

## **Vanderbilt Institute of Nanoscale Science and Engineering (VINSE)**

VINSE provides access and training on state-of-the-art fabrication and characterization equipment inside Vanderbilt University's Engineering and Science Building (ESB). Full-time staff provide training, process assistance and tool troubleshooting. Our facilities include a cleanroom, analytical support core and advanced imaging suite. The cleanroom provides cutting-edge nanofabrication tools for the development of materials and integrated devices as well as microfluidic and nano-photonic systems. An analytical laboratory conveniently located adjacent to the cleanroom contains a comprehensive range of characterization tools. The imaging suite hosts a number of advanced imaging platforms.

### **VINSE Cleanroom**

The VINSE cleanroom is a bay-and-chase design with a total floor space of approximately 10,000 ft<sup>2</sup>: 4500 ft<sup>2</sup> of space under filter; 4000 ft<sup>2</sup> of chase areas; and 1500 ft<sup>2</sup> of hazardous process material (HPM) support corridor and storage rooms. There are two ISO 5 (Class 100) lithography bays with a combined area of 1100 ft<sup>2</sup> plus a separate 250 ft<sup>2</sup> ISO 6 (Class 1000) e-beam lithography (EBL) enclosure designed to noise criterion (NC) 25. Two additional ISO 6 (Class 1000) bays totaling 1400 ft<sup>2</sup> are utilized for deposition, etch and metrology activities. Air temperature and moisture levels are controlled at 68±2°F and 44±4% relative humidity (RH), respectively, via a cleanroom-dedicated make-up air system. Twelve recirculation air-handling units maintain pressure cascades across areas of different cleanroom classifications. Central utilities for house and high-purity nitrogen, compressed dry air (CDA), process vacuum, process cooling water and type E-1 ASTM electronics and semiconductor grade water are provided along with solvent and corrosive exhaust systems that utilize point-of-use (POU) scrubbers for specialty gases. Hazardous process gases are distributed via a system of gas cabinets and valve manifold boxes (VMBs) while a header-based distribution arrangement is used for non-hazardous process gases. The cleanroom has been designed with flexibility for adding future equipment and expanding and/or reconfiguring floor space including an area for converting 500 ft<sup>2</sup> of chase area into a fifth processing bay. All utilities were installed to allow the addition of new equipment and process capabilities without disruptive modifications affecting existing cleanroom operations. Located on the main floor of the Vanderbilt ESB with floor-to-ceiling windows, the VINSE cleanroom design provides a safe and unique viewing experience for tours, outreach groups and casual observers from both inside and outside the building.

#### Lithography Equipment:

- Assorted spinners and hot plates
- Mask Aligner - Karl Suss MA-6 with backside alignment
- Laser Writer - Heidelberg Instruments µPG 101
- Electron Beam Lithography - Raith eLiNE
- Photoplotter - Bungard Filmstar-PLUS Small

#### Etch Equipment:

- Dry Etch Chlorine - Trion Minilock II
- Dry Etch Fluorine - Trion Phantom II ICP
- Deep Reactive Ion Etch - Oxford PlasmaPro 100 Cobra ICP
- Microwave Plasma Asher - PVA TePla IoN Wave 10
- Plasma Cleaner - Harrick Plasma PDC-32G
- Porous Silicon Etching System - AMMT MPSB 100
- XeF<sub>2</sub> Vapor Etch – SPTS Xactix e2

#### Deposition Equipment:

- Dual Angstrom Amod Deposition Systems – Combined e-beam, thermal evaporation and sputter deposition chamber and standalone thermal evaporation deposition chamber with integrated glovebox system
- Sputter Deposition - AJA International ATC-2200
- PECVD - Trion Orion II
- Atomic Layer Deposition (ALD) System – Picosun R200 Advanced ALD Reactor
- Electroplating System - Silicon Valley Wafer Plating Immersion Beaker-on-a-Stick

#### Thermal Processing Equipment:

- 1" CVD Tube Furnace – Lindberg Blue M
- 4" CVD Tube Furnace – MTI OTF-1200X
- Rapid Thermal Processor – SSI Solaris 150
- HMDS Vapor-Prime/NH<sub>3</sub> Image-Reversal Vacuum Oven - Yield Engineering Systems (YES) 310TA
- Standard vacuum and general-purpose ovens

#### Process Hoods:

- RCA Clean
- Photoresist Spin/Bake
- Photoresist Develop
- Liftoff
- Microfluidics
- EBL Support
- HF
- Acid/Base
- General Use

#### Miscellaneous Equipment:

- Nikon Optical Microscope with digital image capture, custom transfer stage for 2D materials and a custom heated stage
- Olympus Optical Microscope with digital image capture
- Wire Bonder - Westbond Wedge 7476D
- Dicing Saw - Disco DAD3220
- Probe Station – Micromanipulator 450PM, Keithley 4200A semiconductor parameter analyzer, light enclosure
- Custom Solar Cell Test Bed - 100W Xe lamp with AM 1.5G filter, Oriel Inst. Cornerstone 130 monochromator, Keithley 2400 SMU
- Screen Printer - MTI EQ-SPC-2-LD
- Wax Printer - Xerox ColorQube 8750
- 3D Printer - Prusa I3 MK3S
- 3D Printer - Prusa SL1
- PDMS Aligner - ThorLabs motion control, DinoLite Optics
- Microfluidic Flow Control System - Fluigent LineUp Series, Motic Stereomicroscope with digital image capture
- Stylus Profilometer - KLA Tencor P-7
- Contact Angle Goniometer – Ossila L2004A1
- Four-Point Probe – Ossila T2001A
- Parylene Coater – SCS Labcoater 3

#### **VINSE Analytical Laboratory**

Conveniently located adjacent to the cleanroom is the 1100 ft<sup>2</sup> VINSE Analytical Support Core containing a comprehensive set of processing and characterization tools that are readily accessible to users. The VINSE Analytical laboratory has the capability for complete chemical and structural characterization of the materials. Analytical suite of high performance analytical instrumentation facilitates the investigation of both individual nanoparticles and bulk materials. This unique combination of materials processing and comprehensive specimen characterization supports the rapid development of novel multifunctional nanomaterials.

- Nitrogen Glovebox – Mbraun Unilab Workstation
- Schlenk Line – Dual Manifold Vacuum/Argon Line
- Spectrophotofluorometer – Jobin Yvon Fluorolog-3
- Spectrophotometer – Agilent Technologies Cary 5000

- UV/Ozone Cleaner – Jelight M42
- Confocal Raman Microscope – Thermo Scientific DXR
- Zetasizer – Malvern Panalytical Nano ZS
- Fourier Transform Infrared Spectroscopy (FTIR) – Bruker Tensor 27
- Quartz Crystal Microbalance with Dissipation Monitoring (QCM-D) – Qsense E4
- Spectroscopic Ellipsometer – JA Woollam M-2000
- Stylus Profilometer – Veeco Dektak 150
- Thermogravimetric Analyzer (TGA) – Instrument Specialists TGA-1000
- NanoSight – Malvern Panalytical NS300
- NanoAssemblr – Precision Nanosystems Benchtop

### **VINSE Advanced Imaging Suite**

The VINSE Imaging Suite, located in a 23-foot deep basement in the Engineering and Science Building (ESB) hosts our advanced optical instrumentation in a space that minimizes ambient noise, vibration and electromagnetic field levels for best imaging resolution. The imaging suite provides high-bay spaces with 16-foot clearances that will easily accommodate future microscopes.

- FEI Tecnai G2 Osiris TEM/STEM (60-200 kV) equipped with SuperX EDS system, Fischione tomography holder with Amira, Aduro Protochips *in situ* heating holder, Gatan *in situ* heating holder
- Model 1020 Plasma Cleaner
- FEI Helios NanoLab G3 CX dual-beam FIB / SEM for milling, slice and view, patterning with nanobuilder, ICE detector for ion imaging, CBS backscatter electron detector, IBID or EBID Pt deposition, XeF<sub>2</sub> insulator etch, Easylift and AutoTEM 4 for TEM lamella preparation, Auto Slice and View 4 for automated volume imaging, Quorum PP3010t cryo preparation system, AutoScript for python-based automation, HAADF-STEM, and Oxford X-Max EDS.
- Zeiss Merlin SEM with Gemini II column – a high-resolution SEM with Oxford X-Max EDS, HAADF-STEM imaging and charge compensation capabilities.
- Bruker Dimension Icon atomic-force microscope (AFM) – characterization of surface features with nanometer resolution.
- Specimen preparation resources including optical microscopes, Grinders, Polishers, and a Cressington 108 Sputter Coater for specimen preparation.