

CENTER FOR NANOSCALE MATERIALS TOOLS AND CAPABILITIES

Nanofabrication and Devices

Lithography

- Electron Beam Lithography: JEOL 8100FS
- Electron Beam Lithography: Raith 150
- Focused Ion Beam: FEI Nova 600 NanoLab
- Heidelberg MLA 150 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
- 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
- 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
- RIE Oxford ICP Etcher (6-inch)

Inspection and Metrology

- Filmetrics f40 Thin Film Analyzer
- Laser Confocal Microscope OLS4100
- Four Point Probe
- Optical Microscope: Olympus MX-61
- Potentiostat
- Bruker FastScan Atomic Force Microscope
- Scanning Vibrating Electrode: SVET M370
- 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 Plasmalab 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 (Arradience 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
- 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

Bench-Top Spectroscopy

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

MEOS: Magneto-Electro-Optical Spectrometer

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

Synthesis

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

Post-Self-Assembly 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

4K UHV STM with Optical Access

Low Temperature Multimode 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

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

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 (in conjunction with FIB cross-sectioning)

Zeiss NVision FIB-SEM

FEI Quanta 400F (E)SEM

- SEI & BSE Imaging (2 – 30 kV)
- XEDS Mapping or Spectrum Imaging
- 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, Electropolishing

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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