

## **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 new 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 nanophotonic systems. An analytical laboratory conveniently located adjacent to the cleanroom contains a comprehensive range of characterization tools and 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 40±4% relative humidity (RH), respectively, via a cleanroom-dedicated make-up air system. 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. 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. 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:

- Trion Minilock II
- Trion Phantom II ICPOxford PlasmaPro 100 Cobra ICP
- PVA TePla IoN Wave 10 Microwave Plasma Asher
- Harrick Plasma PDC-32G Plasma Cleaner
- Porous Silicon Etching System - AMMT MPSB 100

#### 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
- Thermal Evaporator – Kurt J. Lesker Nano 36
- Sputter Deposition - AJA International ATC-2200
- PECVD - Trion Orion PECVD
- Atomic Layer Deposition (ALD) system – Picosun R200 Advanced ALD Reactor
- Ni 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

**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 capabilities for complete chemical and structural characterization of materials ranging from individual nanoparticles to bulk materials. The facility also supports synthesis of both semiconductor and polymer-based nanoparticles. The unique combination of materials synthesis and 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, IBID or EBID Pt deposition, XeF<sub>2</sub> insulator etch, Easylift for TEM lamella preparation, Multispecimen stage, 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.