MICHIGAN ENGINEERING

MICHIGAN CENTER FOR MATERIALS CHARACTERIZATION

The Michigan Center for Materials Characterization, known as $(MC)^2$, is dedicated to the micron and nanoscale imaging and analysis of materials. The center's research scientists offer professional training and education on state-of-the-art microscopy instruments, as well as perform service work. $(MC)^2$ supports a diverse multi-disciplinary user base of more than 450 academic users from various colleges and departments, 100+ internal research groups, and over 20 non-academic companies. For information on becoming a user, see **mc2.engin.umich.edu** or contact us with any questions at **mc2-staff@umich.edu**.

TECH HIGHLIGHTS

- Tescan RISE microscope is one of only a few available offering Raman in SEM, allowing in-situ Raman and SEM/EDS data collection
- High resolution imaging and chemical mapping are available with the 3100R05, along with a K2 camera for low dose imaging and atomic-resolution mapping of sensitive samples
- XPS provides surface chemistry measurements with ion depth profiling
- In-situ TEM holders for reaction experimentation (Hummingbird liquid cell holder)
- Ultra-fast TEM cameras, Gatan OneView and K2, for capture of in-situ reactions

NEW DEVELOPMENTS

We have a new **FEI Helios G4 Plasma FIB UXe** that will be available for use in August 2019.The center will also soon install an **FEI Talos F200X G2**, a 200 kV FEG scanning transmission electron microscope (S/TEM).

$(MC)^2$ has recently begun collaborating with the Michigan Ion Beam Lab in offering unique opportunities for in-situ irradiation experiments using an **FEI Tecnai G2 F30 TWIN TEM** interfaced with a particle accelerator. Two separate ion species can be mixed and delivered to the TEM stage.

INSTRUMENTS/TECHNIQUES

Scanning Electron Microscopy (SEM)

- TESCAN MIRA3 FEG SEM
- TESCAN RISE

- Surface imaging (topology, chemistry, phase contrast) in vacuum or environment
- Chemical analysis and mapping
- Orientation imaging (automated large scale, image stitching)
- Raman spectroscopy and imaging
- Cathodoluminescence and imaging

Scanning Electron and Focused Ion Beam Instruments (SEM/FIB)

- FEI Quanta 3D SEM/FIB
- FEI Nova 200 Nanolab SEM/FIB
- FEI Helios 650 Nanolab SEM/FIB

- Surface and cross section imaging (topology, chemistry, phase contrast)
- Orientation imaging
- Serial milling, imaging, and 3D reconstruction
- TEM and APT specimen preparation
- Environmental imaging (gas control and water vapor)

Transmission Electron Microscopy

- FEI Tecnai G2 F30 TWIN Electron Microscope
- JEOL 2010F Analytical Electron Microscope
- JEOL 2100F Probe-Corrected Electron Microscope
- JEOL 3011 High Resolution Electron Microscope
- JEOL 3100R05 Double Cs Corrected TEM/STEM

- STEM imaging
- Atomic Chemical mapping
- Atomic structure
- In-situ imaging (deformation, gas, liquid, temperature)

Atom Probe Tomography

- Cameca LEAP 5000HR

- Atom-by-atom reconstruction of materials, 3D chemical analysis at the nanometer scale
- Phase transformations
- Semiconductor analysis: dopants, quantum structures

3D X-ray Microscopy

- Zeiss Xradia Versa 520 3D X-ray Microscope with DCT module

- Non-destructive imaging and reconstruction of buried features (pores, particles, defects, etc.)
- Phase contrast imaging for studying low Z or "near Z" elements
- Diffraction contrast for study of crystallographic orientation

Atomic Force Microscopy

- Veeco Dimension Icon AFM

- elasticity, adhesion, electrostatic, magnetic and binding studies
- Mapping of nano mechanical properties
- Applications in materials science, biological sciences, and geological sciences

X-ray PhotoElectron Spectroscopy

- Kratos Axis Ultra XPS

- Depth-profiling
- Study of chemical composition, element state of materials, and element distribution
- In-situ heating and cooling

Mechanical Properties

- Hysitron TriboIndenter

- Study of material deformation and transformation behavior
- Nanomechanical measurement of thin films, soft materials, surface interaction forces

Specimen Preparation

- Gatan Model 691 PIPS
- Gatan Model 656 Dimple Grinder
- Fischione Model 1020 Plasma Cleaner
- SPI-Module Carbon/Sputter Coater
- Reichert-Jung Ultracut E
- Ted Pella LKB 7800 Knifemaker
- Nikon Microscope with Scion CCD Camera
- Nikon SMZ 745T with Panasonic TV Camera
- SBT Model 650 Low Speed Diamond Wheel Saw
- SBT Model 360 Disc Drill
- Thermolyne Type 1000 Stir Plate
- Benchmark Hotplate Stirrer
- Gatan Model 601 Ultrasonic Disk Cutter
- Fisher Scientific FS20D Ultrasonic Cleaner
- Nikon SMZ 745 Microscope
- Buehler Ecomet 3 Variable Speed Grinder-Polisher
- SYBRON-Thermolyne Hot Plate Oven OV 10600

MICHIGAN CENTER FOR MATERIALS CHARACTERIZATION

The Biointerfaces Institute occupies over 56,000 square feet of dedicated space at the North Campus Research Complex. In addition to superbly equipped research facilities and flex space, our state-of-the-art collaboratory features stand-alone speciality research centers, including:

- A **Biotechnicum** for 3D printing of soft and hard materials.
- An **Imaging Lab** designed to allow longitudinal imaging of soft tissues and bone. Instrumentats includes a Caliper IVIS Imaging system for imaging of bioluminescent reporters, a digital capture Faxitron radiography machine and a small Norland densitometry x-ray absorptiometry machine.
- A **Nanotechnicum** for optical, thermal and size characterization of particles and materials.
- An **Optical Image and Analysis Lab** for imaging and characterization of a wide range of materials from colloids to tissues. Instruments include a confocal laser scanning microscope, a confocal laser Raman microscope, a super-resolution SIM microscope and microscopes for live cells.
- A **Single Cell Analysis Core** for isolation and analysis of single cells.
- A **Visualization Lab** for modeling and understanding complex materials comprising 3 high-end graphics workstations with 4K displays and a 10-ft tiled display wall, all with dedicated high-speed internet connections. The VisLab also provides the ability to process data and visualize results interactively.

BI EQUIPMENT INCLUDES:

- **Wes and Milo Western Blot Systems** (Protein Simple)
- **IX83 Microscope for Live Cell & Hanging Drop Imaging** (Olympus America)
- **Structured Illumination Microscope System (SIMS)** (Carl Zeiss Microscopy)
- **Scanning Confocal System** (Nikon Instruments)
- **Mantra Quantitative Pathology Workstation** (Perkin Elmer)
- **Cybi-Felix Robotic Liquid Handler** (Analytik Jena)
- **Synergy Neo Microplate Reader** (Biotek)
- **Fluorchem M Imaging System** (ProteinSimple)
- **In-Vivo Imaging (Ivis Spectrum)** (Perkin Elmer)
- **Quartz Crystal Microbalance with Dissipation** (Biolin Scientific)
- **3DDisovery Bioprinter**(RegenHu)
- **Invio 3D Bioprinter**(Rokit)
- **Digital Radiology System, UltraFocus60** (Faxitron Bioptics)
- **XFe96 Extracellular Flux Analyzer** (Seahorse Bioscience, Inc./Agilent)
- **Raindrop PCR System** (Raindance/Bio-Rad)
- **MicroSquisher** (CellScale Biomaterials Testing)
- **Autopore V Mercury Porosimeter** (Micromeritics Instrument Corporation)
- **Exicor XZT Mueller Matrix Measurement System** (Hinds Instruments)
- **UTM T150 Nano Tensile/Compression Tester** (Keysight Technologies)
- **Particle, Optical and Thermal Characterization Suite of Nanomaterials** (Nanotechnicum)
- **Single Cell Genomics Suite** (Fluidigm)
- **Cryostat**

BI INSTRUMENTS ARE AVAILABLE FOR USE BY ALL UM USERS!

CONTACT US FOR DETAILS:

BI-EQUIPMENT@UMICH.EDU

BIOINTERFACES INSTITUTE

NANOTECHNICUM

Particle Characterization

- **Malvern Zetasizer Nano ZSP**
  Particle Size distribution by dynamic light scattering (~0.3nm-10 µm) and zeta potential measurement
- **Malvern Mastersizer 2000**
  Particle Size distribution by laser diffraction (~0.02µm-2000µm)
- **Malvern Nanosight NS300**
  Particle Size distribution by nanoparticle tracking analysis (~10nm-1µm). Particle concentration information and fluorescent measurement are also available
- **Micromeritics Mercury Porosimeter Autopore V**
  Particle porosity measurement by mercury intrusion for pore size distribution, pore volume etc. (pore size ~0.003-500µm)

Thermal Characterization

- **TA Instruments Discovery Discovery Scanning Calorimeter (DSC)**
  Thermal properties of materials
- **TA Instruments Thermal Gravimetric Analysis (TGA)**
  Degradation behavior of materials
- **TA Instruments Nano DSC**
  Stability of biomolecules in solution
- **TA Instruments Nano ITC**
  Biomolecular binding of biological molecules in solution

Optical Characterization

- **Jasco J-815 Circular Dichroism (CD) Spectrometer**
  Optical CD of samples, often used for chiral materials or for analyzing secondary structures of proteins
- **Jasco J-1700 (CD) Spectrometer**
  This CD features UV and NIR detectors that allow for measurements from wavelengths 163nm-25000nm
- **Jasco Circularly Polarized Luminescence Spectrometer (CPL) 300**
  Chiroptical data on the first excited state of a sample to provide structural properties of samples

University of Michigan

Lurie Nanofabrication Facility (LNF)

Lurie Nanofabrication Facility: Your Resource to Enable Innovation

Complete Fabrication Capabilities:

- More than 13,500 square feet (area under filter) of state-of-the-art class 10/100/1000 and 10,000 with up to 6" (150mm) processing capability and BioSafety Level II facility
- Comprehensive suite of tools that support:
  - General processing, Silicon, compound semiconductors, polymers, and other materials
  - MEMS, BioMEMS
  - Optoelectronics
  - CMOS, MEMS-CMOS integration
  - Microfluidics

Domain Experts for:

- General micro/nanofabrication
- MEMS, BioMEMS, integrated microsystems
- Nanophotonics, nanolithography
- Surface science, electrochemistry, material science

LNF Process Capabilities

Deposition and Growth
CVD, ALD, LPCVD, PECVD, PVD, Parylene Deposition

Lithography, Direct Writing and Mask Making
Optical Lithography, E-beam Lithography, Soft Lithography, Mask Making, InkJet Printing, Dip-Pen Nanolithography

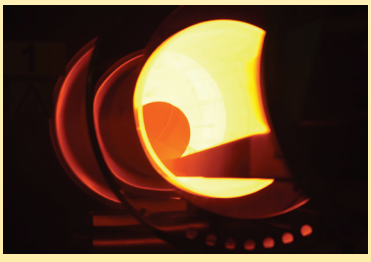
Etching
RIE, DRIE, XeF2

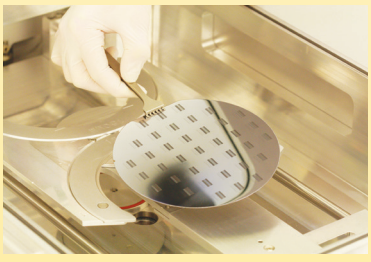
Thermal Processing
Annealing, Oxidation, Doping and Diffusion

Chemical Processing
Wet Etching, Lift-Off, Electroplating

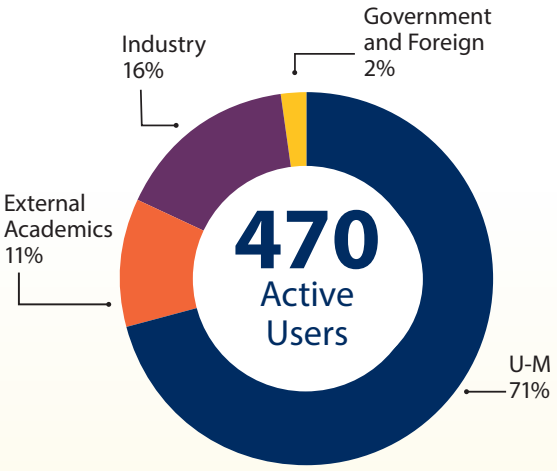
Metrology and Characterization
SEM, AFM, Profilometry, Microscopy (IR, Fluorescent), Ellipsometry, Reflectometry, EDS, μFTIR, 4-pointProbe, Film Stress, Contact Angle

Packaging and Mechanical Finishing (BEOL)
Wafer Bonding, Dicing, Wire Bonding, Flip-Chip Bonding, Polishing, Lapping, CMP





LNF Community



53 Companies

93 Internal Research Groups

23 Internal Departments

34 External Universities

70,000 Hours of Lab Usage

Benefits

Access to a world-class facility providing a broad set of technologies and processes, with technical support from process engineers and domain experts.

FREE project consultation for prospective users

FREE initial assistance from experienced process engineers and scientists

FREE safety and equipment training

FREE access to a web-based equipment reservation system

SHARED office space with internet access and CAD software

REDUCED capital investment necessary to initiate a research project

OWNERSHIP of intellectual property by users

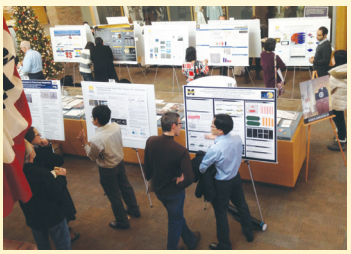
Workshops and Events

Professional Workshops

Technical sessions that cater to the interests and needs of the professional community. Experts present topics related to various research thrusts and associated process technologies currently available within the LNF. Lectures are accompanied by hands-on laboratory activities that benefit professionals from diverse backgrounds.

Community Events

Seminars and community events for academic and professional networking, outreach to the general public, and many more events including our annual LNF Users Symposium.



The mission of the LNF is to provide effective, efficient, safe, and socially responsible access to advanced nanofabrication equipment and expertise thereby promoting, enabling, and encouraging cutting-edge education, research and business development from materials and individual process steps to entire systems.

LNF.umich.edu

Lurie Nanofabrication Facility

E-beam Lithography

Microfluidics

Deep RIE

Packaging

Surface Science

Process Integration

Photonics

Thin Films

Direct Writing

Metrology

Wafer Bonding

Thermal Processes

Onsite Access

- Streamlined access procedure
- Users complete online safety training then work with our engineers and scientists on their project
- Independent usage, 24/7 access available

Process Services

Did you know that LNF can also provide process services? LNF staff members are available to help with your processing and meet your deadlines. See dedicated flyer or contact us for more details.

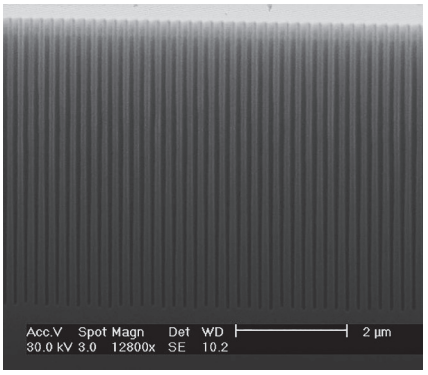
For more information:

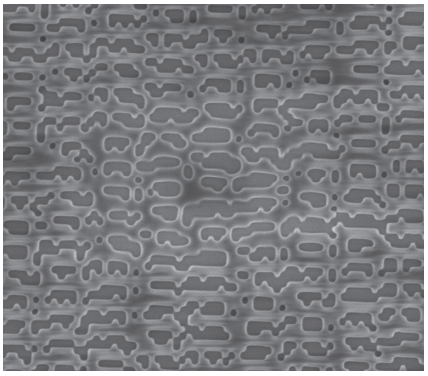
www.LNF.umich.edu **info@LNF.umich.edu**

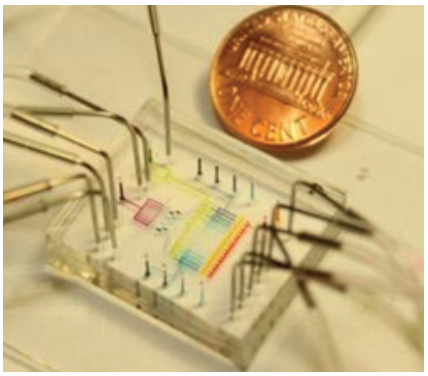
LNF-wiki.eecs.umich.edu

Lurie Nanofabrication Facility

Process Services







The University of Michigan Lurie Nanofabrication Facility (LNF) includes 11,000 sq. ft. of class 10/100/1000 cleanroom and 2,500 sq. ft. of quasi class 10,000 space with a BiosSafety Level 2 space. The LNF provides a wide range of fabrication and characterization capabilities and our highly experienced scientists and engineers are here to help you with your process needs. The LNF offers processing services to researchers unable to come to work onsite themselves.

Here are examples of services that we offer:

- E-beam lithography
- DRIE
- Wafer Bonding
- Thermal Processes
- Soft Lithography
- Analytical Services
- Thin Films

and many more!

LNF.umich.edu info@LNF.umich.edu

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LNF LURIE NANOFABRICATION FACILITY UNIVERSITY OF MICHIGAN

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