## Materials Sciences and Engineering Institute

More info: <https://msei.missouri.edu/>

The MU Materials Science & Engineering Institute (MUMSEI) was founded in 2021 to serve as the hub of multidisciplinary research in materials in the College of Engineering and College of Arts and Science. The objective of the institute is to establish nationally recognized academic and research programs in materials disciplines to respond to national areas of need and to expand the impact of University of Missouri researchers. The institute hosts faculty from 10 academic departments who are affiliated with initiatives at the NextGen Precision Health initiative, MU Research Reactor and more. The Materials Characterization and Fabrication (MCF) Facility was established in 2021 to provide cutting-edge resources for institute researchers and external partners.

MUMSEI brings together interdisciplinary collaborators focused on materials science and engineering research and education. Mizzou Engineering researchers will work with faculty from the NextGen Precision Health Electron Microscopy Core, chemistry, physics, biology, and other sciences at Mizzou to investigate the design and application of high-performing materials through machine learning, atomistic simulations, and other emerging technologies using cutting-edge facilities.

MUMSEI fosters collaboration in existing and new areas, including biomaterials, energy materials, quantum materials, and materials-at-extremes. By uniting the sciences and engineering at Mizzou, the institute creates new opportunities for joint projects and funding proposals. Additionally, affiliated faculty are expected to develop new interdisciplinary academic programs such as certificates and graduate degrees in materials science and engineering to prepare students to work and research in these areas.

Facilities

**Agilent G200 Nanoindenter**

The Agilent G200 nanoindenter is utilized to characterize the mechanical properties (modulus, hardness) of thin films. This indenter features the XP head and can perform indentation and scratch tests; <0.01 nm displacement resolution; 50 nN load resolution – Max load of 500 mN.

**Atomic Layer Deposition**

Cambridge Savannah ALD System is equipped with high-speed pneumatic pulse valves to deposit a conformal and uniform thin film on Ultra High Aspect Ratio substrates. Substrates up to 200mm can be mounted and the temperature of the deposition can be varied from 100 oC to 350 oC. An Ozone generator is also mounted to the system. Currently, the system is configured to deposit Al2O3 using trimethylaluminum and water or ozone. The system can be configured to deposit TiO2 thin film.

**Bruker Innova AFM**

The Bruker Innova is available for routine analysis of samples and can probe the topography of the surface using standard tapping and contact modes, The Innova Atomic Force Microscope delivers accurate, high-resolution imaging, and a wide range of functionality for advanced research in physical and material sciences. This unit has the Lowest Noise and Highest Resolution AFM in its Class.

**Contact Angle Gonimeter**

**T**he ramé-hart Model 200 Standard Contact Angle Goniometer is a powerful tool for measuring contact angle and surface energy. The DROPimage pro software measures contact angle, surface energy, surface tension, and interfacial tension studies.

**Delsa Nano HC Particle Analyzer**

This system measures particle size in the range of 0.6 nm to 7 µm and zeta potential of particles in the size range of 0.6 nm to 30 μm using photon correlation spectroscopy and electrophoretic light scattering. The optional auto titrator enables isoelectric point determination by measuring zeta potential over a range of pH values.

**Differential Scanning Calorimeter (DSC) - DSC Q20**

The TA Instruments DSC Q20 Differential Scanning Calorimeter (DSC) module allows the measurement of differential heat flow from a sample as it is heated to high temperatures. The temperature range of this unit is -70 oC to 400 oC.

**E-Beam Evaporator**

Kurt Lesker Axxix E-beam evaporator is a four-pocket e-beam deposition system. This system can sequentially deposit four different materials like metal and oxides. Process parameters like rate of deposition, thickness, and substrate temperature are computer controlled. This unit can handle 8-inch wafers and the substrate can be heated to 500 oC. Evaporation materials includeTi, Cr, Au, Ag, Al, Si, Ta, and Al2O3.

**Fluorescence Microscope**

The BX51WI epi-illumination fluorescence microscope delivers high-resolution imaging of fluorescent samples. The microscope is equipped with several filter cubes for imaging common fluorophores including DAPI, FITC, Rhodamine 6G, TRITC, and Cy5. Samples can be viewed using 10x, 20x, 40x, 60x Water immersion, and 100x Oil immersion objectives and imaged using our ORCAFlash2.8 CCD camera or a USB4000 Ocean optics spectrometer. The microscope can illuminate the samples using either a high-intensity Xenon arc lamp or a halogen lamp.

**Hall Measurement System**

MMR’s Hall System (VTHS) allows the user to make automatic measurements of resistivity, mobility, and carrier concentration of a wide range of samples using the Van der Pauw method.

**Hysitron TI Premier TriboIndenter**

Bruker Hysitron TI980 Triboindenter is an automatic quasistatic indentation system for nanomechanical testing of materials. This instrument can measure mechanical properties like, including Young’s modulus, hardness, and fracture toughness of coatings and thin films. The patented capacitive transducer technology allows for a high displacement sensitivity and a low thermal drift. Users can select Standard load or High load transducer to characterize their samples.

**Keithley 4200 SCS Semiconductor Parameter Analyzer and Janis ST-500 Cryogenic Probe Station**

Keithley 4200-SCS is a modular, fully integrated parameter analyzer that performs electrical characterization of materials, semiconductor devices, and processes. From basic I-V and C-V measurement sweeps to advanced ultra-fast pulsed I-V, waveform capture, and transient I-V measurements, the 4200-SCS provides the researcher or engineer with critical parameters needed for design, development, or production. For C-V measurement, an HP 4284A precision LCR meter is used. The wide 20 Hz to 1 MHz test frequency range allows the HP 4284A to test components to the most commonly used test standards. These tools are connected with a Janis ST-500 cryogenic probe station. The sample chamber has four micro manipulated probe stations (configured with three SMUs, source-measure units), one of the ports is dedicated for optical fiber. The temperature of the sample chuck can be varied from 80 K to 475 K with liquid nitrogen and lakeshore 336 Automatic Temperature Controller.

**Magnetron Sputtering System**

AJA international-built ATC 2000V sputtering system has three planar magnetron guns. Two of the sputter guns are 3-inches wide and another a 2-inch gun. These sputtering guns can be tilted to maintain control on the thickness of the film deposited at different sample heights. The sputter guns are enclosed in a chimney configuration minimizing cross-contamination between sources. This system has a 1000W DC power supply and a 600W RF power supply, both can be simultaneously used to co-deposition. This system has a load-lock for fast substrate transfer and the main chamber is always at a low base pressure of 5 x 10-8 Torr. This system has two mass flow controllers, one for argon and the other can be configured for reactive sputtering with O2 or N2 to deposit oxides or nitrides. An adaptive pressure control valve (VAT) is used to control the process pressure independent of the gas flow. The system can accommodate 8-inch wafers and the substrate can be heated to 700oC. The process parameters in this system are computer-controlled for reproducible thin film thickness and properties. Sputter targets available are Ti, Cr, Au, Ag, Al, C, Mo, Pt, Si, Ta, ITO, and TiO2.

**Nicolet 470 FT-IR**

FTIR spectroscopy is used for the structural characterization of organic and inorganic molecules in solids, liquids, gases, and on surfaces. Qualitative and quantitative information about the molecule may be obtained. The spectral range of the instrument is 400-4000 cm-1. Attenuated Total Reflectance (ATR)-FTIR accessory is also available.

**OAI 200 Mask Aligner**

The Model 200 is a benchtop mask aligner that utilizes an air bearing/vacuum chuck leveling system. The substrate is leveled quickly for parallel photo mask alignment and uniform contact across the wafer during contact exposure. The alignment module incorporates micrometers for X, Y, and Z-axis. OAI UV light source (i line-365 nm) provides collimated UV light across the wafer. This tool can make repeatable micron-scale patterns in photoresists using a transmission mask.

**Optical Profilometer, Vecco NT 9109**

Optical Profiler measures surface topography from nanometer-scale roughness through millimeter-scale steps, with an unmatched combination of sub-nanometer resolution. This interferometry system provides the most precise, 3D surface metrology. Sub-nanometer resolution for roughness analysis of super-smooth surfaces; fast measurement acquisition over large lateral areas.

**Parylene-C Deposition**

The Specialty Coating Systems, Inc., LABCOTER® 2 vacuum deposition system is a portable system designed for deposition of protective Parylene conformal coatings. Parylene is an inert, nonconductive polymer that is applied in a thin layer to isolate materials such as electronic circuit boards, automotive electronic assemblies, and medical devices from moisture, contaminants, corrosives, and acids. Parylene polymer coatings are performed via vapor deposition. The deposition process begins as the powdered dimer is vaporized under vacuum and heated to form a dimeric gas. The polymerization process occurs at ambient temperatures and does not involve solvents, catalysts, or cure forces. Parylene coatings can be applied in thicknesses from several hundred angstroms to tens of microns. The system is currently configured for Parylene C coatings.

**Raman Spectroscope**

InVia Raman microscope is an instrument used for structural characterization of organic and inorganic molecules in solids, liquids, gases, and on surfaces. This new generation Raman microscope offers a powerful non-destructive and non-contact method of sample analysis. InVia Raman microscope is fitted with two diffraction gratings (1800 lines/mm and 2400 lines/mm) to satisfy all requirements for spectral resolution, spectral coverage and optimized sensitivity and is coupled with a 633nm laser. This system is fitted with a Renishaw HSES automated XYZ stage coupled to a high-resolution color video, 5MP CMOS camera to provide the mapping and imaging capabilities.

**Rapid Thermal Processing**

The Heatpulse 610 is a rapid thermal annealing system capable of heating a sample to temperatures as high as 1100°C in a short time. The system can ramp up rapidly (up to 50 C/s) and the process periods are typically 1-600 seconds. The Heatpulse system uses a set of high-intensity lamps that surround a quartz isolation tube to heat the sample. The system has closed-loop temperature control with thermocouple (TC) temperature sensing. Currently, the process gases available for use are Argon and Forming Gas (5% Hydrogen with Nitrogen balance).

**Rigaku Ultima IV X-ray Diffractometer**

The Ultima IV is a state-of-the-art multipurpose X-ray diffraction (XRD) system. This tool has a multistage goniometer that accommodates powder samples and thin films. The Ultima IV X-ray diffractometer can perform micro-crystalline diffraction, thin-film diffraction, in-plane scattering for minerals, ceramics, film, pharmaceuticals, and other powdered materials. Besides, standard diffraction scan, this tool can perform thin-film reflectivity measurements to determine the density, roughness, interface roughness of multilayer thin films.

**Shimadzu UV-2401 UV-VIS Spectrophotometer**

The Shimadzu UV-2401 UV-VIS spectrophotometer is a standard research-grade UV-VIS spectrophotometer capable of scanning from 190-900 nm. The software can acquire data in spectrum mode, photometric mode, and kinetic data. There are two attachments available, the standard 2-cell sample/reference holder and the other to hold flat substrates.

**Thermal Analysis: DSC and TGA**

Simultaneous DSC TGA (SDT 600): This system provides simultaneous measurement of weight change (TGA) and differential heat flow (DSC) on the same sample from ambient to 1,500°C. The system is equipped with a Platinum-Rhodium thermocouple-based temperature control unit, horizontal furnace, and gas purge system.

**VASE Ellipsometer**

The Variable Angle Spectroscopic Ellipsometer (VASE) is the most accurate and versatile ellipsometer for research on all types of materials: semiconductors, dielectrics, polymers, metals, and multi-layers. Spectroscopic ellipsometry involves the measurement of the change in the polarization state of light as a function of wavelength and analysis of ellipsometric data is used to determine the film thickness and optical constants of the materials. WVASE32® software package provides easy calibration, data acquisition, and analysis for all different applications. Spectral Range – 193nm to 2700nm; Reflection and Transmission Ellipsometry; Generalized Ellipsometry. The angle of Incidence: 15 degrees to 90 degrees.

**Xenon Difluroide Etcher**

The XeF2 etcher uses Xenon Difluoride crystals to produce fluorine vapors in a vacuum chamber, which isotropically etch silicon. At room temperature, xenon difluoride, or XeF2, is in a solid crystalline form. When exposed to low pressures, the XeF2 crystals become a gas by sublimation. The XeF2 gas selectively etches silicon, however, it does not etch silica, most photoresists, oxides, nitrides, and many metals.