Wisconsin Centers for Nanoscale Technology Facilities Day Open House

Thursday, May 18th
8:00 AM – 4:30 PM
University of Wisconsin–Madison
Mechanical Engineering Building
Madison, WI

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

University of Wisconsin
MRSEC

Welcome!

We would like to thank you for your participation in the 8th annual Facilities Day Open House co-hosted by the Materials Research Science and Engineering Center (MRSEC) and the Wisconsin Centers for Nanoscale Technology (WCNT).

This year, our event features tutorials for common microscopy, microanalysis, and nanofabrication techniques available in the UW–Madison shared facilities. These tutorials and introductions are an excellent learning opportunity for everyone, from faculty and graduate students to industrial users.

The WCNT serve hundreds of researchers from UW–Madison, other academic institutions, industry partners, and national labs.

This event is possible because of the support from our sponsors:

- Bruker
- Hitachi High-Tech America, Inc.
- Horiba Scientific
- Oxford Instruments
- TA Instruments
- Thermo Fisher Scientific
- Zeiss

In this booklet, you will find the agenda, maps, and presentation abstracts.

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, Wisconsin Centers for Nanoscale Technologies
jerry.hunter@wisc.edu

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8:00 AM	***Registration Opens / Breakfast & Coffee***	
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	Microscopy Techniques **Room 1106**	**Microanalysis** **Room 1153**
9:00 AM	Transmission Electron Microscopy (45 min) Paul Voyles, UW–Madison MSE User Applications (15 min) Nikhil Pokharel, UW–Madison ECE Nick Hagopian, UW–Madison MSE	Optical Spectroscopy (45 min) Nolan Wong, HORIBA Scientific User Applications (15 min) Sebastian Manzo, UW–Madison MSE Ziyan Wu, UW–Madison CEE
10:00 AM	***Break***	
10:15 AM	Scanning Electron Microscopy (45 min) Julie Morasch, UW–Madison WCNT User Applications (15 min) Xiaoqi Zheng. UW–Madison MSE Nina Desianti, WI State Lab of Hygiene	Surface Analysis (XPS and SIMS) (45 min) Jerry Hunter, UW–Madison WCNT User Application (15 min) Junguang Yu, UW–Madison ECE Jiarui Gon, UW–Madison ECE
11:15 AM	EDS and EBSD (45 min) Alfredo Díaz González, Oxford Instruments	Nanoindentation (30 min) Nick Bulloss, UW–Madison WCNT User Application (15 min) Aditya Nagaraj, UW–Madison ME
12:00 PM	***Lunch***	
1:15 PM	Focused Ion Beam (45 min) Dan Lawrence, ThermoFisher User Applications (15 min) Rogelio Herrera, UW–Madison ME	Geology (20min) Will Nachlas, UW–Madison Nuclear Reactor (20 min) Bob Agasie, UW–Madison Water Sciences (20 min) James Lazarcik, UW–Madison
2:15 PM	***Break***	
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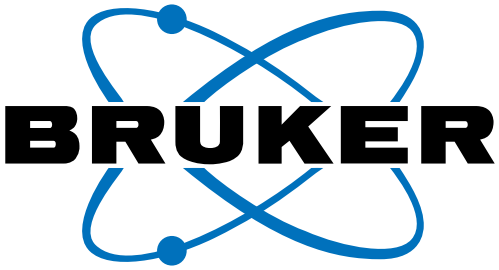
3:30 PM	X-ray Analysis Methods (XRD, XRR, etc.) (45 min) Don Savage, UW–Madison WCNT User Applications (15 min) Nathan Curtis, UW–Madison MSE Surjava Sanyal, UW–Madison ECE	Basics of Nanoscale Fabrication (45 min) Frank Flack, UW–Madison WCNT User Applications (15 min) Ben Harpt, UW–Madison Physics Conjeepuram Ambarish, UW–Madison Physics
4:30 PM	**Wrap Up in Room 1106** Jerry Hunter, UW–Madison WCNT	
4:40 PM	***Adjourn***	

Thank you to our Sponsors



Presentation Abstracts

General Session - Room 1106

Opening Presentation

Jerry Hunter, WCNT Director, UW–Madison

This presentation will introduce the Wisconsin Centers for Nanoscale Technology and then quickly cover the range of techniques available and discuss learning objectives for the day. A broad outline of how the various techniques fit together to provide a comprehensive characterization and fabrication solution will also be discussed.

Microscopy Techniques - Room 1106

9:00 AM

Transmission Electron Microscopy

Paul Voyles, Professor, Materials Science and Engineering and Director, Wisconsin MRSEC, UW–Madison

What if we could know everything there was to know about the structure of a piece of material? Complete knowledge would constitute something like a list of all the 3D positions of all atoms, with the element of each atom specified, and measurement of all the electronic states at high resolution in real and momentum space. Modern electron microscopy cannot provide quite all of that information, but it can get surprisingly close. This talk will review the basics of TEM and STEM, including imaging, diffraction, and spectroscopy, then provide examples of cutting-edge applications measuring atomic structure, defects, and electronic states in a variety of materials and in various sample environments.

SPEAKER BIO:

Paul Voyles is Professor of Materials Science and Engineering and Harvey D. Spangler Professor of Engineering at the University of Wisconsin-Madison. He earned degrees in physics from Oberlin College and the University of Illinois, Urbana-Champaign, then worked as a post-doctoral member of technical staff at Bell Labs in Murray Hill NJ. He joined the UW-Madison in 2002 as an Assistant Professor. His research specialty is the structure of materials, investigated primarily with electron microscopy, supplemented by simulations and data science. He has worked on metallic and other glasses and on materials for microelectronics, spintronics, and superconductors. He was Chair of the Materials Science and Engineering Department from 2018 to 2018 is currently director of the UW-Madison NSF Materials Research Science and Engineering Center. He has published over 200 journal articles, book chapters, and conference proceedings.

USER APPLICATIONS:

- Nikhil Pokharel, UW–Madison ECE
- Nick Hagopian, UW–Madison MSE

10:15 AM

Imaging with the Scanning Electron Microscope

Julie Morasch, UW–Madison WCNT

The SEM is a versatile and heavily used imaging technique for both high resolution imaging and compositional analysis. This tutorial will briefly give an overview the microscope, describe beam sample interactions, discuss how the SEM forms an image, and give some practical advice for your SEM imaging. I will also describe the capabilities of the SEMs in the NIAC.

SPEAKER BIO:

Julie is an Instrument Manager in the Nanoscale Imaging and Analysis Center (NIAC) for the SEM and FIB instruments. She received her B.S. Electrical Engineering from UW-Madison and her Ph.D in Materials Science from the University of Minnesota. She did her postdoctoral work at Sandia National Laboratories. She spent 7 years as a research scientist at the UW before moving to her current position in the NIAC, where she has been for over 10 years. During those years she has supported many of the techniques in the center, including AFM, nanoindentation and confocal microscopy.

USER APPLICATIONS:

- Xiaoqi Zheng. UW–Madison MSE
- Nina Desianti, WI State Lab of Hygiene

11:15 AM

EDS and EBSD

Alfredo Díaz González, Applications Specialist, Oxford Instruments NanoAnalysis

Energy Dispersive Spectrometry (EDS) and Electron Backscatter Diffraction (EBSD) are scanning electron microscope (SEM) based techniques that are commonly used to characterize materials. EDS is used to identify which elements are present within a surface. In EBSD, the electron beam interacts with a tilted crystalline sample producing a diffraction pattern. The diffraction pattern provides information about the crystal structure and orientation. This presentation will offer an overview of both techniques, discussing how the techniques work and what information can be obtained from it. Some applications will be shared to illustrate how EDS/EBSD can solve research problems.

SPEAKER BIO:

Alfredo Díaz González is an Applications Specialist at Oxford Instruments NanoAnalysis and holds a M.S. and Ph.D. in Mechanical Engineering from University of Puerto Rico and The George Washington University, respectively. He worked in the development of electrically conductive nanocomposites, development of AFM methods and structure-property relations in nanomaterials. He joined Oxford instruments in 2018 as a customer service engineer and later transitioned into applications.

1:15 PM

Focused Ion Beam

Dan Lawrence, ThermoFisher

USER APPLICATION:

- Rogelio Herrera, UW–Madison ME

2:30 PM

Atomic Force Microscopy – Overview and Recent Developments

John Thornton, Bruker Nano Surfaces

The field of Atomic Force Microscopy (AFM) encompasses a variety of techniques that provide the ability to visualize and measure surfaces at high resolution in three dimensions in air and fluid environments. A common application of AFM is the study of surface morphology and dimensional measurements of heights, widths, and roughness, down to sub-nanometer resolution in some cases. However, AFMs are also frequently used to measure mechanical properties, such as modulus and adhesion, as well as electrical properties, such as current or work function of materials. The combination of these abilities produces a wide range of measurements and properties that can be studied with a single AFM. Furthermore, the ability of the AFM to make measurements in a fluid environment at the nanoscale makes it unique, and is often used for biological and electrochemical studies. More recent developments in the AFM field include chemical identification using AFM-IR image and spectroscopy techniques. This presentation will concentration on providing an overview of the AFM techniques and applications, with an emphasis on the capabilities of the AFM instruments at UW-Madison, but will also mention some new developments in the AFM field.

John Thornton is a Senior Applications Scientist at Bruker Nano Surfaces and Metrology with 30+ years of experience in the field of Atomic Force Microscopy (AFM). He learned AFM at North Carolina State University in the 1990s, and then joined Digital Instruments, a pioneering company in early AFM development, and continued with the company through acquisitions by Veeco Instruments, and then Bruker. John has co-authored many scientific publications and developed scanning probe microscopy training courses. Currently, John spends a significant amount of time running AFMs, working with researchers, and educating others on techniques. He currently works from his home in Virginia, and from the Bruker AFM applications lab in Billerica, MA.

USER APPLICATION:

- Ilhan Bok, UW–Madison ECE

3:30 PM

X-ray Analysis Methods (XRD, XRR, etc.)

Don Savage, UW–Madison WCNT

USER APPLICATIONS:

Nathan Curtis, UW–Madison MSE

Surjava Sanyal, UW–Madison ECE

9:00 AM

Optical Spectroscopy:

Nolan Wong, Sales Engineer, North Central Region, HORIBA Scientific

USER APPLICATIONS:

- Sebastian Manzo, UW–Madison MSE
- Ziyan Wu, UW–Madison CEE

10:15 AM

Surface Analysis (XPS and SIMS)

Jerry Hunter, WCNT Director, UW–Madison

SPEAKER BIO:

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.

USER APPLICATIONS:

- Junguang Yu, UW–Madison ECE
- Jiarui Gon, UW–Madison ECE

11:15 AM

Nanoindentation

Nick Bulloss, UW–Madison WCNT

USER APPLICATION:

Aditya Nagaraj, UW–Madison ME

1:15 PM

Electron Microprobe Research at UW–Madison

Will Nachlas, Assistant Scientist, Electron Microbeam Research Labs, University of Wisconsin–Madison

The electron probe microanalyzer (EPMA), or electron microprobe, is an analytical instrument that uses a focused beam of electrons to stimulate characteristic X-rays from the sample which are diffracted and analyzed using Wavelength Dispersive X-ray Spectrometry (WDS) and Energy Dispersive X-ray Spectroscopy (EDS). The electron microprobe is capable of measuring all elements from Be to U to approximately 0.01% abundance from sub-micron regions of a polished sample surface.

This talk will present a background of the EPMA technique, description of EPMA instruments at UW-Madison, and several applications including characterization of complex multi-component materials, quantitative X-ray mapping, light element analysis, and thin film analysis.

SPEAKER BIO:

Will Nachlas is a Scientist and Director of the Electron Microbeam Laboratories in the Department of Geoscience at UW-Madison. Prior to arriving to UW-Madison in 2020, he received a BSc in Geology from Virginia Tech (2006-10), PhD in Geology from University of Minnesota (2010-15), and postdoc in Geochemistry from Syracuse University (2016-19). He has been practicing the use of electron microprobes since 2008, has participated in the decommissioning and installation of multiple instruments, and is interested in applications and maintenance of EPMA equipment.

Neutron Science at the University of Wisconsin Nuclear Reactor

Robert Agasie, Reactor Director, University of Wisconsin Nuclear Reactor

Robert Agasie, Reactor Director, will present on the University of Wisconsin Nuclear Reactor's (UWNR) role in providing neutron radiation for radioisotopes production, novel radiation detectors and neutron based research techniques. Techniques discussed will include Instrumental Neutron Activation Analysis (INAA), neutron depth profiling and neutron radiography.

SPEAKER BIO:

Agasie has been working at university research reactors for 28 years, serving as the Operations Engineering at the University of Missouri-Columbia Research Reactor (MURR) and, for the last 22 years, as the Reactor Director at the UWNR. He is licensed by the U.S. Nuclear Regulatory Commission (US NRC) as a Senior Reactor Operator and is the Nuclear Material Custodian for the UWNR.

Oversimplified – Water Analysis is not Trivial

James Lazarcik, Instrumentation Technologist, Water Science and Engineering Laboratory, University of Wisconsin–Madison

Simplification is an important and necessary tool in teaching complex concepts (1,2) but oversimplifying analysis or method development strategy while sharing technical results can be detrimental to research replication and advancement. Researchers often come to WSEL with an incomplete picture on how to conduct an experiment or perform a test presumably because necessary technical information was omitted from the reference or omitted from discussion, yet this information is often vital to producing any research at all. At WSEL, researchers have an opportunity to be trained on independent operation of our instrumentation in addition to how to appropriately frame questions through an analytical lens, how to demonstrably generate high quality data, and how to reduce research turn-around-times by developing concise testing plans and reading between the oversimplifications included in many research reports.

Refs:

1. https://link.springer.com/article/10.1007/s11367-020-01821-w

2. https://journals.sagepub.com/doi/pdf/10.1177/030631283013002002

SPEAKER BIO:

James Lazarcik received a Master of Science in Earth System Sciences from the University of New Hampshire in 2016. After two years at a contract research laboratory, he moved to the Water Science and Engineering Laboratory where he guides the Core for Advanced Water Analysis and supports the endeavors of the Environmental Chemistry and Technology graduate program. James was a founding member of the Core in 2019, and since has worked to offer increasingly accessible cradle-to-grave analytical services through the Core to researchers at UW-Madison, private companies, and higher education institutions across the United States.

2:30 PM

Polymer Characterizations on Rotational Rheometers – Standard and Non-Traditional Methods

Gregory W Kamykowski PhD; TA Instruments

One of the key ways of characterizing polymers and other materials is by rotational rheometry. Steady flow testing and dynamic oscillatory testing are both performed routinely on polymer melts to provide information on the molecular weight and molecular weight distribution of the polymers and other properties that determine a resin's suitability for particular applications. It is also a sensitive way to determine the effects of regrind addition can have on the processability of a resin. Rotational rheometry can also be performed on sold specimens to determine the material's mechanical properties.

Some basic rheology will be presented in this talk. Then standard test methods will be described, as well as non-standard methods that have given additional insight into the processability and mechanical properties of typical polymers.

USER APPLICATION:

- John Estela, UW–Madison CBE

3:30 PM

Basics of Nanoscale Fabrication

Frank Flack, UW–Madison WCNT

USER APPLICATION:

- Ben Harpt, UW–Madison Physics
- Conjeepuram Ambarish, UW–Madison Physics

Wrap Up

Jerry Hunter, WCNT Director, UW–Madison

This presentation will summarize the learning for the day and discuss rules for determining which technique is the most appropriate for your characterization and fabrication needs.

Parking Directions

Interactive map with real-time availability:

http://map.wisc.edu

Parking is available in Lot 17 located at the end of Engineering Drive. There is also some, limited parking in Lot 80, below Union South.

Rates: $2 per hour. $15 per day.