

# CENTER FOR NANOSCALE MATERIALS TOOLS AND CAPABILITIES

\*Indicates remote operation is available

## Nanofabrication and Devices

### Lithography

- Electron Beam Lithography JEOL 8100FS\*
- Electron Beam Lithography: Raith 150\*
- FIB/SEM: FEI Nova 600 NanoLab\*
- Heidelberg MLA150 Maskless Lithography\*
- Interferometric Lithography System
- Laser Pattern Generator (Microtech LW405, Direct Write Optical Lithography)
- SUSS MA6/BA6: Contact aligner for front side and front-to-back side alignment
- Wafer Priming Oven: YES-TA Series
- Stepper: ASML PAS 5000 Wafer Stepper

### Post-Processing

- AS-One 150 Rapid Thermal Processor
- Cleaving Machine: LatticeGear Ax 420
- Critical Point Dryer (Leica CPD030)
- ADT Dicing Saw\*

### Wet Chemistry

- Electroplating (Au, Cu, Fe, Ni, Pt)
- Selective Wet Chemical Etching

### Dry Etching

- Hydrofluoric Acid Vapor Etcher
- PlasmaTherm Deep Reactive Ion Etcher for Silicon (DRIE)
- RIE Oxford ICP Etcher (6-inch)
- RIE March CS-1701, Chlorine Chamber
- RIE March CS-1701, Fluorine Chamber
- RIE Oxford PlasmaLab 100, Chlorine and Fluorine Chambers
- Xactix X4 Xenon Difluoride Etcher

### Inspection and Metrology

- Bruker FastScan AFM\*
- Filmetrics f40 Thin Film Analyzer\*
- Four Point Probe
- Keyence 3D Laser Scanning Confocal Microscope, VK-X1000\*
- Laser Confocal Microscope OLS4100
- Optical Microscope: Olympus MX-61
- Potentiostat
- Three-Dimensional Contact Profilometer: Dektak 8
- UVISEL Spectroscopic Ellipsometer: Horiba Jobin Yvon
- Scanning Electron Microscope VEGA 3

### Deposition

- AJA Oxide Sputtering, 3-inch targets\*
- Temescal FC2000 Electron Beam Evaporator
- AJA Sputtering, 2-inch targets\*

- Lambda Microwave Plasma CVD System: Nanocrystalline Diamond Deposition\*
- Oxford Plasmlab 100 Inductively Coupled Plasma Enhanced Chemical Vapor Deposition
- Thermal/PECVD System for CNT and Graphene Synthesis
- AJA Dielectric Sputtering System\*
- AJA Metal Sputtering System\*
- Atomic Layer Deposition (Arradance Gemstar)\*
- Integrated UV-Ozone Cleaner and Molecular Vapor Coater (Nanonex Ultra-100)

### Piezo-Optomechanical Spectrometer (POMS)

### Ultralow Temperature/Strong Magnetic Field Measurements\*

- BlueFors LD400 Dilution Refrigerator System: <10mK base temp, free-space optical access, dc wires, microwave cables, high-pressure fill lines, expedited top-loading sample mechanism, low-noise amplifiers for qubit research
- AMI Superconducting Vector magnet: 5T in Z axis, 1T in Y axis, 10mG field stability, integrated persistent switches

### Wear/Friction Measurements

- Multifunctional Tribometer with controlled environments\*
- PicolIndenter, in situ TEM (PI-95)
- Sonotek Ultrasonic Spray Coating System

## Theory and Modeling

### CNM High-Performance Computing Cluster (Carbon)

### Computational Nanoscience Software and Modeling Expertise

- BLAST (Bridging Length/Timescales via Atomistic Simulation Toolkit)
- Dacapo
- Density-Functional-Based Tight-Binding (DFTB)
- FANTASTX (Fully Automated Nanoscale to Atomistic Structure from Theory and eXperiment)
- GPaw, a real space, grid-based DFT-PAW code
- MPI-Based Parallel Versions of Nanophotonics
- Time-Domain Nanophotonics Simulation Package
- VASP, Ab-Initio Molecular Dynamics Calculations

- Other specialized analysis software or modeling expertise

## Nanophotonics and Biofunctional Structures

### Adiabatic Demagnetization Refrigerator (ADR)\*

### Bench-Top Spectroscopy

- UV-Visible Absorption
- Emission (uv-vis, NIR, MIR)
- FTIR Absorption
- Circular Dichroism
- Cryostat/Temperature Control

### Magneto-optical Microscope (MOM)

### Magneto-Electro-Optical Spectrometer (MEOS)

### Raman Spectroscopy

- Temperature-Controlled Stage

### Electron Paramagnetic Resonance Spectroscopy (EPR: CW and Pulsed)

### Electrochemical Workstation (BASi Epsilon)

### GC-MS (Agilent 5975C Series GC/MSD)

### HPLC (LabAlliance)

### Isothermal Titration Calorimetry (ITC)

### ZetaSizer Nano, Malvern (particle size potential)

### Time-Resolved Emission Spectroscopy

- Time-Correlated Single Photon Counting (TCSPC) Spectroscopy (uv-vis, NIR)
- TCSPC Microscopy (400 – 800 nm)
- Visible and Near-IR TCSPC with Streak Camera
- Near-IR TCSPC with Superconducting Nanowire Single Photon Detector

### Transient Absorption Spectroscopy

- Visible Probe
- Near-IR Probe
- Mid-IR Probe
- THz Probe
- Cryostat

### Visible and Near-IR Microscopy

- Lamp Illumination
- Laser Illumination
- Visible Detection
- Near-IR Detection
- Cryostat

### Correlation/Antibunching Measurements

- Visible (350 – 800 nm) Detection with APD Detectors

- NIR (800 nm – 2 μm) Detection with Superconducting Nanowire Single-Photon Detectors (SNSPD)

**Field Emission Scanning Electron Microscope, JEOL JSM-7500F**

**Laser Scanning Confocal Microscope, Zeiss LSM 510 Meta**

**Optical Microscope, Zeiss Axio Imager Z1 M Upright\***

**General Wet Lab Space for Sample Prep**

**Surface Preparation**

- Harrick Plasma Cleaner
- UVO Surface Cleaner

**Autoclaves**

**Centrifuges**

**Drop Shape Analysis Tool**

**Lyophilizer**

**Ossila Slot-Die Coater**

**Rotary Evaporator**

**Schlenk Lines**

**Solar Simulator, Oriel**

**Internal/External Quantum Efficiency Measurement System (Oriel IQE-200)**

**Glove Box, MBraun LabMaster 130**

**Integrated Glove Box System**

**Biological Safety Cabinets, Labconco Purifier Delta Series (Class II, B2)**

**Peptide Synthesizer\***

**Solution-Shearing Station**

**Synthesis**

- Surface Modification of Nanoparticles
- Functionalization
- Quantum Dots
- Metal Nanoparticles
- Metal Oxide Nanoparticles

**Post Processing**

- External Field, Ultrasound, Dip-coating

**Quantum and Energy Materials**

**Synchrotron X-Ray Scanning Tunneling Microscopy (SX-STM) at APS Sector 4\***

**Agilent Inductively Coupled Plasma Optical Emission Spectroscopy ICP-OES**

**Electrical Characterization**

- Associated High-Sensitivity Test Systems
- Keithley 4200-SCS/F Semiconductor Parameter Analyzer

**FT-IR with Hyperion Microscope, Bruker Vertex 70**

**Langmuir-Blodgett, Kibron MicroTrough X**

**Luminescence spectrometer, Perkin-Elmer LS 55**

**Magnetometry**

- Quantum Design MPMS-XL
- Quantum Design PPMS-9

**Physical Vapor Deposition, common loadlock is shared\***

- Lesker E-beam Evaporator (PVD250)
- Lesker Sputtering System (CMS18)

**Rheometer, AntonPaar Physica MCR301**

**Rheo-XPCS at APS Sector 8**

**Scanning Probe Microscope, Veeco MultiMode 8**

- PeakForce Quantitative Nanomechanical Mapping, Tapping
- Fluid Imaging
- Low Current STM
- Magnetic Force
- Variable Temperature Imaging

**Spin Coater, Laurell WS-400, not for lithography resist work**

**Synthesis Lab – Inorganic Crystals**

**Thermal Analysis**

- Differential Scanning Calorimetry, Mettler Toledo 823
- Thermogravimetric Analysis, Mettler Toledo 851

**Tube furnaces (1-inch)**

- Argon, Oxygen, MTI

**UV-Vis-NIR spectrometers, Perkin-Elmer Lambda 950 and Cary 5000**

**VT-UHV-Atomic Force Microscope/Scanning Tunneling Microscope (AFM/STM; Omicron VT-AFM XA)\***

- Contact AFM
- Magnetic Force Microscopy
- Non-Contact AFM
- Scanning Tunneling Spectroscopy

**Optical UHV VT STM/AFM\***

- Lasers for Optical UHV VT STM/AFM
- Contact and non-contact AFM, MFM
- Scanning Tunneling Spectroscopy

**UHV Cryo SFM with 6T Magnetic Field, Omicron**

**Low Temperature Scanning Tunneling Microscopy (LT-STM, Createc)\***

**Laser Scanning Interferometric Microscope**

**SPM Tip Etching**

**West-Bond Wire Bonder\***

**X-Ray Diffractometer Bruker D2 Phaser**

**X-Ray Diffractometer Bruker D8 Discover**

- Grazing Incidence, High-Resolution Four-Circle, Reciprocal Space Mapping, Reflectivity, Rocking Curves, Eiger2

**Electron and X-Ray Microscopy**

**Hard X-Ray Nanoprobe, Sector 26\***

- Multimodal Chemical and Structural Nanoimaging
- Scanning Nanodiffraction, Bragg Ptychography

**UEM: Ultrafast Electron Microscopy\***

- Temporal resolution ca. 1 ps
- Spatial resolution ca. 1 nm
- Energy resolution ca 1 eV
- Pump laser wavelengths: 515, 325-450, 650-900, 1030, and 1200-2000 nm
- Repetition rate: 10-500 kHz (fs laser), 1-100 kHz (ns laser)

**ACAT: Argonne Chromatic Aberration-Corrected TEM\***

- Cc/Cs-Corrected HRTEM and EFTEM Imaging and Diffraction

**JEOL IT800HL SEM\***

**Talos F200X (S)TEM\***

- TEM Imaging and Diffraction (80, 120, & 200kV)
- STEM Imaging (HAADF & BF; DF2, DF4, DPC, 80, 120, & 200 kV)
- XEDS, Super-X, 4SDD EDX System

- EDS Mapping (profiles and/or maps)
- Lorentz Imaging (200 kV)
- Tomography (200 kV)

**Field Emission Transmission Electron Microscope, JEOL JEM-2100F\***

- TEM Imaging and Diffraction (200 kV)
- EFTEM Imaging (200 kV)
- EELS (200 kV)
- XEDS
- Tomography (200 kV)
- Special Specimen Holders
  - Liquid Flow Holder (room temp)
  - Gas Flow Holder (room temp or 100 – 500C)
  - Single-Tilt Heating Specimen Holder (T <= 900C)

**FEI Tecnai F20ST (S)TEM\***

- TEM Imaging and Diffraction (80, 120, & 200 kV)
- STEM Imaging (HAADF & BF; 80, 120, & 200 kV)
- EFTEM Imaging and Diffraction (120 & 200 kV)
- EELS (120 & 200 kV)
- XEDS
- Spectrum Imaging (profiles and/or maps)
- Lorentz Imaging (200 kV)
- Tomography (200 kV)
- Special Specimen Holders:
  - Double-Tilt Liquid N2-Cooled (T >= 97 K)
  - Double-Tilt Heating
  - Tilt-Rotate Liquid He-Cooled

**Zeiss 1540XB FIB-SEM**

- TEM Sample Preparation
- 3D FIB-SEM Serial Sectioning
- SEI & BSE Imaging, FIB cross-sectioning

**Zeiss NVision FIB-SEM\***

**FEI Quanta 400F (E)SEM\***

- SEI & BSE Imaging (2 – 30 kV)
- High-Vacuum Mode (P < 10-5 torr)
- Low-Vacuum Mode (P ~ 0.1 – 2 torr)
- ESEM Mode (P ~ 2 – 20 torr)
- ESEM Mode with a gas other than air or water vapor
- Peltier-Cooled Stage (T ~ 248 – 328 K)
- Heating Stages (T < 1273 K or T < 1773 K)

**Hitachi S-4700-II SEM\***

- SEI & BSE Imaging (0.5 – 30 kV)
- XEDS Mapping or Spectrum Imaging

**Specimen Preparation Resources (not FIB)**

- Cutting from bulk, Grinding/Polishing, Dimpling, Ion-Milling\*, Vacuum-Coating with gold or carbon

**Data Analysis**

- Image Processing
- HRTEM Image Simulation
- Diffraction Pattern Simulation
- XEDS Analysis (inc. spectrum images)
- EELS Analysis (inc. spectrum images or EFTEM spectrum images)

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