Facilities Available to NU-ACCESS Staff and Participants

Northwestern University Facilities

Northwestern University relies heavily on shared or core facilities, where the research community shares instruments and technical support. These facilities depend on user fees for operational support. Among the facilities available to the Center are:

Electron Probe Instrumentation Center (EPIC) Various electron microscopes in the McCormick School of Engineering and Applied Science have been consolidated in the EPIC, making for one of the world's most complete arsenals of routine and state-of-the-art electron microscopes. Included in EPIC is the SEM facility, containing a LEO Gemini 1525 sFEG SEM, Hitachi S-3500N variable-pressure SEM, FEI Quanta sFEG environmental SEM and a top of the line Hitachi S-4500 cFEG SEM.

EPIC also houses the TEM facility, which contains a JEOL JEM-2100F FEG FasTEM, a Hitachi H-8100 TEM and a Hitachi HF-2000 analytical electron microscope, and a specimen preparation facility (SPF). With these microscopes comes an array of analytical techniques, including high spatial resolution electron energy loss spectroscopy (EELS) and energy dispersive spectroscopy (EDS), atomic-resolution imaging, electron holography, convergent beam electron diffraction (CBED), and digital spectrum acquisition in the TEM, electron backscatter diffraction pattern (EBSP) analysis and orientational imaging microscopy and e-beam lithography in the SEM.

Ceramics and Metals Processing Facility Equipment is available to prepare, mill, and characterize ceramic powders and then fabricate them by arc melting, pressing, isostatic pressing, slip casting, extrusion, hot pressing, and sinter forging. An ultrasonic machine tool for drilling ceramic specimens is offered. The facility also includes a variety of high temperature furnaces for use in both ambient air and controlled atmosphere. A Micromeritics AutoPore 9500 Porosimeter affords characterization of porosity including pore fraction and pore size distribution.

Integrated Molecular Structure Education and Research Center (IMSERC) provides access to and educates students on the proper use of instrumentation needed for molecular structure characterization. Instruments include nuclear magnetic resonance, mass spectroscopy, inductively coupled plasma-mass spectroscopy, inductively coupled plasma-atomic emission spectroscopy, optical spectroscopy, and trace metal analysis.

Nanoscale Integrated Fabrication, Testing and Instrumentation Center provides a wide range of imaging instrumentation and support facilities for atomic to molecular imaging. These include a **Hysitron Triboindenter**, which provides high-resolution nanomechanics measurements of hard and soft materials. The system includes an integrated heating (200 $^{\circ}$C) and cooling (-10 °C) stage for variable temperature operation and a dynamic modulus analyzer (nano-DMA) module for loss and storage moduli extraction. The instrument allows for ultra-low contact force imaging, ideally suited for soft systems, with a noise floor < 30 nN and resolution < 1nN. The normal displacement resolution is < 0.2 nm. A dedicated digital signal processor and field-programmable gate array (FPGA) provides high-speed data acquisition and offers both load and displacement feedback control modes. **Brucker Dimension FastScan AFM** has fast

scanning rates, automated laser and detector alignment, and built-in measurement automation software. Peak Force Tapping® utilizes pico-newton force control to collect atomic resolution images, while Peak Force QNM® enables quantitative mechanical property measurements at the atomic scale. The instrument allows atomic resolution measurements on both large and small samples in air or fluid, on samples from sub-nanometer to hundreds of nanometers in height without loss of resolution.

Keck Interdisciplinary (Keck II) Surface Science Center hosts Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS), X-ray Photoelectron Spectroscopy (XPS/ESCA), Fourier Transform Infrared Spectroscopy (FT-IR), and Confocal Raman Spectroscopy. In addition, a high-resolution stylus profilometer, a spectroscopic ellipsometer, and an IR microscope are available. A Zetasizer Nano provides the ability to measure three characteristics of particles or molecules in a liquid medium, specifically, particle size, zeta potential and molecular weight.

Central Laboratory for Materials Mechanical Properties MTS servohydraulic, servoelectric, and screw-driven machines are interfaced with computers for studying the mechanical behavior of materials. The machines operate in either a manual or computer-controlled mode for static or dynamic testing. They allow study of elasticity, plasticity, fatigue life, and/or fracture of materials. Real-time crack growth can be observed with a metallurgical microscope attached to the testing units. Temperature (4.2 K to 1373 K)-, environment-, and rate-dependent properties can be observed over a wide range of all parameters.

Art Institute of Chicago Facilities

The **conservation science** laboratory at the Art Institute of Chicago houses state of the art facilities for micro-destructive and non-invasive characterization of artworks, which are comparable to those of other conservation science departments at major American museums. Additionally, fully equipped facilities for the Conservation of paintings, objects, textiles, photography and works of art on paper are available at the Museum. Available scientific instrumentation is described below:

Micro-Fourier Transform Infrared (FTIR) spectrophotometer A Bruker tensor 27 FTIR spectrophotometer with mid-IR glowbar source and DTGS detector, coupled to Hyperion 2000 Automated FTIR microscope with nitrogen cooled mid-band and broad-band MCT detectors (covering the range 7000-600 and 10000-450 cm^{-1}, respectively) is available. Diamond anvil cell and Attenuated Total Reflected objectives with Ge and Diamond crystals for micro-ATR measurements are available.

Raman Microscope The laboratory is equipped with a Jobin Yvon Horiba Labram 300 confocal Raman microscope, equipped with Andor multichannel air cooled open electrode charge-coupled device (CCD) detector (Andor DV420-OE322, 1024x256), BXFM open microscope frame (Olympus) offering high flexibility for analysis of large samples, holographic notch filter, two dispersive gratings (950 and 1800 grooves/mm) and excitation lines of a air cooled frequency doubled Nd:Yag solid state laser (λ_0 = 532 nm), He-Ne laser ($\lambda 0$=632.8 nm), and a solid state diode laser (λ_0 =785.7 nm).

Micro/Macro FT-Raman Spectrophotometer This instrument, funded through the National Science Foundation, Division of Materials Research, Major Research Instrumentation Program, grant DMR-0723053, is composed high resolution (0.4 cm^{-1}) Fourier Transform Infrared Spectrometer (VERTEX 70-BS) coupled with a macro-FT-Raman module (RAMII-1063) and Ramscope III FT-Raman Microscope and open architecture external arm adapted for the study of art objects (ArtArm). The instrument is equipped with a D418-T/R high-sensitivity Ge detector and Nd^{3+}/YAG laser, with excitation wavelength at 1064 nm. The maximum nominal laser power is 530 mW, and microscope objectives of 10x and 40x, in addition to 40xLWD are available with a large sample microscope chamber. An external articulated mount for the RamScope III (ArtArm) provides enhanced positional control of the Raman microscope for FT-Raman microanalysis of samples that are too large for positioning in the micro-Raman sample compartment.

ArtTAX non-destructive, portable µ-X-ray fluorescence (XRF) spectrometer The XRF spectrometer has variable collimators with spot sizes ranging between 0.2 to 2 mm, interchangeable excitation tubes with Mo and W targets, 40 W maximum power (max. 50 kV, max. 1 mA) Be window (0.2 mm thickness air cooled, with Cu-radiator), X-Flash® detector, 5 mm2, energy resolution 160 -165 eV for Mn-Kα at 10 kcps. Maximum count rate 400 kcps, dead time < 10 % at 50 kcps. Analysis can be performed in air, with light element detection available when activating a He stream (60l/min at the sample)

Bruker/Keymaster TRACeR III-V™ energy dispersive X-ray Fluorescence analyzer This portable, hand-held XRF analyzer has Peltier cooled advanced high-resolution Silver-free SiPIN detector with a 13 µm Be window and resolution of approximately 175 eV for the full width at half maximum of the Mn Kα line. The system also has Titanium and Aluminum changeable filters, and is equipped with a rhodium (Rh) transmission target with max voltage of 45kV and tunable beam current of 2-25µA.

Agilent Ion-Trap Gas Chromatographer/Mass Spectrometer A 3800 GC System gas chromatograph (Agilent) equipped with a CombiPal multi-technique autosampler is coupled with a 2200 mass selective detector (Agilent) ion trap mass spectrometer. The mass spectrometer is operated in the EI positive mode (70 eV). Chromatograms are acquired in total ion chromatogram (TIC) mode. For the gas chromatographic separation an Ultra $ALLOY^{+}$-5 fused silica capillary column (5% diphenyl- 95% dimethylpolysiloxane, 30 m × 0.25 mm ID, 0.25 µm film thickness, Frontier Laboratories Ltd., Japan) coupled with Vent-free GC-MS adapter Ultra ALLOY fused silica column (0.5 m × 0.25 mm i.d., Frontier Laboratories Ltd., Japan) is used. The carrier gas is used in the constant flow mode (He, ultra high purity 99.999%) at 1.0 mL/min. The GC-MS system is equipped with a Frontier PY-2020iD multi-functional pyrolizer that allows the sample to be analyzed in one of five analytical modes: pyrolysis (single-shot), thermal desorption followed by pyrolysis (double-shot), multi-step desorption (TD), evolved gas analysis (EGA), and hear cuts based on the EGA thermogram.