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UNIVERSITY OF MINNESOTA
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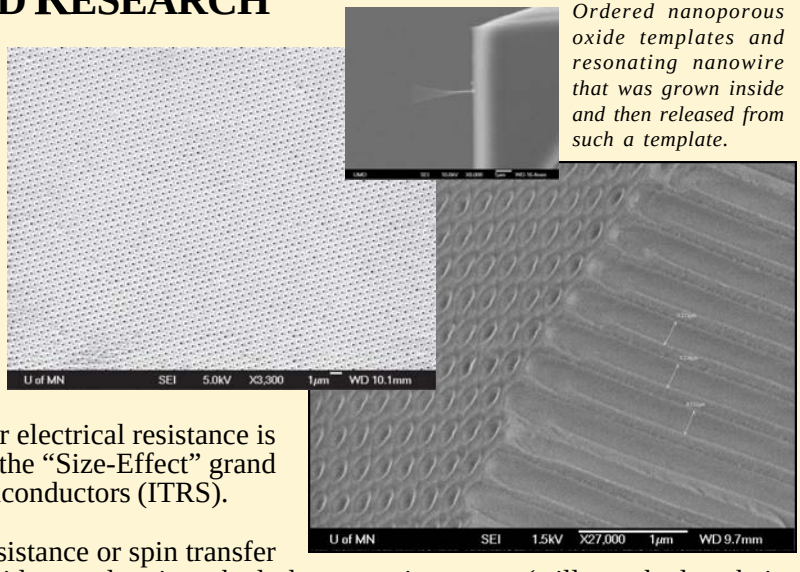
NANOTECHNOLOGY NEWS FROM THE UNIVERSITY OF MINNESOTA

FALL 2012

NATIONAL NANOTECHNOLOGY INFRASTRUCTURE NETWORK FEATURED RESEARCH



Ordered nanoporous oxide templates and resonating nanowire that was grown inside and then released from such a template.

Nanoporous oxides provide templates with aspect ratios of 10 to 10,000. No other lithography tool reaches these dimensions, but now the door is open for applications like biomimetic cilia and flagella, extremely high density random access memory (RAM), biomagnetic nanobots. The tie that binds these applications together is magnetic nanowires. Using the Nanofabrication Center and equipment in Stadler's lab, layered magnetic/nonmagnetic nanowires are grown by electrochemical deposition into these oxide templates. The resulting nanowires have easily tailored magnetic properties that can be used in ordered arrays (as-grown) or that can be released from the oxide template and functionalized in solution. The wires are mechanically durable and have diameters as small as 8nm even with lengths of 100um. Their electrical resistance is equivalent to bulk values,* which may provide a solution to the "Size-Effect" grand challenge of the International Technology Roadmap for Semiconductors (ITRS).

As grown, these wires can store data using either magnetoresistance or spin transfer torque phenomena for RAM (work with MRSEC). If the oxide template is etched, the nanowire arrays (still attached to their growth electrode) can be used for flow sensors in microfluidic channels (collaboration with Diagnostic Biosensors LLC) and for vibration sensors (collaboration with Shield in Civil Engr). Completely released nanowires have been incubated with several cell lines to allow manipulation and/or separation using external magnetic fields (collaborations with Lam in Neurosurgery and Hubel in Mechanical Engr). Other projects involving these nanoporous templates involve easy fabrication of thin films with periodic porosity for superconductors (collaboration with Dahlberg in Physics) and for plasmonics via template-stripping. Ordered pores are possible over large areas (in^2).

In short, these nanoporous oxide templates are cheap and easy to make, and have a wide variety of Nano Applications.

*Mazin Maqableh, Xiaobo Huang, Liwen Tan, Randall H. Victora, Bethanie J.H. Stadler, "Low Resistivity 10nm Diameter Magnetic Sensors," *Nano Letters* **12** 4102-4109 (2012). DOI: 10.1021/nl301610z

8th Annual Minnesota Nanotechnology Workshop

REGISTER NOW! The 8th Annual Nanotechnology Workshop is November 7-8, 2012. Topics include Nanoparticle Synthesis and Reactivity, Advanced Electronic Materials, Nano Toxicity, and Photovoltaics. Facility tours as well as introductory short courses will be offered at the Nanofabrication Center and Characterization Facility. And as always, we will host a Reception and Poster Session on the evening of November 7 which is a great opportunity to network and talk to researchers one on one. Visit the workshop website for details and information on registering: http://www.nano.umn.edu/secondary.php?nav=workshop. We hope you can join us this year!

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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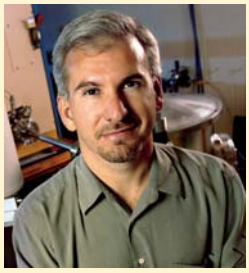
Characterization Facility News

CharFac Director's Message



CharFac Director, Greg Haugstad

We are excited to announce another success in instrument-acquisition funding. The National Science Foundation has awarded a grant (lead PI professor Lorraine Francis of the Department of Chemical Engineering & Materials Science, CEMS) for a new cryogenic scanning electron microscopy system (cryo-SEM). This will replace the Hitachi S4700 currently in our Hasselmo Hall site as well as ancillary hardware for specimen preparation and vacuum introduction. The majority of the work performed with this current system has involved cross-sectional imaging of liquid-applied coatings (e.g., latex). Here the concept is to see all ingredients, both solid and liquid, by fast freezing to solid state then fracturing the coating under vacuum, and keeping at cryogenic temperatures (i.e., solid) during electron-beam based imaging. The new system will upgrade and improve our capabilities in this line of work, and will importantly lower the effort barrier for new users to "enter the cryo-SEM game" in a growing range of applications. For information on using any of our cryo-SEM systems in the future, please contact staff members Chris Frethem or Jake Warner (all staff contact information is on the CharFac web site). To discuss exemplary applications of cryo-SEM in cutting-edge

(continued, top right)

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Greg Haugstad, Director

research at the University of Minnesota, please contact CEMS Profs. Lorraine Francis or Alon McCormick.

As previewed in recent news, a Laue X-ray diffractometer has been installed and is now available for use. Laue is the fastest and most reliable technique to orient and co-mount crystal samples. It provides our investigators with what has been a standard capability at some peer institutions, bolstering our competitiveness. Please contact staff member Mike Manno about using this system. Secondly, the 20-year upgrades to our Bruker AFMs, as installed in May, have seen heavy and excited usage this past summer (but there is room for more users). Please contact me or Jake Warner for more information about the new systems and/or to discuss your AFM needs. Currently we are pursuing grant funding to add thermal probe capabilities, which enable so-called NanoTA (ramp temperature in a submicron sample region, analogous to temperature-scanned calorimetry) as well as the imaging of thermal conductivity across a sample; and moreover the ability to measure and map sample temperature, for example in an operating microelectronic device. We are eager to discuss potential applications with both current and potential AFM users.

The CharFac role in the university curriculum continues to grow. An annual fall course in the CharFac for materials science juniors, Structural Characterization Lab (MatS 3801), now serves roughly twice as many students as it did just three years ago. This increase reflects in part the growth in interest in the Materials Science major, but also points directly to the importance of the CharFac, both instrumentation and staff. This type of partnership, between a research core facility and an academic department, is certainly uncommon and serves as a proud example. It is not surprising that the usage of CharFac in MatS 3801 has been touted in CEMS recruiting presentations to prospective undergraduates.

NANOFABRICATION CENTER NEWS

NFC DIRECTOR'S MESSAGE

NFC Director, Steve Campbell

As always, I want to start with equipment upgrades. Although there are still a few problems remaining to be corrected, our new Heidelberg system is running and making masks. Once all of the problems are resolved, we plan to begin allowing experienced users to start making their own masks and using the system for direct-write optical. Look for that later this year. Our new Oxford etch system is now running. It is a major improvement over the etcher that we removed. Etch rates are much faster and the etch profiles appear to be more vertical. My thanks to Professor Mo Li who helped organize this. Finally, we are in the process of ordering a new ion mill. The new system, which was selected after considerable user input, will provide higher etch rates, better wafer cooling, and much better reliability. I expect this will be delivered in the spring of 2013.

As we mentioned in the last newsletter, the construction of the new Physics and Nanotechnology building is on schedule. The contractor is now beginning to enclose the building so that interior work can be done over the winter. Cleanroom installation will begin in the spring of 2013. Substantial *(continued, top right)*

completion is projected for mid-November of next year. At that point we will begin moving and installing new process tools. A detailed move plan will be issued in mid-2013 so researchers will know when to expect systems to be unavailable. The NFC office and some of our staff will be moving in January 2014.

NEW RATES FOR PHOTOMASKS

With our recent purchase of a DWL200 laserwriter system from Heidelberg Instruments, we are now able to provide improved maskmaking capabilities at a lower cost. We have two laser write heads for the DWL200, one capable of features down to 1.5 microns, the other to 1.0 microns.

Heidelberg DWL200 Laserwriter

Previously, we could not routinely go below 1.5 microns. This new system also allows simplified design rules and lower pricing. Pricing for academic masks is $206 for features down to 1.5 microns, and $363 down to 1.0 microns. Industrial pricing has also been reduced to $465 for features down to 1.5 microns. The design rules and mask submission form can be found on the lower left side of the NFC home page (www.nfc.umn.edu). Questions can be emailed to nfcmasks@umn.edu.

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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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