
CHARACTERIZATION
MEASURE IT AT BIRCK
PURDUE
UNIVERSITY

Pushing the boundaries of

POSSIBLE

Research at the Birck Nanotechnology Center leads to fundamental science discoveries and development of new technologies that can revolutionize industries. Our center is home to a talented team of researchers, engineers and scientists who are committed to pushing the boundaries of what's possible in nanotechnology.

We welcome users from academia and industry to our leading-edge characterization facility. In-depth training by research scientists is available for users who wish to use the equipment; our team of experts also offers measurement and analysis services.

All laboratories are designed for low acoustic noise, less than 1 milligauss EMI, and ± 1 °C temperature stability. Additionally, the first-floor laboratories achieve NIST A vibration rating. The TEM laboratory has yet tighter temperature controls, specialized airflow patterns, and special acoustic materials on the walls and floors.

ELECTRON MICROSCOPY

RESEARCHER IN CHARGE

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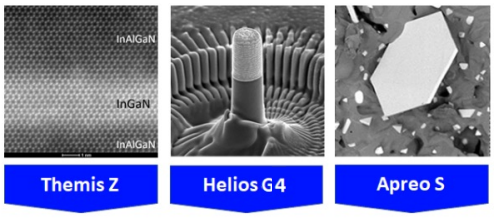
Scanning and transmission electron microscopes and focused ion beam (FIB), including these instruments: *Themis Z Double Aberration Corrected S/TEM, Helios G4 UX DualBeam SEM/FIB*, and *ThermoScientific Apreo FE-SEM.*

- one-to-one sessions and user support
- Imaging and Elemental Chemical Analysis
- Patterning and Slice-and-View
- TEM sample preparation
- Tomography and 3D reconstruction



	Themis Z	Helios G4	Apreo S
Type	TEM/STEM	SEM/FIB	SEM
Resolution	0.65 Å @ 300kV 1.8 Å @ 80kV	0.6nm @ 30kV	0.8nm @ 30kV 1nm @ 1kV
Detectors	EDX, EELS, ADF, BF, HAADF, 4-Quadrant DF	EDX, STEM TLD (SE/BSE) ETD (SE), ICE SI/SE	IC T1 (BSE) IC T2 (SE) ETD, IC T3 (SE/BSE)
Accelerating Voltage	60 – 300kV	e- : 350V – 30kV Ion: 500V – 30kV	0.8 – 30kV

SCANNING PROBE MICROSCOPY

RESEARCHER IN CHARGE

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A variety of scanning probe microscopes are available. Samples can be imaged in air or liquid environments. Measurement modalities include:

Contact mode and tapping mode; Force displacement; Contact resonance and bimodal (AM-FM); Magnetic force microscopy (MFM); Electrostatic force microscopy (EFM); Piezoelectric force microscopy (PFM); Kelvin probe force microscopy (KPFM).

Available AFMs include *Park NX20, Asylum Cypher S AFM, Asylum MFP-3D- Bio AFM*, and *Bruker Catalyst*.

For vacuum AFM/STM, see Surface analysis section.

Park NX20 AFM (credit: parksystems.com)

SURFACE ANALYSIS

RESEARCHER IN CHARGE

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X-ray Photoelectron Spectroscopy (XPS) is used to examine the chemical composition of a solid surface.

Kratos Axis Ultra DLD Imaging XPS: Monochromatic X-ray source, charge neutralizer to study non-conducting samples; Real time imaging XPS to allow x- y- chemical mapping; Reaction cell (CatCell) to treat samples under different gas mixtures up to 6 bar at up to 1000 °C; Sputtering gun, which can use either Ar^+ or coronene ($C_{24}H_{12}$) for non-destructive depth profiling; UV-lamp to perform Ultra-Violet Photoemission Spectroscopy (UPS); Ar-filled glove-box attached directly to the entry- lock of the XPS instrument to analyze air- and moisture-sensitive samples.

Omicron Surface Analysis Cluster: a unique multi-tool instrument, which houses X-ray photoelectron spectroscopy (XPS), low energy electron diffraction (LEED), UHV scanning tunneling microscopy and atomic force microscopy (STM/AFM) and high-resolution electron energy loss spectroscopy (HREELS). The system is equipped with a UHV treatment chamber, where a sample can be heated (1000 K) or cooled with LN_2 (120 K), exposed to different gasses including metal-organic precursors. A mass-spectrometer, e-beam evaporator, atomic hydrogen source, metal sputtering source and several thermal evaporators are installed on the treatment chamber.

X-ray diffractometry (XRD) *(Panalytical MRD X'Pert Pro)* can determine the atomic crystalline structure, orientation, and quality as well as density and film thickness; samples can be films, crystals and polycrystalline materials up to 4" wafer; measurements up to 900°C; Spatial mapping (100 x 100 mm motion) of sample surfaces; High speed wide angle x-ray diffraction and fast mode reciprocal space mapping; Pole figure; Low angle measurement down to 0.1 °.

MATERIALS AND ROLL-TO-ROLL CHARACTERIZATION

RESEARCHER IN CHARGE

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Rheometry *(TA Instruments DHR-3 Rheometer):* Accessories are available for measurement of viscometry, viscoelastic properties, dynamic mechanical analysis, and dielectric properties of solids, liquids, and viscoelastic materials. Many tests have temperature control over a wide range, and some can also be carried out under humidity control. UV accessory is available to measure property changes during UV curing processes.

Thermogravimetric Analysis, Dynamic Scanning Calorimetry *(TGA Netzsch TG 209 Tarsus, DSC Netzsch DSC 214 Polyma):* Automated temperature ramps, cycling, and hold tests are available, or advanced programming is possible to simulate process. Nitrogen atmosphere.

Instrumented Drier *(custom apparatus "JOEY")* Measure weight, thickness, temperature, and optical birefringence to determine time to dry polymer solutions, as well as dynamic development of anisotropy.

Mechanical Load Frame *(custom apparatus)* Tensile testing with temperature control and in-situ optical measurements for thermomechanical and opto-mechanical property measurements on solid films.

ELECTRICAL AND THERMAL PROPERTIES

RESEARCHER IN CHARGE

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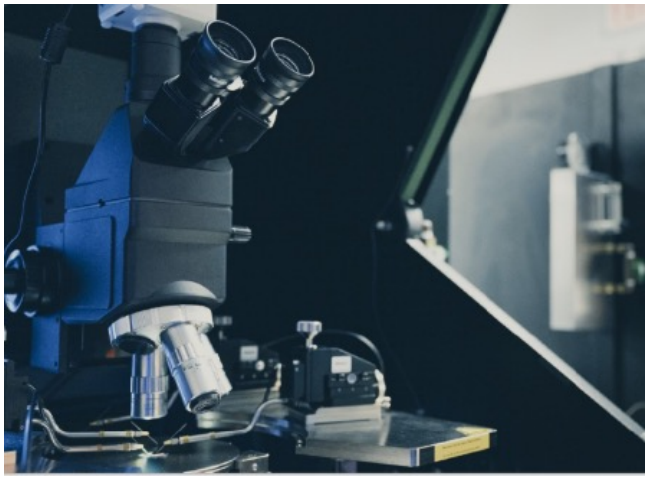
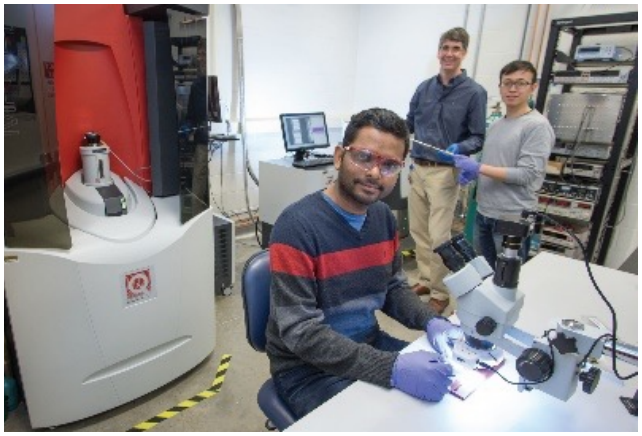
Electrical properties such as carrier mobility and concentration, resistivity, dielectric constant and breakdown can be measured on films, bulk samples, or devices using a suite of probe stations and cryostats in conjunction with parameter analyzers and lock-ins. Environments include air, vacuum, and controlled atmosphere. Measure large device arrays with semi-automated probe stations.

Thermal properties of heat capacity, thermal conductivity, and Seebeck effect can be measured on bulk materials. See page 4, Optical characterization section for thin film thermal measurement capabilities.

Cryostats include a *Quantum Design DynaCool PPMS* (electrical and thermal properties; Temperatures from 1.8 K – 400 K and magnetic fields up to 9 tesla) and an *Oxford Instruments Triton* dilution refrigerator (10 mK, 12 tesla).

Probe stations from *FormFactor, SemiProbe, Micromanipulator, EverBeing, LakeShore, Jandel:* temperatures from 3.2 – 675 K and magnetic fields up to 2.5 tesla. Wafer size up to 8" with automated probing for large device arrays.





MAGNETIC PROPERTIES

RESEARCHER IN CHARGE

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Measure such properties as magnetization, permeability, magnetic anisotropy, phase transitions and GHz spin dynamics. Samples can be thin films, powder, bulk or single crystals. Magneto-optic Kerr effect (MOKE) of micron-scale materials is also available (see page 5, Faculty owned equipment section).

SQUID magnetometry *(Quantum Design MPMS-3 EverCool):* high sensitivity 10^{-8} emu (10^{-11} A·m ^{2}); SQUID-AC susceptibility from 0.1 to 1000 Hz; temperatures 1.8 – 1000 K; magnetic fields up to 7 tesla.

Broadband ferromagnetic resonance (FMR) spectroscopy *(Quantum Design DynaCool PPMS)* to 18 GHz; vibrating sample magnetometry (VSM); temperatures 1.8 – 400 K, magnetic fields up to 9 tesla.

OPTICAL CHARACTERIZATION

RESEARCHER IN CHARGE

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Raman spectroscopy is a method of measuring frequencies and strengths of molecular vibrations. These frequencies typically belong in the infrared area of electromagnetic spectrum, but Raman spectroscopy allows measuring them using visible or near-IR light. Vibrational spectra of molecules are used to identify different species or crystalline structures of solids.

Thermo Scientific DXR3xi Raman Imaging Microscope:

- Excitation: 455 nm and 532 nm laser lines
- Raman mapping: fast 3D positioning stage with 100-nm step sizes in the X-Y direction and 200-nm in the Z direction
- Light detection: EMCCD camera
- Spectral resolution: 2 to 5 cm^{-1}, depending on the spectral window

Ellipsometry is used to infer information about thickness, permittivity and refractive index of thin films (down to ~nm).

J.A. Woollam RC2 Spectroscopic Ellipsometer: measurements of refractive indices, permittivities and Mueller matrices of bulk materials and thin films; composition, roughness and thickness of thin films, scatterometry and transmission, 210–2500 nm.

J.A. Woollam V-Vase Spectroscopic Ellipsometer: 200–3000 nm range, in air, temperature range of 80–1273 K

Grating spectrophotometry *(PerkinElmer Lambda 950):* capable of measuring transmittance, absorbance, reflectivity and scattered light spectra over a 190–3000 nm range, and is equipped with an integrating sphere for reflectivity and scattered light spectra measurements in various geometries.

Thermo Scientific DXR3xi Raman Imaging Microscope (credit: thermofisher.com)

For access to the clean room optical microscopes listed below, please contact: Ron Reger, rreger@purdue.edu, (765) 494-6667.

Digital 3D microscope *(Keyence VHX-950F):* 20x-2000x; compound light with multiple lighting modes, image contour enhancement, glare removal, and vibration compensation. The depth composition feature produces sharp (focus-stacked) images and enables a full 3D reconstruction of the sample.

Optical microscopes *(several, including Olympus BX-60* and *Nikon Eclipse L150)* offering 5x-150x lenses, bright/dark field and Nomarski, and CCDs with SPOT software for image capture.

Keyence VHX-950F Digital Microscope (credit: keyence.com)

OTHER ADVANCED MEASUREMENTS AVAILABLE IN RESEARCH LABS

Several research groups at Birck are making select instruments available for collaborations:

WiTec Alpha300R Raman/ Photoluminescence(PL)/ Photocurrent Imaging Microscope
wavelengths of 405 nm, 488 nm, 532 nm, 785 nm; temperature range of 80–600 K
Prof. Thomas Beechem lab
tbeechem@purdue.edu

Horiba Xplora Raman/PL microscope
red and green laser wavelengths (638 nm and 532 nm); temperatures down to 10 K
Prof. Yong Chen lab
chen276@purdue.edu

Horiba LabRAM800 Raman spectrometer
Prof. Xianfan Xu lab
xxu@ecn.purdue.edu

JA Woollam IR-VASE Mark II Spectroscopic Ellipsometer
temperature range of 80–600K
Prof. Thomas Beechem lab
tbeechem@purdue.edu

Magneto-optic Kerr effect (MOKE)
is an optical measurement of magnetic properties of films. We have a MOKE optical cryostat (temperatures down to 6 K) equipped with a 5 tesla superconducting magnet.
Prof. Yong Chen lab
chen276@purdue.edu

Ultrafast pump-probe thermoreflectance (Coherent Mira)
for thermal conductivity and interface resistance
Prof. Xianfan Xu lab
xxu@ecn.purdue.edu

Ultrafast VIS-IR pump-probe spectroscopy system (Coherent Legend) to measure ultrafast carrier dynamics
Prof. Xianfan Xu lab
xxu@ecn.purdue.edu

Scattering near-field scanning optical microscopy
Prof. Xianfan Xu lab
xxu@ecn.purdue.edu

FTIR and Continuum IR microscopy
(Thermo Electron Nicolet IS50R)
Prof. Xianfan Xu lab
xxu@ecn.purdue.edu

CONTACT US

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For more information on Birck's facility **resources** including characterization and nanofabrication.

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