INSIDE:

Carnegie Mellon University Nanofabrication Facility

Carnegie Mellon's Nanofabrication Facility occupies space in the University's Hamerschlag Hall.

The Carnegie Mellon Nanofabrication Facility (CMNF or "Nanofab") is a premier research laboratory in the College of Engineering at Carnegie Mellon University (CMU) in Pittsburgh, PA, which includes a 4,000 square-foot cleanroom, three thin film labs, and a photo reduction darkroom. The Nanofab is managed by the data storage systems center (DSSC), and occupies space in the electrical and computer engineering (ECE) department in the university's Hamerschlag Hall, as well as in the College of Engineering building, Roberts Engineering Hall.

History

According to Chris Bowman, director of the Nanofab since its inception, the cleanroom was constructed in 1983 with funds awarded by Richard Cyert, then president of Carnegie Mellon, in support of magnetic storage and semiconductor research in the electrical engineering department. Professor Mark Kryder — as the major user of the facility and director of the magnetics technology center (MTC) — initiated the funding for the original construction and subsequent equipment purchases. The MTC later grew into the DSSC and enjoyed ten years (1990-2001) of substantial funding from the NSF Engineering Research Center program. This funding contributed to extensive upgrades and expansions within the facility.

In 1998, under DSSC Robert White, the Nanofab was established as an independent organization within the ECE. This was done in response to increasing use by other members of the CMU community and recognition that nanotechnology on campus was expanding beyond information storage. To oversee the facility and represent the broader constituency, Professor White constituted the Nanofab Steering Committee, composed of the Nanofab director and faculty who are the major users of the facility. In 2004, Ed Schlesinger was appointed the third DSSC director, and is now chairing the Nanofab committee. The committee, which includes representation from the ECE, the DSSC, the MEMS lab, and the material science and engineering department, provides direction for long-term goals, major equipment acquisitions, and laboratory policies.

Goals

Carnegie Mellon's Nanofab started out as a facility heavily focused on magnetic information storage, and was used exclusively by on-campus university researchers. Over the past two decades, it has grown into a facility that serves a broad community of users, with great emphasis in information storage technology and MEMS technology.

Bowman stated, "The short-term goals of the facility are to continue to increase the visibility of this facility among an even broader set of users on the CMU campus and in the local high-tech community. We are encouraging participation in the Nanofab from faculty members in biology and chemistry, in addition to the traditional engineering departments. We anticipate that the recent acquisition of an e-beam lithography system will substantially improve the attractiveness of the facility for this community."

Bowman added that the long-term goals of the center are to double the Nanofab usage levels over

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the next five years, and to develop a user base that is one-third industrial users, one-third off-campus academic users, and one-third on-campus users. With this increased activity level, staffing levels would be increased to six from the three permanent staff currently employed. It would then be possible to have at least one full-time process engineer who could perform process services, and allow greater participation in process exchanges systems like the MEMS exchange in which the Nanofab currently participates.

Research

Research requiring the use of the facility is inherently multidisciplinary. Faculty, staff, and students access the labs and collaborate on projects from the DSSC, ECE, materials science and engineering, physics, robotics, chemical engineering, mechanical engineering, and industry. However, a majority of the research activity originates from the ECE's data storage systems center and MEMS laboratory. Currently, the research is about two-thirds data storage-related and one-third MEMS.

Information storage can be interpreted very broadly as the development of thin film storage media, including magnetic media, phase change media, ferroelectric, and semiconductor films. Additionally, novel devices for writing information to and reading information from these media, like magnetic recording heads and very small aperture lasers (VSAL's) for thermal writing are being developed.

CVC Connexion sputtering system process chamber each with six each twelve-inch diameter sputtering cathodes. Chris Bowman pictured looking into the wafer exchange chamber.

Karl Suss MA6 backside wafer/bond aligner with near field holography system and fixturing for small chips to six-inch diameter wafers. Han Dong of Bridge Semiconductor pictured preparing to load a mask.

Devices using MEMS technology are fabricated to have microscopic moving parts and have numerous applications. Inertial sensing (gyroscopes and accelerometers) is one of the largest areas of activity, but chemical sensors and other microfluidic components also are being studied and developed in the lab.

These two areas have produced strong synergy in the Nanofab, as evidenced by the probe storage activity that has been ongoing at CMU for a decade and makes significant use of the Nanofab. MEMS probe storage uses MEMS probe arrays to mechanically address bits with the precision of an atomic force microscope. In the future, this capability will be extended to not only allow bits to be addressed with MEMS probe arrays, but also to allow circuits to be reconfigured (connections made or broken) or non-linear devices activated. This will represent the full development of nanotechnology within the CMU Nanofab — devices being fabricated at the microscale being used to address and manipulate devices at the nanoscale in a parallel fashion.

Users

When the Nanofab became an independent organization in 1998, it began deriving its operations budget solely from the user fees. The Nanofab Facility's $10-million, 4,000-square-foot cleanroom with full complement of equipment is available to firms that are developing a wide spectrum of novel micro devices. Over the past five years, the Nanofab has substantially increased its industrial user base, particularly among high-tech startups in the Southwest Pennsylvania area.

Newly installed FEI Sirion 600 scanning electron microscope and Nabity NPGS electron beam lithography system with 10 nm writing resolution of complex shapes on up to six-inch diameter wafers. PhD students Matthew Moneck and Chun Wang pictured training to use the system. (Photos Courtesy of Ken Andreyo of CMU)

"The research going on within this laboratory is truly diverse," said Bowman. "Gone are the days of a cleanroom used exclusively for semiconductor devices. Researchers share equipment and ideas. Probably the most valuable part of the facility is the ability to share the wealth of processing knowledge that has been accumulated by the staff over the years," Bowman added.

At present, Bridge Semiconductor, Akustica, IC Mechanics, and several researchers from Pennsylvania State University and the University of Pittsburgh are accessing the lab and expectations are that more local companies will take advantage of the available facilities.

Equipment

The facility has acquired an impressive range of processing equipment during the 21 years of its existence. The processing techniques utilized in the Nanofab have predominately been developed in-house for novel device fabrication. Much of the equipment has been modified, updated, or wholly constructed by the staff to suit the needs of the research community. Evolving from the large data storage effort are 14 sputtering systems for depositing films of many different materials and alloys. A reactive ion etcher for deep silicon etching, and a newly acquired backside wafer aligner are the workhorses of MEMS-related research. An existing 5-nanometer focused ion beam etcher and a newly ordered 10-nanometer resolution electron beam lithography system extend the lab's capabilities well into the nanometer scale.

The Nanofab features 2,600 square feet of Class 100 cleanroom space (Zone One) and 1,200 square feet of Class 10 cleanroom space (Zone 2). To ensure consistent and dependable temperature and humidity control throughout the year, the cleanroom recently underwent a major renovation of the HVAC system. Digital controls maintain the temperature throughout the cleanroom to 68°F ±1°F and the humidity to 35% RH ±3% RH.

Constructed in 1997, the Roberts Engineering Hall building has four labs with Class 1000 space, which provide additional equipment space with exhaust hoods, laminar flow hoods, and laminar flow wet benches. These labs are utilized as overflow space for the cleanroom and are generally used for materials studies and thin film development work.

The cleanroom has been in continuous operation for 21 years with many upgrades and modifications. Additionally, the Nanofabrication Facility has accumulated an extensive spare parts inventory to insure minimal downtime of facilities and equipment.

For more information on working with the Nanofab at Carnegie Mellon University and to learn more about the lab's facilities, contact Christopher Bowman at: ccbowman@ece.cmu.edu; Tel: 412-268-2471; or visit ***www.ece.cmu.edu/research/dssc/nanofab***.