UNIVERSITY OF NOTRE DAME | RESEARCH

Exploring Tomorrow's Innovations Today



The Notre Dame Nanofabrication Facility (NDNF) is a world-class teaching and research cleanroom. The NDNF provides a comprehensive suite of state-of-the-art equipment for designing and manufacturing integrated circuits and devices with geometries ranging from centimeters down to a few nanometers.

The 9,000 Square Foot Cleanroom

A cleanroom is a space that contains a small amount of environmental contaminants, such as dust, airborne microbes, aerosol particles, and chemical vapors. Cleanrooms are classified according to the number of particles of a certain size per cubic foot of air. The NDNF cleanroom is divided into three sections: a Class 10,000 bay (1,227 square feet), a Class 1,000 bay (2,336 square feet), and a Class 100 bay (2,700 square feet). The smaller the Class number, the cleaner the section. For example, the Class 100 bay—demarcated by its amber-tinted windows—has fewer than 100 particles exceeding half a micrometer in diameter per cubic foot of air. As a comparison, typical air in an urban environment contains over 1 million such particles per cubic foot, making the air of Clean 100 bay 10,000 times more clean than the air we breathe every day.

Learn More

nanofabrication.nd.edu

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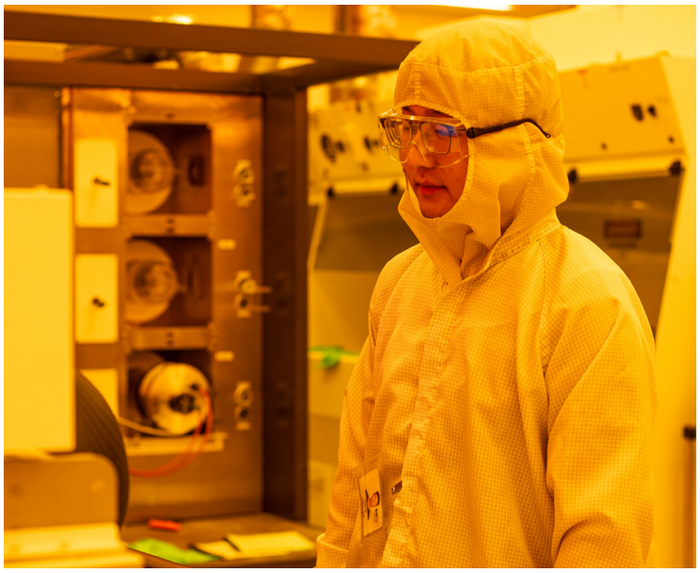


Facility Design on Three Levels

While teaching and research happens on the first floor in the cleanroom, the facility operates across three levels within Stinson-Remick Hall. Air handlers, filters, and controls operate on the second floor, visible through the windows at the top of the atrium stairs. The air handling system circulates approximately 250,000 cubic feet of air per minute, using High Efficiency Particulate Air (HEPA) filters for decontamination and recirculation. Air enters the first floor uniformly through filters in the ceiling and flows with little turbulence to the floor, after which it is returned to the second floor via the space within the double glass walls which face the atrium. The basement below the cleanroom houses support hardware for the research tools on the main floor, including an ultra-pure water system, vacuum pumps, and gas and electrical supply.

Beyond Clean: Other Facility Controls

In addition to dirty air, surface vibrations, electromagnetic waves, and fluctuations in temperature and humidity can interfere with the nanoscale patterning which happens in the cleanroom. Floor vibrations are carefully monitored and managed so as to remain below VC-E (≤ 100 min/sec RMS velocity) in critical locations. Ambient noise is also minimized; the typical noise level is below 60 dBa. AC magnetic fields within the cleanroom are designed to be below 0.1 mG. For comparison, the Earth's DC magnetic field is approximately 500 mG in northern Indiana. Since photolithographic processes typically use ultra-violet sensitive chemicals, amber lighting and window tints are used in the Class 100 area to prevent any stray light from interfering with the process. Temperature is actively controlled to remain within five degrees of 69 degrees Fahrenheit, while humidity is actively controlled to remain within five percent of 40 percent humidity.



Equipment Capabilities

The NDNF is a CMOS and III-V semiconductor fabrication facility as well as a MEMS and microfluidics facility. Cleanroom equipment includes tools to implement all of the processing steps typically used in the fabrication of electronic devices, optoelectronics, microfluidic devices, and novel nanodevices.



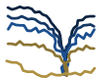
High-resolution lithography: Contact and I-line projection optical lithography, direct-write maskless optical lithography, and a 100 kV electron beam direct-write electron beam lithography.



Etching: Reactive-ion etching (RIE), multiple inductively-coupled RIE systems, a DRIE system for MEMS fabrication, and several plasma cleaning systems.



Deposition: Electron-beam evaporators, thermal evaporators, and several systems for both DC and RF magnetron sputtering of a wide range of metal and dielectric materials. Chemical vapor deposition (CVD) systems include plasma-enhanced chemical vapor deposition (PECVD), atomic layer deposition (ALD), plasma-enhanced ALD, and low-pressure (LPCVD).



Electrical characterization: Ellipsometry, step profilers, a thin-film measurement system, and an analytical probe station.



Microscopic characterization: Full suite of Olympus microscopes, from stereo zoom to a confocal system, and Hitachi S4500 scanning electron microscope providing 5 nm resolution. Each microscope is connected to a high-resolution camera along with a line width measurement system.



Back-end-of-line processing: Chemical-mechanical polishing (CMP), lapping and polishing, backside grinding/thinning, dicing/singulation, and several wire bonding and die attach systems.