CENTER FOR NANOSCALE MATERIALS
TOOLS AND CAPABILITIES

Nanofabrication and Devices

Lithography
- ☐ Electron Beam Lithography System: JEOL 8100FS
- ☐ Heidelberg MLA 150 Maskless Lithography
- ☐ Electron Beam Lithography System: Raith 150
- ☐ Focused Ion Beam: FEI Nova 600 NanoLab
- ☐ 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)
- ☐ Thermocarbon Dicing Saw: TCAR 864-1

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 Chamber
- ☐ RIE Oxford PlasmaLab 100, Fluorine Chamber
- ☐ Xactix X4 Xenon Difluoride Etcher
- ☐ RIE Oxford ICP Etcher (6-inch)

Inspection and Metrology
- ☐ Filmetrics f40 Thin Film Analizer
- ☐ Laser Confocal Microscope OLS4100
- ☐ Four Point Probe
- ☐ Optical Microscope: Olympus MX-61
- ☐ Potentiostat
- ☐ Scanning Probe Microscope (PSIA Park Scientific XE-HDD)
  - ○ Contact and Non-Contact Modes
  - ○ Magnetic Force Microscopy
  - ○ Scanning Thermal Microscopy
- ☐ Scanning Vibrating Electrode: SVET M370
- ☐ Three-Dimensional Contact Profilometer: Dektak 8
- ☐ UVISEL Spectroscopic Ellipsometer: Horiba Jobin Yvon
- ☐ Scanning Electron Microscope VEGA 3 (tungsten filament)

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 (Arradiance Gemstar)
- ☐ Integrated UV-Ozone Cleaner and Molecular Vapor Coater (Nanonex Ultra-100)

Wear/Friction Measurements
- ☐ Multifunctional Tribometer: Friction and Wear Measurements in Controlled Environment

Sonotek Ultrasonic Spray Coating System

Ultralow Temperature/Strong Magnetic Field Measurement
- ☐ BlueFors LD400 Dilution Refrigerator System: <10mK base temperature, 5x free-space optical access, 100x dc wires, 20x microwave cables, 2x high-pressure fill lines, expedite top sample loading mechanism, low-noise amplifiers for qubit research
- ☐ AMI Superconductor Vector Magnet: 5T in Z axis, 1T in Y axis, 1T in X axis, 10mG field stability, persistent switches integrated

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 the 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

Microfluidic Droplet Generation and Imaging

MEOS: Magneto-Electro-Optical Spectrometer

Raman Spectroscopy
- ☐ Temperature-Controlled Stage

Electron Paramagnetic Resonance Spectroscopy (EPR)

Electrochemical Workstation (BASi Epsilon)

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

HPLC (LabAlliance)

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

U.S. DEPARTMENT OF ENERGY
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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

Autoclave

Centrifuge
- ☐ Beckman Coulter Avanti J-E Centrifuge
- ☐ Beckman Coulter Optima L-100 XP Ultracentrifuge

Drop Shape Analysis Tool

Lyophilizer

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 OPV

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 Entanglement Microscope

Quantum and Energy Materials

Synchrotron X-Ray Scanning Tunneling Microscopy

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

Integrated Glove Box System

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

Scanning Probe Microscope, Veeco MultiMode 8
- ☐ PeakForce Quantitative Nanomechanical Mapping
- ☐ PeakForce Tapping
- ☐ Torsional Resonance Mode
- ☐ Contact or Tapping mode
- ☐ Fluid Imaging
- ☐ Low Current Scanning Tunneling Microscopy
- ☐ Magnetic Force
- ☐ Variable Temperature Imaging (-30 to 250 C)

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 Gas
- ☐ Oxygen Gas

MTI Tube Furnace

UV-Vis-NIR spectrometer, Perkin-Elmer Lambda 950

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

UHV 4K SPM 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 XRD)

X-Ray Diffractometer (Bruker D8 Discover, Point Detector, VANTEC-1 Linear Detector)
- ☐ Grazing Incidence
- ☐ High-Resolution Four-Circle
- ☐ Reciprocal Space Mapping
- ☐ Reflectivity
- ☐ Rocking Curves

Electron and X-Ray Microscopy

Hard X-Ray Nanoprobe
- ☐ Chemical and Structural Nanoimaging
- ☐ Scanning Nanodiffraction

ACAT: Argonne Chromatic Aberration-Corrected TEM
- ☐ Cc/Cs-Corrected HRTEM Imaging and Diffraction
- ☐ Cc/Cs-Corrected 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; may need to provide chips)
  - ○ Gas Flow Holder (room temp or 100 – 500C; may need to provide chips)
  - ○ 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 Specimen Holder (T >= 97 K)
  - ○ Double-Tilt Heating Specimen Holder (T <= 1270 K)
  - ○ Tilt-Rotate Liquid He-Cooled Specimen Holder (T > 20 K; pre-funded user account required to purchase liquid He)

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 < 10⁻⁵torr)
- ☐ 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 (including spectrum images)
- ☐ EELS Analysis (including spectrum images or EFTEM spectrum images)

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