionix, Gerry O’Loughlin, Elionix
11:30 – 11:55am Vendor Presentation #3: TOF-SIMS Tandem MS Imaging for Unambiguous Identification and High Resolution Imaging in Geology, Polymers, Materials and Biology, Greg Fisher, Physical Electronics, Inc.
12:00 – 1:00pm  Group Picture and Lunch
1:00 – 2:00pm  Poster Session and Judging – Students & Cores
2:05 – 2:25pm  Vendor Presentation #4: Overview of CAMECA’s Analysis Instruments, Thomas F. Kelly, CAMECA
2:30 – 2:50pm  Vendor Presentation #5: TEM Orientation Imaging, Muriel Veron, NanoMEGAS
2:50 – 3:00pm  Announcement of Poster Winners
3:00 – 4:30pm  Facility Tours, Instrumentation Demos and Networking
                (Meet at the Podium)

Wi-Fi Network Guest Access at the University of Wisconsin Madison:

When the screen on the right pops up in your browser, guests of the University should select “Request guest access”. To register, simply enter your full name, email address, and reason for visiting campus. Once you have read and agreed to the Terms of Use, click Log In to submit your information. Registering with this method will give your computer access to the network for one day, after which point you will need to re-register. Please note that failure to provide a valid email address will result in a loss of wireless access.
Wisconsin Center for Applied Microelectronics (WCAM)

WCAM maintains a suite of semiconductor and microfabrication processing equipment in a clean room laboratory. WCAM houses over 60 advanced tools for materials micro/nano fabrication.

WCAM offers services for:

- Lithography
- Deposition
- Packaging
- Assembly
- Thermal processing
- Plasma etching
- Wet chemical benches

Materials Science Center (MSC)

The MSC contains sophisticated microscopy and analysis instruments for characterizing materials and nanostructures.

Techniques offered include:

- Transmission Electron Microscopy (TEM)
- Focused Ion Beam (FIB)
- Atomic Force Microscopy (AFM)
- Confocal Microscopy
- X-ray Diffraction (XRD)
- Small Angle X-ray Scattering (SAXS)
- X-ray Photoelectron Spectroscopy (XPS)
- Raman Spectroscopy
- Fourier Transform Infrared Spectroscopy (FTIR)
- UV-Vis/Near Infrared Spectroscopy (UV/VIS/NIR)
- Nanoindentation
- Atom Probe Tomography (APT)
- Full suite of sample preparation tools

Soft Materials Lab (SML)

The SML provides a research facility for analysis and characterization of synthetic polymers, soft materials and polymer devices.

Techniques offered include:

- Differential Scanning Calorimetry (DSC)
- Thermo Gravimetric Analysis (TGA)
- Rheometry
- Dynamic Mechanical Analysis (DMA)
- Gel Permeation Chromatography (GPC)
- Ellipsometry
- Contact Angle Measurement
- Zetasizer

All equipment is available to qualified users from the University of Wisconsin system, other educational or government institutions, or industry. For more information, please visit our websites, email jerry.hunter@wisc.edu, or call 608-263-1073.

WCAM: http://wcam.engr.wisc.edu/
MSC: http://msc.engr.wisc.edu/
SML: http://softmaterials.engr.wisc.edu/
Geoscience Overview

The mission of the Department of Geoscience is to research and disseminate information on the structure, chemistry, physics and evolution of the Earth; life on Earth and in the solar system; and the interaction between physical, chemical, and biological processes that shape the Earth. We strive for breadth and excellence in our coverage of the subdisciplines within geoscience and in the creation, integration, application and transfer of knowledge in these fields. We aim to be at the forefront of scientific research, to reach a broad audience from students to specialists, and to provide useful knowledge to society. We believe that research and the creation of new knowledge are intimately inter-related with, and essential to, our programs of graduate and undergraduate education, to the Wisconsin Idea, and to the extension of the Wisconsin Idea to the world.

Research Facilities

Electron Microprobe Lab: Dr. John Fournelle
johnf@geology.wisc.edu

Fluid Inclusion Lab: Prof. Phil Brown
pbrown@geology.wisc.edu

ICP-TIMS Lab: Prof. Clark Johnson
clarkj@geology.wisc.edu

WiscAr Geochronology Lab: Prof. Brad Singer
bsinger@geology.wisc.edu

Scanning Electron Microscope (SEM) Lab: Dr. John Fournelle

Stable Isotope Lab: Prof. John Valley
valley@geology.wisc.edu

Wisc-SIMS Wisconsin Secondary Ion Mass Spectrometer
The Ion Microprobe Lab: Prof. John Valley

X-ray Diffraction Lab: Prof. Huifang Xu
hfxu@geology.wisc.edu

For more information, please visit our website:
www.geoscience.wisc.edu/geoscience/research/facilities.
Physical Sciences Lab Overview

The Physical Sciences Laboratory is a research and development laboratory that provides a range of service including consulting, design, fabrication, and calibration services in scientific instrumentation. At our facility south of Madison, Wisconsin, which includes machinery and electronics shops, PSL offers a highly trained staff in electrical engineering, mechanical engineering, and physics to address the unique needs of research projects of every scale and complexity.

PSL has served as a partner with UW Madison researchers since 1967 and has worked on over 6000 projects. Over time, PSL has broadened its client base to include other public institutions within Wisconsin and out of state, private industry, as well as foreign customers. PSL has also evolved to where it is able to facilitate large-scale design, engineering and fabrication projects such as the IceCube Neutrino Observatory at the South Pole and the Large Hadron Collider at CERN in Switzerland.

PSL will help to solve your unique research, development, or prototype needs.

Equipment and Research Tools

A fully staffed machine shop that includes a high bay with 5-ton crane.

Machines include: 3 CNC mills, 1 CNC lathe, multiple manual mills, a horizontal boring mill, 6 foot vertical lathe, surface grinders, optical comparator, and hardness tester.

An excellent welding facility with experience in vacuum quality welding.

A 2000 square foot electronics shop with RF and microwave test equipment and surface mount assembly capability.

For more information, please visit our website: www.psl.wisc.edu
Contact Information: psl@psl.wisc.edu
Bob Paulos, Director: rpaulos@psl.wisc.edu
Anita Herrick, Assistant Director: aherrick@psl.wisc.edu
NMRFAM Overview

The National Magnetic Resonance Facility at Madison (NMRFAM) is a resource for biomolecular nuclear magnetic resonance (NMR) spectroscopy and related techniques that aims to expand the frontiers of biomolecular NMR spectroscopy through technology, research, and development programs.

Fast data collection and automated data analysis of bio-macromolecules

Technology for larger proteins, nucleic acids, and complexes

Investigations of metal-containing (paramagnetic) proteins

Dynamics of macromolecules

Structure-function investigation of RNA molecules and their complexes with metal ions and proteins

Metabolomics and natural products

Solid State NMR

For more information, please visit our website:
http://www.nmrfam.wisc.edu/
Contact Information: Lai Bergeman, NMRFAM Administrator
lai.bergeman@wisc.edu
Paul Bender Chemical Instrument Center Overview

The Paul Bender Chemical Instrument Center houses the Chemistry Department’s major shared instrumentation used primarily to characterize low-molecular weight compounds. Expert staff provide user training, and collaborative and service work in support of Departmental, University, and outreach education and research. The Center is located on the second floor of the Chemistry building.

Magnetic Resonance:

Seven nuclear magnetic resonance (NMR) and one electron spin resonance (ESR) spectrometers are located in the Center. NMR provides one of the best methods for characterizing compounds in solution. Quantitation, reaction monitoring, purity assays, diffusion, and ligand-binding are also studied using NMR. Our staff assist with characterization of semi-solid to solid-state materials utilizing NMR capabilities at our sister facility, NMRFAM. Free-radical chemistry can be studied with an X-band ESR spectrometer equipped with a super-high sensitivity cavity. Sample temperatures can range from 4 to 373 K. Training is provided for use of all instruments.

Mass Spectrometry:

The Instrument Center’s collection of mass spectrometers makes four types of ionization available for analyzing new compounds and intermediate synthesis products. The ionization methods include matrix-assisted laser desorption/ionization (MALDI), electrospray ionization (ESI), electron impact (EI), and atmospheric solids analysis probe ionization (ASAP-MS). Operator training is available to graduate students and post doctoral associates as needed.

X-ray Crystallography:

The Molecular Structure Laboratory specializes in single-crystal X-ray analysis and X-ray powder diffractometry. The lab is equipped with two state-of-the-art single-crystal X-ray diffractometers with Mo and Cu radiation sources and one powder X-ray diffractometer with a Cu radiation source. The single-crystal diffraction experiments are routinely conducted in the 90-400 K temperature range. The samples range from air-stable to solvent-dependent and air- and moisture-sensitive compounds.

For more information, including rate schedules, contact:
Charles G. Fry, fry@chem.wisc.edu, 608-262-3182
Please visit our website at: pbcic.chem.wisc.edu
UNIVERSITY of WISCONSIN-MADISON
ADVANCED MATERIALS INDUSTRIAL CONSORTIUM
Gateway to materials research and resources for industry at UW-Madison

UW-Madison chapter of Regional Materials and Manufacturing Network (RM2N)

Easy point of contact for industry who want to interact with the University
Facilitated access to CoE Shared Instrument Facilities (20% discount for members)
Networking (B2B and student) at Annual Meetings and Facilities Days Open Houses

www.uwamic.wisc.edu

Regional Materials and Manufacturing Network
Gateway to Materials and Manufacturing in Wisconsin

Your access to materials and manufacturing resources in the greater Wisconsin region.

Work with us to increase your opportunity, efficiency, and access to resources.

Campus partners include:

University of Wisconsin
Eau Claire

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Milwaukee

University of Wisconsin
Platteville

University of Wisconsin
Stevens Point

University of Wisconsin
Whitewater

wiscmat.org
SPEAKER BIOS

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Felix Lu, Faculty Associate, Electrical and Computer Engineering
Co-Director, Advanced Materials Industrial Consortium (AMIC)

Felix Lu is the Co-Director of the Advanced Materials Industrial Consortium (AMIC) at the University of Wisconsin-Madison, Assistant Director for Industry Outreach for the Grainger Institute for Engineering, and a Faculty Associate in the Department of Electrical and Computer Engineering. A significant portion of his job includes reaching out to regional companies to find synergies among the various industry sectors and connect them to resources, subject matter experts and students at the University. He received his Ph.D. in Materials Science and Engineering from the University of California at San Diego and his technical background is in processing of semiconductor electronics.

Erin Gill, Administrative Director, Wisconsin MRSEC
Co-Director, Advanced Materials Industrial Consortium (AMIC)

Erin Gill is the Administrative Director of the Wisconsin Materials Research Science and Engineering Center (MRSEC) and Co-Director of the Advanced Materials Industrial Consortium (AMIC) at the University of Wisconsin-Madison. Prior to joining the MRSEC she worked as a Scientific Director at a startup company, in research support at IUPUI and the IU School of Medicine, and in technology transfer at WiSys Technology Foundation. She received her Ph.D. in Biomedical Engineering from the University of Wisconsin-Madison and her technical background is in tissue multiphoton imaging.

Isabelle Girard, Director, Office of Campus Research Cores

The Office of Campus Research Cores is a new initiative from the Office of the Vice Chancellor for Research and Graduate Education (VCRGE) to enhance access to and support of research services at UW-Madison. The mission of the Office of Campus Research Cores is to support, coordinate and optimize core structure and services for campus researchers and external clients. Isabelle Girard has a Ph.D. in Organismal Biology from the University of California, Los Angeles and has formerly served as the Associate Director of the Biotron Lab at UW-Madison, Program Analyst for UW-Madison Office of Research Support and Compliance, and Associate Professor of Biology at University of Wisconsin-Stevens Point.

Charlie Fry, Director, Magnetic Resonance Facility
Paul Bender Chemistry Instrumentation Center

Charlie Fry is the Director of the Magnetic Resonance Facility in the Paul Bender Chemistry Instrumentation Center. After receiving his Ph.D. in physical chemistry from Iowa State University, he came to UW-Madison and has been the NMR Director at PBCIC for the last 24 years. The Magnetic Resonance Facility provides state-of-the-art NMR instrumentation to support research and research-directed education in chemistry. The Facility is exceptional in its support of multinuclear and variable temperature studies that are key characterization techniques for synthetic and mechanistic chemistry. Dr. Fry is also leading the addition of new techniques specific to materials research, such as solid-state NMR and SQUID magnetometry.
John Markley, Steenbock Professor of Biomolecular Structure

Director, National Magnetic Resonance Facility at Madison (NMRFAM)
Professor Markley received his Ph.D. from Harvard University and is currently a professor in the UW-Madison Department of Biochemistry as well as Director of the National Magnetic Resonance Facility at Madison (NMRFAM). His research interests include NMR spectroscopy and its biological applications; structure function relationships in proteins; stable-isotope-assisted multinuclear magnetic resonance spectroscopy; processing and analysis of multi-dimensional NMR data; structural genomics and metabolomics.

Bob Paulos, Director, UW-Madison Physical Sciences Lab

Bob Paulos is an alumnus of the UW-Madison Department of Mechanical Engineering. Since then he has contributed to multiple projects affiliated with the UW-Madison including the Hubble Space Telescope High Speed Photometer, the Hubble Axial Replacement Instrument, and the Diffuse X-ray Spectrometer project. He also managed the initial contract with NSF for the Ice Coring and Drilling Services here, and the $275M IceCube Project. Bob became Director of the Physical Sciences Laboratory Fall of 2016.

John Valley, Professor of Geology
Charles R. Van Hise Professor of Geology

John W. Valley received his Ph.D. in 1980 from the University of Michigan at Ann Arbor, where he first became interested in the early earth. He and his students have since explored the ancient rock record throughout North America and in Western Australia, Greenland and Scotland. Valley is past-president of the Mineralogical Society of America and Charles R. Van Hise Professor of Geology at the University of Wisconsin–Madison, where he founded the WiscSIMS Laboratory, which includes a CAMECA IMS 1280 ion microprobe that enables a diverse range of research; besides zircons, Valley and his colleagues prove many rare or extremely small materials ranging from stardust to microfossils.

Jerry Hunter, Director, Shared Instrument Facilities

Jerry Hunter obtained a Ph.D. in Chemistry from the University of North Carolina – Chapel Hill in 1991 and was a Postdoctoral Researcher at North Carolina State University until 1992, and is now the-director of the University of Wisconsin – Madison College of Engineering Shared Research Facilities. Prior to his current position, Dr. Hunter was Associate Director of the Nanoscale Characterization and Fabrication Laboratories at Virginia Tech and Research Professor in the Departments of Materials Science and Engineering and Geosciences. He also spent 15 years in Silicon Valley where he had management and technical positions at Philips Semiconductors, Intel, Accurel Systems and Evans Analytical Group.

Ron Kelley, FEI, part of Thermo Fisher Scientific

Ron has focused charged particle beams for nearly 20 years, starting in failure analysis labs to his current applications engineer position at Thermo Fisher Scientific. Availability of the high current Xe ion source has solved many traditional analytical challenges and opened up new application spaces. His main focus today is optimizing the plasma FIB for new applications, including large volume 3D data collection, TEM prep and large area cross-sectioning.
Gerry O’Loughlin, SEMTech Solutions, Inc.
Gerry O’Loughlin is a graduate of Boston College and is currently the President of SEMTech Solutions, Inc. For 10 years, SEMTech Solutions and Elionix have worked together to provide sales, service, and applications in both North America and Europe. Gerry manages the Elionix Electron Beam Lithography (EBL) product line in North America and Europe. Gerry has more than 25 years of electron beam instrumentation experience in various roles. Prior to SEMTech Solutions, Gerry held positions at AMRAY, KLA-Tencor, Veeco, and Physical Electronics.

Greg Fisher, Physical Electronics, Inc.
Dr. Gregory L. Fisher is a Principal Scientist at Physical Electronics specializing in TOF-SIMS applications and instrument development. Greg attended college at the University of Wisconsin - LaCrosse where he earned B.S. degrees in Chemistry and Physics. He went on to study under Prof. Nicholas Winograd at the Pennsylvania State University where he earned his Ph.D. in Chemistry. While at Penn State, Greg participated in the development of TOF-SIMS analytical instruments as well as research concerning the fundamental physics of ion-solid interactions.

Thomas F. Kelly, CAMECA
Thomas F. Kelly received his Bachelor of Science in Mechanical Engineering with highest honors from Northeastern University in June 1977. He then entered graduate school at the Massachusetts Institute of Technology and received a Ph.D. in Materials Science in December 1981. After one year as a postdoctoral associate at M.I.T., he joined the faculty of the Department of Metallurgical and Mineral Engineering of the University of Wisconsin-Madison in January 1983. He was a Full Professor from 1994 until his departure in 2001 from the renamed Department of Materials Science and Engineering. Tom was also Director of the Materials Science Center from 1992 to 1999.

Muriel Veron, NanoMEGAS
Muriel Veron received her engineering degree and her Ph.D. in Material Science and Engineering from Grenoble-INP, France. After completing her Ph.D. in 1995, she joined the department of Materials Science and Engineering at McMaster University, Canada as a Postdoctoral Research Associate. In 1996 she moved back to France to take an Assistant Professor position at Grenoble-INP and SIMaP Laboratory (Material Science and Process Laboratory). Muriel Veron has contributed significantly to the development of TEM automated orientation mapping in association with the pioneering work of Dr. Edgar Rauch (CNRS). This has resulted in orientation and phase maps at the nanometer scale, and provided the scientific and industrial communities with a new and powerful tool to investigate materials.

FOR FULL SPEAKER BIOS, PLEASE VISIT THE EVENT WEBSITE
1. Controlling Packing and Orientation in Vapor Deposited Glasses

K. Bagchi¹*, C. Bishop¹, and M.D. Ediger¹

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Physical vapor deposition is currently used to fabricate organic electronic devices, such as OLEDs. In this work, we vary the substrate temperature during deposition to control the packing of Alq₃, an electron transport material and light emitter, and the orientation of itraconazole, a highly anisotropic, model glassy liquid crystal system. For itraconazole, the substrate is modified to create in-plane orientation. A temperature gradient setup produces distinct glasses over a wide temperature range in a single deposition [1]. The materials produced by PVD are characterized by techniques such as WAXS, GIWAXS, and ellipsometry. It has been shown that tuning the anisotropy and packing in glassy systems improves charge carrier mobility [2]. By tuning substrate temperature and composition, we hope to enable engineering of glassy systems for various organic electronic and optical applications.


2. Microstructure and Wear Resistance of Ti₆₆Al₄V Surfaces Processed by Pulsed Laser

Shixuan Chen¹*, Ahmet Usta² and Melih Eriten²

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Surfaces prepared with pulsed laser processing (PLP) experience a cycle of thermal processes involving extremely high heating/cooling rates that might lead to microstructure evolution [1]. In this study, we investigate the influence of PLP on microstructural evolution, resulting hardness, and wear resistance of Ti₆₆Al₄V. The microstructures before and after PLP are investigated with LEO 1530, and we observe that martensitic phase forms in the vicinity of processed surface. Nanoindentation, nano/microscale and mesoscale wear tests are applied to the processed regions to identify the effects of microstructure on hardness and wear resistance. We utilize TI 950 Triboindenter by Hysitron to obtain hardness and wear maps of the processed surface at nano/micro-scale, and perform scratch test with NTR2 by Anton-Paar GmbH at meso-scale. The result shows that the mixture of hard martensitic surface layer resulting from PLP and the underlying ductile substrate facilitates superior resistance to abrasive wear.


3. Bi Uniformity and Phase Separation in Metastable GaAs₁₋ₓBiₓ Solid Solutions

Weixin Chen¹*, Adam W. Wood¹, Honghyuk Kim², Yingxin Guan¹, Kamran Forghani³, Luke J. Mawst², Thomas F. Kuech³, Susan E. Babcock¹

¹Materials Science and Engineering, ²Electrical and Computer Engineering, ³Chemical and Biological Engineering, University of Wisconsin-Madison,
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The high sensitivity of electronic structure of GaAs₁₋ₓBiₓ to the Bi concentration provides opportunities for developing optoelectronic devices with new capability or improved performance. This sensitivity also demands the development of GaAs₁₋ₓBiₓ materials that are homogeneous in Bi distribution at the nanoscale and stable during post processing. Due to the extremely low solubility of Bi in GaAs, controlled and uniform incorporation of Bi is challenging. Phase separation and Bi clustering are often present in GaAs₁₋ₓBiₓ materials. This work used laser-pulsed atom probe tomography (APT) and high-angle annular dark-field (HAADF) scanning transmission electron microscopy (STEM) to explore the distribution of Bi atoms in as-grown and annealed GaAs₁₋ₓBiₓ samples. Statistical analysis of the APT data indicated the homogeneous Bi distribution in the as-grown samples. Furthermore, the results revealed the segregation of Bi and Ga within 5-10 nm Bi-rich particles in the annealed samples.

Yajin Chen$^1$*, M. Humed Yusuf$^1$, Yingxin Guan$^1$, Susan Babcock$^1$, Thomas F. Kuech$^2$ and P. G. Evans$^1$

$^1$Department of Materials Science & Engineering, $^2$Department of Chemical and Biological Engineering, University of Wisconsin-Madison

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Complex oxides have fascinating electronic properties, including high dielectric constant, but face significant challenges in integration into emerging 3D devices. Part of this challenge involves the kinetics of epitaxial growth, which is often required to form materials with the most favorable properties. Alternatives to epitaxy on crystalline substrates include the crystallization of amorphous thin films, for which only limited insight into the crystal growth kinetics is available. In this work, we utilize perovskite oxide SrTiO$_3$ (STO) as a model system to study the fundamental phenomena of complex oxide crystallization from the amorphous phase. We compare the different nucleation and growth kinetics of STO on single-crystal (001) STO and (001) Si with native oxide. We observe that at relatively lower annealing temperatures, crystallization of amorphous STO on STO can be achieved before polycrystal nucleation occurs for STO on SiO$_2$. Crystallization from a seed before polycrystal nucleation, as observed here, is the key to the formation of STO and other complex oxides in sophisticated geometries where STO would act as the crystalline template and a dielectric, such as SiO$_2$, as a mask. This observation provides the basis for the fabrication of 3D optical and electrical devices, composed of oxide materials, for which conventional synthesis routes are not viable.

5. Highly Anisotropic Glasses Prepared by Vapor Deposition

Ankit Gujral$^1$*, Jaritza Gomez$^1$ and M.D. Ediger$^1$

$^1$Department of Chemistry, University of Wisconsin-Madison

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Physical vapor deposition is a commercial method of fabricating glassy films for organic electronic applications such as OLEDs. Because these glasses are free of grain boundaries and pinholes, they often perform better than crystalline films. It has been shown that glasses with highly anisotropic structures exhibit enhanced charge carrier mobility, making them of technological importance in the field. In this study, we use physical vapor deposition to prepare highly anisotropic glasses of several small organic molecular systems. Using a high-throughput x-ray scattering screening method developed at the Materials Science Center, with grazing incidence x-ray scattering at a synchrotron, we show that substrate temperature during deposition is a key parameter to controlling anisotropy in films. In this way, many structures can be prepared, paving the way towards engineering glasses for specific organic electronic applications.

6. The Effect of Dehydration on Cartilage Micromechanical and Dissipative Properties

G. Han$^*$, C. Hess$^+$, M. Eriten, and C. Henak

Department of Mechanical Engineering, University of Wisconsin-Madison

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Mechanical properties of cartilage have been the subject of numerous studies due to its remarkable abilities to support and distribute high loads [1–3]. Few studies have evaluated cartilage recovery after dehydration [4,5]. Understanding the recovery of cartilage properties would lead to a better understanding of potential changes in cartilage due to dehydration during surgical operation. The effect of dehydration on micromechanical and dissipative properties of cartilage was investigated by performing quasi-static microindentation tests on the articular surface and cross-section of hydrated, dehydrated, and rehydrated cartilage. This study showed cartilage dehydration does not affect micromechanical and dissipative properties of rehydrated cartilage. As a continuation to this research, dynamic indentation tests were conducted on articular cartilage to investigate its dynamic response over a frequency range of 1-250Hz. All tests were performed by utilizing a 50 µm radius diamond spherical-conical tip and the Hysitron TI 950 Triboindentor in the Material Science Center.

7. Isolation of Pristine Electronics Grade Semiconducting Carbon Nanotubes by Switching the Rigidity of the Wrapping Polymer Backbone on Demand

Yongho Joo,1* Gerald J. Brady,1 Matthew J. Shea,1 M. Belén Oviedo,2 Catherine Kanimozhi,1 Samantha K. Schmitt,1 Bryan M. Wong,2 Michael S. Arnold,1 and Padma Gopalan1

1Department of Materials Science and Engineering, 2Department of Chemical and Environmental Engineering, and Materials Science and Engineering Program, University of California-Riverside

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Conjugated polymers are among the most selective carbon nanotube sorting agents discovered and enable the isolation of ultrahigh purity semiconducting singled-walled carbon nanotubes (s-SWCNTs) from heterogeneous mixtures that contain problematic metallic nanotubes. The strong selectivity though highly desirable for sorting, also leads to irreversible absorption of the polymer on the s-SWCNTs, limiting their electronic and optoelectronic properties. We demonstrate how changes in polymer backbone rigidity on demand can trigger its release from the nanotube surface. To do so we choose a model polymer namely poly[(9,9-dioctylfluorenyl-2,7-diyl)-alt-co-(6,60-(2,20-bipyridine))] (PFO-BPy) which provides ultrahigh selectivity for large-diameter s-SWCNTs, which are useful specifically for FETs and has the chemical functionality (BPy) to alter the rigidity using mild chemistry. Upon addition of Re(CO)5Cl to the solution of PFO-BPy wrapped s-SWCNTs, selective chelation with the BPy unit in the copolymer leads to the unwrapping of PFO-BPy. UV-Vis, XPS, and Raman spectroscopy studies show that binding of the metal ligand complex to BPy triggers up to 85% removal of the PFO-BPy from arc-discharge s-SWCNTs (diameter = 1.3-1.7 nm) and up to 72% from CoMoCAT s-SWCNTs (diameter = 0.7-0.8 nm). Importantly, Raman studies show that the electronic structure of the s-SWCNTs is preserved through this process. The generalizability of this method is demonstrated with two other transition metal salts. Molecular dynamics simulations support our experimental findings that the complexation of BPy with Re(CO)5Cl in the PFO-BPy backbone induces a dramatic conformational change that leads to a dynamic unwrapping of the polymer off the nanotube yielding pristine s-SWCNTs.

8. MOCVD Grown Strain-Compensated Ga(As)(P)/Ga(As)(Bi) Quantum Wells for Laser and Solar Cell Applications

Honghyuk Kim,1*, Y. Guan2, K. Forghani1,3, T. F. Kuech1 and L. J. Mawst1

1Department of Electrical and Computer Engineering, 2Department of Chemical and Biological Engineering, 3Department of Material Science and Engineering, University of Wisconsin-Madison

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GaAsx-Bix alloys have been drawing much attention as it was shown both experimentally and theoretically that a small amount of Bi incorporation into GaAs can induce a rapid reduction in the band gap energy (Eg) by 60-80meV per %Bi in GaAsx-Bix, showing its potential for the solar cell and laser diode applications [1]. The GaAs1-xBi0.6 quantum well structures on GaAs substrate grown by metal-organic vapor phase epitaxy and its applications to diode lasers with the emission wavelength in 965nm and to the solar cell as an alternative to the conventional InGaAs and InGaAsN 1eV solar cell. [1] USMAN, Muhammad, et al. “Impact of alloy disorder on the band Structure of Compressively Strained GaBi1-xAsx.”, Physical Review B, 2013
9. SI2-SSI Collaborative Research: A Computational Materials Data and Design Environment


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This NSF Software Infrastructure for Sustained Innovation – Scientific Software Integration award has produced an automated workflow manager and post-processing tool, online GUI tools and data visualization webpages, and research results in several areas of computational materials science, including a database of over 300 dilute solute diffusion coefficients, the screening of perovskite oxides for catalysts and solar cell materials, and assessments of defect stability. The UW-Madison Center for High Throughput Computing and UW-MRSEC contributed some of the computational resources used.

10. Graphene-Induced Ge (001) Surface Faceting


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Advances in the development of two-dimensional materials have produced impressive new functionalities, but have also posed significant characterization challenges as a result of the small sample thickness and corresponding broadness of the reciprocal space features. This work has demonstrated that x-ray reflectivity can resolve this issue by leveraging simultaneous advances in x-ray sources, optics, area detectors, and reflectivity modeling. In particular, this reflectivity study of a high-angle-faceted graphene/Ge(001) interface provides timely and crucial insight into the interplay between surface energetics and kinetics in single-layer graphene/Ge systems. Without precise scattering measurements of the faceted structures, the atomic-scale structure is unknown. Using x-ray reflectivity, it was shown that during a controlled growth of graphene nanoribbons on Ge, the underlying Ge surface tends towards [1 0 7] facets with an angular spread of approximately ±1°. This work opens the way to examine similar crucial issues in other emerging 2-D materials.

11. Flat Optical and Plasmonic Devices in the Infrared Using Ion-Implanted Semiconductors

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We demonstrate the potential of patterned highly doped silicon as a CMOS-compatible platform for mid- and far-infrared optics and plasmonics. We utilized ion-implantation of dopants in conjunction with lithography to locally tune the optical properties of an undoped silicon wafer to create functional diffractive optical elements (e.g. Fresnel zone plates) and plasmonic devices (e.g. frequency selective surfaces) that operate in the mid to far-IR regime. As part of the design process, we extracted the complex permittivity of silicon at various doping levels using variable-angle spectroscopic ellipsometry and Fourier transform infrared (FTIR) spectroscopy. Our designs were validated with finite-difference-time domain (FDTD) and ion stopping simulations, and verified experimentally. The resulting optical devices are monolithic, flat, resilient to thermal and physical damage, and can be easily integrated into other silicon-based platforms.

12. Optics Using Materials with Refractive Index Below Unity

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Conventional transparent materials have refractive index values ($n$) that are greater than unity (typically between about 1.0 and 4.0). We explore the opportunities that emerge from using materials that have refractive indices less
than unity, focusing in fused silica (SiO₂), a polar dielectric with strong phonon resonances in the mid infrared that result in a region of n < 1 with modest optical losses. Using this conventional easy-to-deposit material, we demonstrated three new optical phenomena: greater reflection than best metallic mirror at very oblique incident angles due to total external reflection, frustration of external reflection, and direct coupling to surface plasmon polaritons (SPPs) from free space. Our work suggests that materials with refractive index below unity can be integrated into various optical devices, from high-efficiency mirrors to new types of waveguides.

13. Focused Ion Beam Fabrication and X-ray Nanodiffraction Characterization of Elastically Strained Sub-Micron SrTiO₃ Sheets

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Controlling elastic strain provides a mechanism to influence functional materials properties. Misfit strain from thin film epitaxy of complex oxides can alter band structure and increase ferroelectric and ferromagnetic transition temperatures [1]. More strain values are accessible using methods based on chemical exfoliation or epitaxial lift off to create thin oxide materials that allow the substrate to elastically relax during thin film growth [2,3]. We demonstrate a lithographic approach using a focused ion beam to pattern sub-micron-thick SrTiO₃ crystalline sheets, and we demonstrate elastic compliance by depositing a strained SiNx thin film. Lattice distortion in the SrTiO₃ was characterized with synchrotron x-ray nanodiffraction at the Advanced Photon Source at Argonne National Laboratory. Analysis of the x-ray diffraction patterns using methods we developed for nanodiffraction problems showed the SrTiO₃ was elastically strained by the SiNx, which is consistent with a force-balancing model using the observed force per unit length applied by the SiNx [4].


14. Block Copolymer Lithography for Quantum Dot Lasers

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Block copolymer (BCP) lithography is an emerging patterning technology that overcomes the limitations of traditional photolithography to create nanostructures within sub-20nm length scale with high throughput and high fidelity. With PS-b-PMMA, a well-studied and yet the most practical BCP for lithography, we have created SiNx nanowells and SiO₂ nanoposts with ~20nm diameters which will serve as templates to grow (In)GaAs quantum dots (QDs) for laser diodes (LDs) either via a bottom-up or a top-down approach. The LD employing the QDs grown from the bottom-up approach showed a significant reduction of the threshold current density (Jth = 385A/cm²) at 80K. Via the optimized top-down approach, the number of regrowth of the semiconductors can be reduced to further improve the device performance due to the less crystal defects.

15. Understanding the Time, Temperature and Structural History of Ancient Zircon through Correlative Microanalysis.

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Zircon is a common accessory phase well-suited for correlated analysis of radiometric age, trace element and isotope systematics on the micron scale; as a result, zircon remains one of the few ways to directly study tectonic and magmatic processes on the early Earth and Moon [1-4]. While pristine zircon is physically and chemically resistant, self-irradiation (due to alpha decay events within the ²³⁸U→²⁰⁶Pb, ²³⁵U→²⁰⁷Pb and ²³²Th→²⁰⁸Pb decay chains)
damages the zircon structure on the nanometer scale; if this damage is not annealed, it increases the potential for open system chemical exchange. Correlative SEM/BSE/CL/EBSD, EPMA, laser Raman, SIMS, and atom probe tomography allows us to investigate element mobility on the length-scale of the damage accumulation and annealing processes. We can evaluate (1) the presence/absence of element mobility at the nanometer-scale, (2) its timing and spatial manifestation, and (3) its relation to temperature, damage accumulation and annealing.


16. Integrating μm-scale δ18O and δ13C SIMS Data into Sediment Burial Histories: Records of Temperature and Fluid Composition in Illinois Basin Sandstones

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The ability to correlate in situ SIMS isotopic data with mineral micro-textures provides a unique tool for investigating the fluid and thermal histories recorded in the cementing minerals that compose a sedimentary rock. Improving our understanding of the conditions that lead to cementation and resultant porosity changes remains a priority for predicting the quality of hydrocarbon and groundwater reservoirs, interpreting basin history, and optimizing carbon sequestration. Diagenetic quartz and carbonate cements were analyzed by SIMS for δ18O and δ13C in a suite of samples collected from the Ordovician St. Peter and Cambrian Mt. Simon sandstones of the Illinois Basin in the central Midwest (U.S.). These cements are interpreted to contain isotopic records from initial depositional environment on through deep burial and heating, and preserve gradients of up to 10% across distances of 10 µm or smaller. Traditional bulk analysis methods would otherwise homogenize signals recorded on such a fine scale.

17. QGIS as a Tool for the Integration of Multiple in situ Microanalytical Datasets

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Microanalytical methods in geoscience are unlocking data from micron-scale records that provide new insights into Earth processes at a wide range of timescales. The number of samples, methods per sample, and analyses per sample produced with in situ methods have grown considerably in just the last few years. Researchers integrate images and point analyses from multiple techniques to develop spatially registered datasets of hundreds of pieces of information on a sub-1-cm² sample. A single, unified software environment for the display, analysis, and sharing of these datasets has not been widely adopted to manage these exceptional datasets. The free and open source software QGIS (qgis.org) is an ideal platform for these purposes. We demonstrate integration in QGIS of electron microprobe, ion microprobe, scanning electron microscopy, and light microscopy data collected with instrumentation in the UW Department of Geoscience. We highlight the utility of the software for grain-mount and rock chip analysis of recently published datasets. Further development and adoption by the microanalytical community has the potential to enable archiving and sharing of research data in an accurate and open way. This data management framework can be integrated with databases to provide convenient access to large datasets for continued exploration after publication as a research or teaching tool.


Linzmeier, B.J., Landman, N.H., Kozdon, R., Peters, S.E., and Valley, J.W. Stable isotope evidence for the mode of life of juvenile ammonites: Implications for survival at the K/Pg boundary. For submission to Paleobiology.

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