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# NANOTECHNOLOGY NEWS FROM THE UNIVERSITY OF MINNESOTA

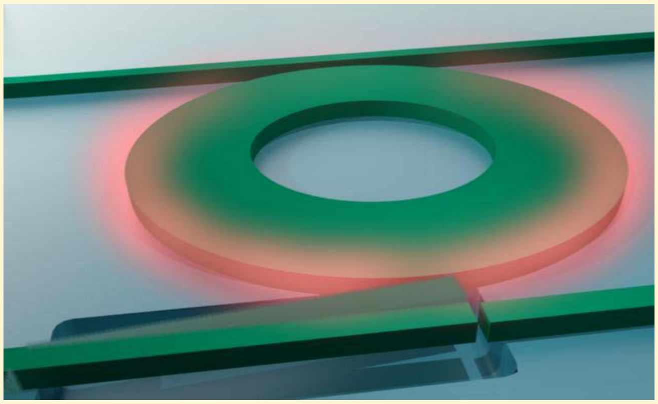
SPRING 2013

## NATIONAL NANOTECHNOLOGY INFRASTRUCTURE NETWORK FEATURED RESEARCH

### Nano Optomechanical Relay Amplifies Signals All-Optically

*Huan Li, Yu Chen, Semere Tadesse, Mo Li*
*Department of Electrical and Computer Engineering*
*University of Minnesota*

Optical fibers can connect your home to the internet at 100 times faster speed than electrical cables because each glass optical fiber can carry many channels using different color of light. This is possible because, unlike electrical currents, light in different colors does not like to interfere with each other. Recently, in the journal Nature Communications, Professor Mo Li's group in the Electrical and Computer Engineering Department at the University of Minnesota reported a new device which allows one optical signal to directly control another optical signal of a much higher power level so that signal amplification is achieved.



The device was fabricated in the Nanofabrication Center (NFC) using tools such as the new Vistec EBPG-5000+ e-beam lithography system and the Oxford PlasmaLab 100 etcher. In the device there are two optical waveguides, each carrying an optical signal (see the image on the left). Between them is an optical resonator in the shape of a microscale donut with very high optical quality, which means light can circulate thousands of rounds in it before leaking out. Utilizing this resonance effect, the optical signal in the first waveguide is significantly enhanced and generates a very strong optical force on the second waveguide. The second waveguide is released from the substrate so that it moves when a force is applied on it. The mechanical motion of the waveguide alters the transmission of the optical signal it carries. When the first optical signal, which generates an amplified force on the second waveguide, is modulated, it controls the position of the second waveguide. If light of a different color with a higher power level is input in the second waveguide, the information is thus transferred from one color of light to another color with amplified amplitude. Such a device is a direct analogy to electromechanical relays but operates completely with light.

The optical relay device currently operates at 1-10 MHz and can be improved to 1GHz so it is sufficiently fast for radio-frequency photonics and sensor applications. Funding support of the project is provided by the College of Science and Engineering and the Young Investigator Program (YIP) of the Air Force Office of Scientific Research (AFOSR).

**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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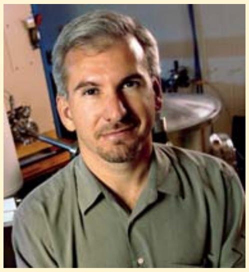
# Characterization Facility News

## CharFac Director's Message



*CharFac Director, Greg Haugstad*

In equipment news, a Grant-in-Aid awarded to Prof. Andre Mkhoyan, along with substantial matching funds from Andre, the MRSEC and CharFac's equipment fund (CSE dean), will be used to purchase an advanced plasma cleaner for transmission electron microscopy specimens and specimen holders. This will augment a 10-year old system that has experienced substantial downtime with increasing age. Together these systems will cover the ever-heavier usage of a growing suite of TEMs for high-resolution work. The new system will provide greater capacity and the additional ability to mix gases for more precisely controlled chemical action.

In recent times CharFac has begun to contract dedicated IT personnel , shared with departments. In the near term CharFac will be transforming the way it handles networked computers. A major ongoing project is to place many of the instrument-controlling computers on the "academic domain" (i.e., .ad.umn.edu). This will enable improved security and better central troubleshooting, backup and updating of local computers. Users will access data storage on central servers

*(continued, top right)*

and thus a large increase in allotment (GBs) compared to our aging local server (200 MB/user). Relatedly, some data-acquisition computers will be configured for data transfer to a CharFac central computer from which internet transfer may then proceed, obviating the need for direct transfer from individual computers, improving security. In the same vein, local USB drives will be disabled to remove the possibility of virus introduction from infected thumb drives.

Continuing with an IT theme: an important growing need in the CharFac is training for special data processing/analysis software. CharFac is increasingly offering ad hoc training sessions for the usage of third-party software. Experience has shown that our user base is very broad in its need for detailed instruction. We wish to enable those who prefer (paid) instruction over simple *access* to software for data/image manipulation. We are eager for inquiries and feedback on this topic. For those interested in software training, it is usually best to contact the staff member who trained the individual on the technique for which the software is utilized. General inquiries to me are also welcome (as well as specific inquiries on AFM or IBA data analysis, my technical domain). It is also worth noting that CharFac has some history in developing custom software and scripting (e.g., for AFM force-volume data sets). Expressed interest from users greatly increases the priority that programming effort may be given.

An ongoing trend in the CharFac is its increasing use in curricula. This spring several staff members will teach an annual characterization course funded through the College of Continuing Education for 4th-semester students from the Dakota County Technical College (averaging about 10 students per year since 2006). This past fall semester a materials science course, Structural Characterization Lab, enrolled a record-smashing 48 juniors, primarily majors in materials science. In groups of four, these students completed roughly a dozen 3-hour lab exercises in the CharFac using secondary electron and atomic force microscopes, IR and X-ray photoelectron spectrometers, and several X-ray diffractometers. The CEMS department provided four teaching assistants to relieve the CharFac staff of many scores of hours of lab teaching, a commitment to the manageable growth of curricular utilization of core facilities.

## CharFac at the University of Minnesota

**12 Shepherd Labs**
**100 Union Street SE**
**Minneapolis, MN 55455**

**Website: www.charfac.umn.edu**
**Email: charfac@umn.edu**
**Telephone: 612-626-7594**

***Greg Haugstad, Director***

# NANOFABRICATION CENTER NEWS

## NFC DIRECTOR'S MESSAGE

*NFC Director,*
*Steve Campbell*

We have been spending a considerable amount of time recently planning for the new building. (Lab users will already find some sample clean room furniture in the existing facility for evaluation.) The new cleanroom will contain five bays: advanced lithography, optical lithography, thin film deposition, etch, and a bay that will be split between bio nano and a few annealing systems. The intention is to make the new facility the primary location for nano work and the existing facility the primary one for MEMS work. We will be moving the e-beam lithography system, the nano imprint system, the FIB, one of the optical aligners, one of the e-beam evaporators, and one of the sputtering systems. We solicited feedback from the faculty and now have a list of additional equipment that we plan to buy. I want to emphasize, however, that both labs will be part of the same organization. The same rates and training apply and users will only get one bill.

We will be opening two new labs in the new building directly across the hall from the cleanroom. These will also be available to our users. The first is the bio nano lab. It will house equipment for cell culturing, BSL-2 hoods, incubators, total internal reflectance fluorescence, PCR, hyperspectral imaging, and dip pen lithography. We will also set up a lab for nano *(continued, top right)*

materials. Based on faculty feedback, this will be primarily nanoparticle suspensions. Equipment in this lab will include laser diffraction, nano tracking analysis, DLS/electrophoresis, contact angle measurement, and BET gas adsorption for measuring particle surface area. Just as with the clean room, we will train users and make the equipment available.

Due to our expanded role, NFC and CNA will be merged in July, 2013. The new organization will be called the Minnesota Nano Center (MNC). We will be adjusting our staffing slightly to accommodate the new organization. More on that later.

## DRY ETCHING UPDATE

With our recent purchase of an Oxford Plasmalab System 100 high density plasma loadlocked etcher, NFC has significantly improved our dry etch capabilities. The etch gases include $Cl_2$, $BCl_3$, $CF_4$, $CHF_3$, $SF_6$, $O_2$, Ar, and $N_2$. Wafer sizes up to 200mm can be accommodated, including pieces. The tool is used for etching many materials, including aluminum, niobium, silicon, silicon nitride and other dielectrics. Etch rates are nearly 10X those of our previous tool, with improved aspect ratio control. For example, aluminum oxide (deposited in our atomic layer deposition tool) was etched at 15 nm/min in our former tool, while the Oxford etches the same film at 150nm/min. This is a direct result of the improved high density plasma source. Questions?
Contact nfc@umn.edu.

*Oxford Plasmalab System 100*

## NANOFABRICATION CENTER AT THE UNIVERSITY OF MINNESOTA

**1-165 Keller Hall**
**200 Union Street SE**
**Minneapolis, MN 55455**

**Website: www.nfc.umn.edu**
**Email: nfc@umn.edu**
**Telephone: 612-624-8005**

***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.

***Nanotechnology News from the University of Minnesota***
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*200 Union Street SE*
*Minneapolis, MN 55455*

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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