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NANOTECHNOLOGY NEWS FROM THE UNIVERSITY OF MINNESOTA

WINTER 2011

NEW VISTEC EBPG5000+ ELECTRON BEAM LITHOGRAPHY SYSTEM AT THE NANOFABRICATION CENTER

Electron beam lithography is a technology that, since its invention nearly four decades ago, remains one of the highest-resolution methods of top-down nanopatterning available. Steady improvement of EBL tools and processes over the years has led to current state-of-the-art systems capable of producing structures on the order of 10 nm wide—more than a factor of four better than even the best photon-based lithography. While throughput limitations have kept EBL from being used in high-volume semiconductor manufacturing, it remains a key technology for applications where resolution is critical and throughput is not a major issue. EBL is also the only top-down lithographic technology with the resolution to reliably interface with emergent "bottom-up" patterning techniques like templated self-assembly.

The Vistec EBPG5000+ electron beam lithography system recently acquired by the Nanofabrication Center is one of the most high-performance EBL tools available. A 100 KeV maximum beam voltage allows the system to pattern a wide range of resist types and thicknesses with negligible scattering of the beam. The beam current can be adjusted from 0.2 nA to over 100 nA, a feature which allows the user to optimize for either write speed or resolution, depending on the application. In addition to the standard laser-interferometer stage for positioning, the system uses a laser height sensor to dynamically determine the distance between the beam and the sample and adjust the focus accordingly.

The EBPG5000+ was installed in the NFC in December and recently passed initial site-acceptance testing. The performance of the system during testing was well beyond the tool specifications—both field stitching and layer-to-layer alignment errors were within 10 nm for a 500-µm-wide field. This ensures that large, complex, multilayered structures can be written with the EBPG with minimal distortion of the intended pattern. Raw resolution on the tool, an example of which can be seen in figure 1, was better than 6-nm-wide isolated lines in some cases—an improvement of more than a factor of ten on the Raith-150 system the EBPG is replacing.

The EBPG5000+ represents a quantum leap in the submicron patterning capabilities of the NFC. While the Raith-150 is a capable nanopatterning system, the EBPG surpasses it in nearly every respect, including resolution, throughput, beam voltage, and stitching/alignment accuracy, which will allow a wide variety of previously-impossible fabrication work to take place in the NFC. For more information about the system or for system training, contact Bryan Cord (bcord@umn.edu).

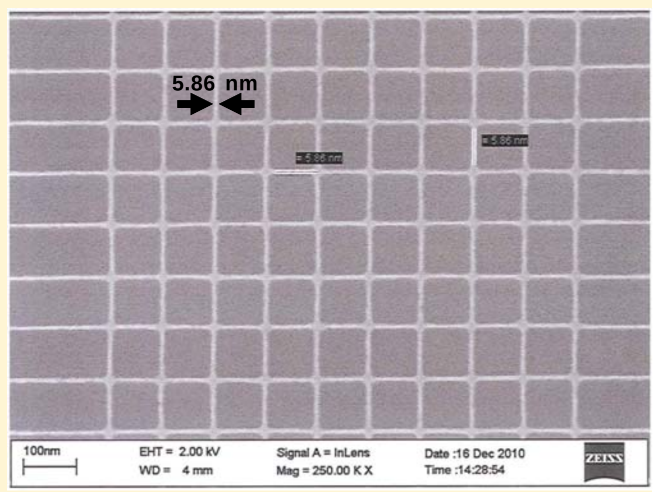

Figure 1: Resolution test structures fabricated in 20 nm of hydrogen silsesquioxane (HSQ) on Si during acceptance testing of the EBPG5000+. The developed lines are less than 6 nm wide in both directions.

Reminder: If your work uses the Nanofabrication Center please add the following in the acknowledgements section of any publication: "Parts of this work were carried out in the University of Minnesota Nanofabrication Center which receives partial support from NSF through the NNIN program."

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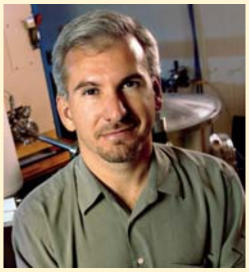
CHARACTERIZATION FACILITY NEWS

CHARFAC DIRECTOR'S MESSAGE



CharFac Director, Greg Haugstad

CharFac is excited to announce a new 120-kV FEI Tecnai Spirit transmission electron microscope (TEM) to be installed in February, funded by a successful NIH MRI proposal by lead author Wei Zhang (of CharFac staff and research faculty of the College of Dentistry). The site will be the 18th floor of Moos tower, the former location of a 30-year old TEM in the Institute for Molecular Virology. This new instrument will be part of the CharFac-managed suite of complementary TEMs, accessible to its entire user base. The TEM's unique BioTWIN lens is designed for optimal contrast of biologicals and organics/polymers, even unstained material. A series of embedded side-mount and bottom-mount CCD cameras provide instant, high-quality digital results. Fast automation performs many routine procedures – tune, align, saturate, and condition the gun; illumination, focus/defocus the image; and minimize astigmatism. The TEM is also optimized for cryogenic work, and thus will become the instrument of choice for low-energy cryo-TEM, complementing the high-energy TEM in CharFac Hasselmo (and ultimately replacing the aged JEOL 1210 in CharFac Shepherd). The new TEM will be under the direct management of staff member Bob Hafner, with Wei and the EM faculty committee providing additional oversight. Wei and Bob are specialists in cryo-TEM of

(continued, top right)

polymers and biologicals, with offices located near the CharFac Moos TEM.

A new FTIR microscope has been installed to replace a mid-1990s version. This was funded by a Grant-in-Aid award (spearheaded by staff member Jinping Dong in collaboration with Prof. Joey Talghader). The previous microscope had a failed detector and severely aging mechanical control of alignment and positioning. The new system is a Thermo Electron Continuμm FTIR microscope, with infinity corrected optics for both IR and visible light, implementing on axis. This allows viewing of sample while collecting data. The system includes a motorized ReFlec aperture with X, Y, and θ control, automated reflectance/transmission sampling modes, and motorized sample focus; plus the capacity to add fluorescence illumination, Nomarski differential interference contrast and polarized light.

Ongoing in the CharFac is the increase in visibility of its technical staff, given its national reach as well as broadening collaborations. Beginning with this issue we recap recent activities to emphasize the kinds of expertise and cooperation users can tap:

Chris Frethem gave a tutorial on cryo-SEM techniques for biological and soft materials specimens at the annual meeting of the Microscopy and Microanalysis Society in Portland.

Ozan Ugurlu (collaborator Prof. Bill Gerberich) worked with Prof. Ikuhara at the Crystal Interface Laboratory of University of Tokyo, on *in-situ* deformation of Si pillars in TEM; this included the nucleation and propagation of dislocations in mechanically stressed silicon nanopillars. Results were presented at the fall Materials Research Society (MRS) national meeting in Boston.

Jinping Dong (collaborator Prof. John Bischof) presented at the International Conference on Raman Spectroscopy in Boston, on cryopreservation issues for biological molecules and mammalian cells, using confocal Raman microscopy to study the phase segregation and molecular activity.

Nick Seaton (collaborator Prof. Donna Whitney) presented at a workshop in Concord, MA run by Oxford Instruments on electron backscattering diffraction.

Greg Haugstad gave two presentations at the fall MRS meeting, one on novel shear-based atomic force microscopy (AFM) methods (collaborator Prof. Dan Frisbie & co-advised students), the other on AFM force-distance mapping of polymer-drug coatings during elution (collaborator Dr. Klaus Wormuth of Surmodics). Greg also taught a short course on AFM at the NSTI Nanotech annual meeting in Anaheim.

CHARFAC AT THE UNIVERSITY OF MINNESOTA

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Greg Haugstad, Director

NANOFABRICATION CENTER NEWS

NFC DIRECTOR'S MESSAGE

NFC Director,
Steve Campbell

In the accompanying front page article, Bryan Cord tells you about our new e-beam lithography system. As you read this, we will have completed training our first users on the system. The results from the acceptance testing were extremely impressive. I hope that it will enable cutting edge nano research at Minnesota. You may be interested to know that our Raith system was sold to colleagues at the University of Louisville where it is up and running. Two other systems slated for delivery in November were delayed, but both the new AJA sputtering system and the new STS etch tool should be installed in February.

I am pleased to report that planning for the new building is continuing. The nano part of the new building will occupy almost all of the first floor with a few labs in the basement and a couple of offices on the second floor. As mentioned earlier, the lab will more than double our clean room space and should be a great resource for our work and for attracting new people to Minnesota. The University's Government Relations Department is working with Governor Dayton's office and the legislature to secure the necessary bonding. To support this we have prepared an extensive report on Minnesota Nanotechnology to the Legislature. This report focuses on the health, safety, and ethical implications of the *(continued, top right)* work. A copy of the report can be found at the University nano website: www.nano.umn.edu. Just click on the new report link. Information on the building can be found at: http://physicsnano.umn.edu/mn.html.

PROCESSING CAPABILITY - CHEMICAL VAPOR DEPOSITION (CVD) TECHNIQUES

An important aspect of many micro- and nanofabrication processing sequences is the deposition of thin films. Chemical vapor deposition techniques make use of gases and a chemical process, such as a decomposition or reaction, to generate the material to be deposited. For example, silane (SiH_4) is a common source for silicon in CVD systems. At sub-atmospheric pressures and elevated temperatures (620°C is common), silane chemically breaks down, resulting in silicon deposition. NFC currently has two different CVD systems. The low pressure CVD (LPCVD) system uses high temperatures (400 to 850°C) to drive the chemical processes to deposit films such as polysilicon, silicon nitride and silicon dioxide. The polysilicon films can be doped with phosphorus to increase the conductivity of the resulting film, and the SiO_2 films can be doped with phosphorus and/or boron. Silicon nitride also comes in two varieties: standard stoichiometric Si_3N_4, and more silicon rich films commonly known as low stress silicon nitride. The low stress silicon nitride films can be deposited to thicknesses of over 2um, and can be used to form freestanding cantilever beams and thin membranes as is often seen in MEMS devices. Plasma-enhanced CVD (PECVD) operates at lower temperatures (100 to 350°C), and hence is compatible with aluminum metallization. NFC can deposit silicon dioxide, silicon nitride and amorphous silicon by PECVD.

If you are interested in knowing more about these materials and CVD, please contact NFC at nfc@umn.edu.

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Steve Campbell, Director
Greg Cibuzar, Lab Manager

SAFETY TRAINING

NFC is offering safety training for new users twice each month. On the first Thursday of every month, the training sessions begin at 1:00PM, and on the third Thursday of the month sessions begin at 10:00AM. The training includes watching our safety video and taking a brief quiz. Also, a NFC staff member provides a tour showing some of the safety related equipment and the gowning process used for the NFC cleanroom. Finally, there is training on using the Coral lab software. The safety training takes about two hours to complete, and must be done before users will be granted access to NFC facilities.

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Contact: Becky von Dissen at vondi001@umn.edu or 612-625-3069

Center for Nanostructure Applications

The primary mission of the Center for Nanostructure Applications is to seed interdisciplinary nano research projects that will go on to attract external support. Active nanostructures include applications of nano as diverse as energy conservation and production, large area displays and lighting, printed electronics, smart fabrics, electronic noses, drug delivery, cancer therapy, and new types of medical imaging.

These applications often require significant participation across traditional disciplines and the Center is designed to foster the cross-disciplinary research necessary to bolster the nano applications area at the University.

The Center also organizes workshops, speaker series, and short courses, as well as serving as a focal point for nano at the University.

For more information, visit http://www.nano.umn.edu/

The National Nanotechnology Infrastructure Network

The National Nanotechnology Infrastructure Network (NNIN) is an integrated networked partnership of user facilities, supported by the National Science Foundation, serving the needs of nanoscale science, engineering and technology. The mission of the NNIN is to enable rapid advancements at the nano-scale by efficient access to nanotechnology infrastructure. The NNIN supports the Nanofabrication Center at the University of Minnesota. As a node in NSF's National Nanotechnology Infrastructure Network (NNIN), the NFC provides access to advanced multi-user facilities to both industry and academic researchers, the latter at a subsidized rate.

For more information, visit www.nnin.org