NIST National Institute of Standards and Technology • U.S. Department of Commerce

NanoFab News

Volume 2, Issue 2 June 2010

Center for Nanoscale Science and Technology

The NIST NanoFab offers:

- A streamlined application process designed to get projects started in a few weeks;
- A professional staff with over 200 years of collective experience and available for expert consultation;
- Hands-on training for all tools and processes.

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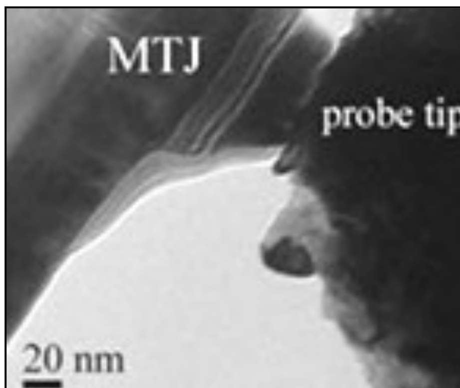
Welcome to the June 2010 Issue of the *NanoFab News*

We are pleased to distribute the *NanoFab News* for current and potential users of the NanoFab at the NIST Center for Nanoscale Science and Technology (CNST). The NanoFab provides researchers from industry, government, and academia rapid access to a comprehensive suite of tools and processes for nanofabrication and measurement. This newsletter is intended to keep users up to date on project highlights, fabrication process development, tool installations, safety and access policies, and other notable news.

In situ Tunneling Magnetoresistance (TMR) Measurements on Individual Nanomagnetic Tunnel Junctions

Magnetic tunnel junctions (MTJs) are critical components in technologies such as read heads in hard drives, magnetic sensors, and magnetoresistive random access memories. Nanometer scale defects such as pinholes and hotspots that arise during fabrication or processing can change junction tunneling barrier characteristics, ultimately causing device failure. Using test structures fabricated in the CNST NanoFab, researchers from NIST and Brookhaven National Laboratory have made *in situ* measurements that shed light on individual MTJ nanodevice performance.



TEM probe in contact with a magnetic tunnel junction.

As described in the June 30 issue of *Applied Physics Letters*, the authors performed *in situ* tunneling magnetoresistance (TMR) measurements in a transmission electron microscope (TEM) for the first time on a series of fully operational 100 nm x 150 nm MTJs. This size is relevant to real world applications, and restricting the current flow through these constricted dimensions made quantitative comparison between adjacent devices feasible, allowing for a unique energy barrier to be measured for each device. The researchers also have, for the first time, achieved *in situ* TMR measurements on isolated nanoscale devices that are part of a TEM sample. The entire test structure, except for the active parts of the MTJ stack, was prepared in the NanoFab using lithography, deposition, and etch tools.

In Situ Tunneling Measurements in a Transmission Electron Microscope on Nanomagnetic Tunnel Junctions, J. W. Lau, P. Morrow, J. C. Read, V. Höink, W. F. Egelhoff, L. Huang, and Y. Zhu, *Applied Physics Letters* **96**, 262508 (2010).

The CNST NanoFab is available to researchers from industry, academia, NIST, and other government agencies.

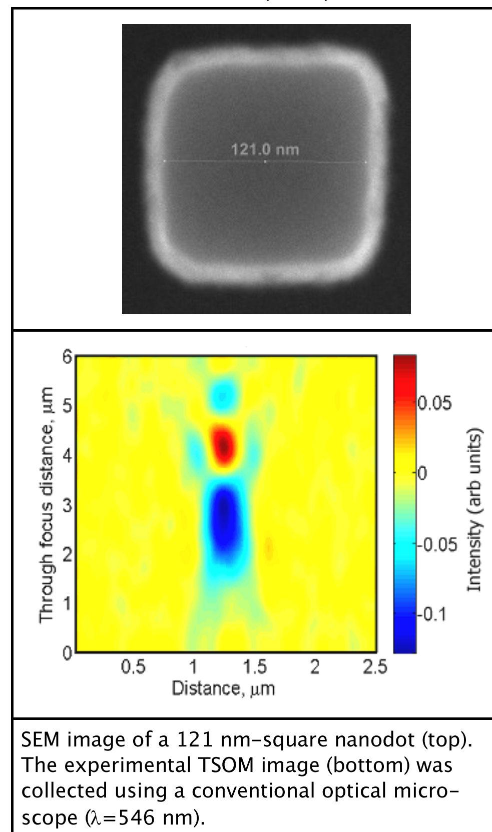
Through-Focus Scanning Optical Microscopy Method for Nanoscale Dimensional Analysis

Through-focus scanning optical microscopy (TSOM), a new metrology technique developed in NIST's Manufacturing Engineering Laboratory, has won the 2010 R&D 100 award. The method uses a conventional bright field optical microscope; but, rather than taking a "best focus" image, it scans the microscope focus through a sample, collecting multiple two dimensional images at different focal plane positions. A computer then extracts optical intensity profiles from these images and uses differences between them to construct the TSOM image. By combining the information found in multiple out-of-focus images, TSOM may potentially transform conventional optical microscopes into tools for measuring length changes in three dimensions with nanometer sensitivity. In demonstrations with nanostructures fabricated in the NanoFab, TSOM has been shown to have an experimental measurement resolution as small as one nanometer.

Lead researcher Dr. Ravikiran Attota believes that TSOM has the potential to detect dimensional changes between two samples with a measurement resolution comparable to SEM or AFM in cases where direct imaging of samples is not required. Because it relies on an optical microscope for gathering data, the method should be able to analyze targets with sizes ranging from tens of nanometers to hundreds of micrometers. The method should also work on both transparent and opaque target materials, with shapes ranging from simple nanoparticles to those found in complex semiconductor devices, including structures buried under transparent films.

In June 2010, at the Nanotech 2010 Conference in Anaheim, California, Dr. Attota demonstrated TSOM's usefulness by presenting experimental results showing the technique could evaluate the dimensions of nanodots with sizes ranging from 65 nm to 160 nm.

Nanoparticle Size and Shape Evaluation Using the TSOM Optical Microscopy Method, R. Attota, R. Kasica, L. Chen, P. Kavuri, R. Silver, and A..Vladar, *NSTI-Nanotech 2010* **3**, 172 (2010).



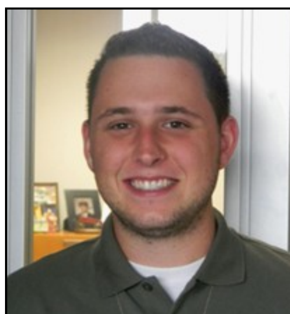
SEM image of a 121 nm-square nanodot (top). The experimental TSOM image (bottom) was collected using a conventional optical microscope (λ=546 nm).

Disclaimer: Certain commercial equipment and software are identified in this documentation to describe the subject adequately. Such identification does not imply recommendation or endorsement by the NIST, nor does it imply that the equipment identified is necessarily the best available for the purpose.

NanoFab Hours Extended Until Midnight

The NanoFab hours of operation now extend from 7 pm until midnight, Monday though Friday. The expanded hours are expected to increase the equipment availability during normal hours (7 am to 7 pm), especially for users without out-of-hours access to the NIST campus.

Process Engineer Marc Cangemi, along with our new Process engineer, Justin Dickinson, will provide training and process support during these evening hours.



Justin Dickinson supports users during the NanoFab's evening hours.

New Chuck Design Protects Fragile Membranes from Vacuum Damage

Process Engineers Rich Kasica and Chet Knurek, working with CNST Instrumentation Specialist Steve Blankenship, have designed a new non-vacuum mechanical gripping mechanism to replace the vacuum chucks commonly used to hold samples during resist coating. The new chuck can be used to hold wafer pieces containing membranes without using a vacuum that might rupture the fragile membranes. It can accommodate irregularly shaped substrates with a maximum thickness of 2 mm. In the past, various users have constructed chucks with fixed dimensions for individual applications; the new, more universal design (shown on the right) can accommodate varying sizes and shapes of small wafer pieces, microscope slides, and membrane dies when a vacuum is not desirable. Part centering is achieved thru alignment via concentric rings milled into the surface. The chuck is now available for use. Contact Chet Knurek for additional information at 301-975-2515, chester.knurek@nist.gov.

New adjustable mechanical chuck holds wafer pieces without using a vacuum. This design allows a uniform layer of resist to be applied while reducing the risk of rupturing fragile nitride membranes.

Improvements Allow Sputter Deposition of Au and Ni Films with Sub-nanometer Thickness Control

Process recipes have been developed to sputter-deposit Au and Ni layers at low RF powers, resulting in sputter rates as low as 0.01 nm/s. Sub-nanometer thin films can now be sputter-deposited with controllable repeatability. These thin layers are especially useful for coating TEM grids; e.g., with 0.1 nm Au and 0.5 nm Ni. The deposition recipes have been posted by the sputter tools in the NanoFab cleanroom. Contact Gerard Henein for additional information at 301-975-5645, gerard.henein@nist.gov.

The next NanoFab Users Meeting will be from 2-4 pm, September 17, 2010, in Building 215, conference room C103.

New Processes Remove Native Oxides *In-situ* Prior to Deposition

Process recipes have been developed to remove the native oxide from silicon substrates *in-situ* prior to deposition in the two sputtering tools and in E-beam evaporator #2. The recipes are now posted on the tools and included in the tool instruction manuals. In the sputtering tools, Argon ion bombardment can be used to sputter off the oxide at a rate of approximately 0.02 nm/s. In the E-beam tool, oxygen ion pre-cleaning removes the native oxide at about 0.01 nm/s. Contact Gerard Henein for additional information.

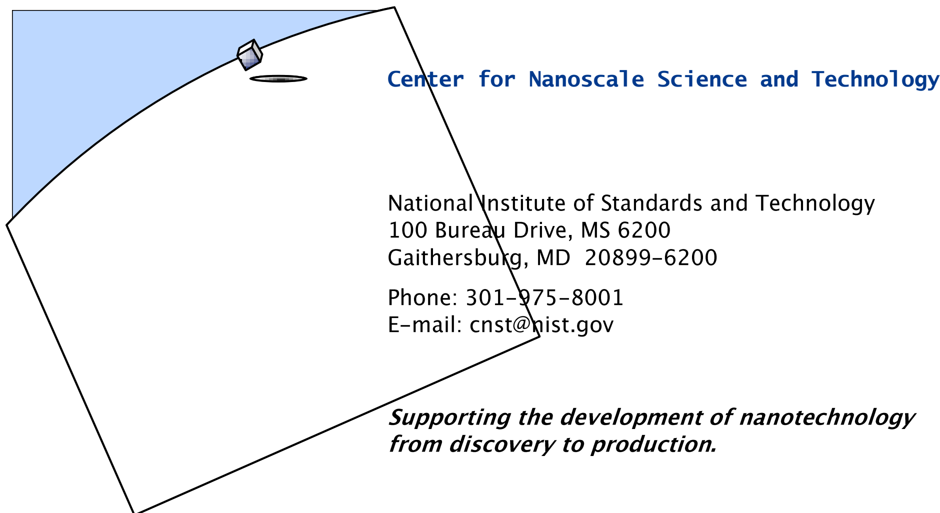
Second E-beam Evaporator Available

A second electron beam evaporator is now available for use in the NanoFab cleanroom. Deposition recipes are available for Ag, Al, Au, Co, Cr, Cu, Fe, Ni, Permalloy, Pt, Ti, W, Si, Al_2O_3, SiO_2 and TiO_2.

The evaporator has a 6-pocket electron gun, two quartz crystal monitors for crystal averaging, and an ion gun to densify refractory films for better control over their refractive indices. The ion gun can also be used to pre-clean the wafers prior to film deposition. (See note above.)

Wafers are mounted on a planetary fixture and undergo a double rotation. The device yields uniformity of 2% to 3% over 100 mm. It can accept four 100 mm or 150 mm wafers, eight 75 mm or 50 mm wafers, or even wafer pieces. This new tool, along with our recently extended hours, has eased the bottleneck for metallization processes. Contact Gerard Henein for additional information.

A second vacuum E-beam evaporator is now available in the NanoFab cleanroom.



Center for Nanoscale Science and Technology

National Institute of Standards and Technology
100 Bureau Drive, MS 6200
Gaithersburg, MD 20899-6200

Phone: 301-975-8001
E-mail: cnst@nist.gov

Supporting the development of nanotechnology from discovery to production.

The NIST Center for Nanoscale Science and Technology supports the U.S. nanotechnology enterprise from discovery to production by providing industry, academia, NIST, and other government agencies with access to world-class nanoscale measurement and fabrication methods and technology. The CNST is the only national nanocenter with a focus on commerce.

If you would like to subscribe to this newsletter, please send a blank e-mail to listproc@nist.gov with "Subscribe nanofab_news *your name*" in the body of the email; e.g., "Subscribe nanofab_news John Doe."

www.nist.gov/cnst

NanoFab Acknowledgment Procedures

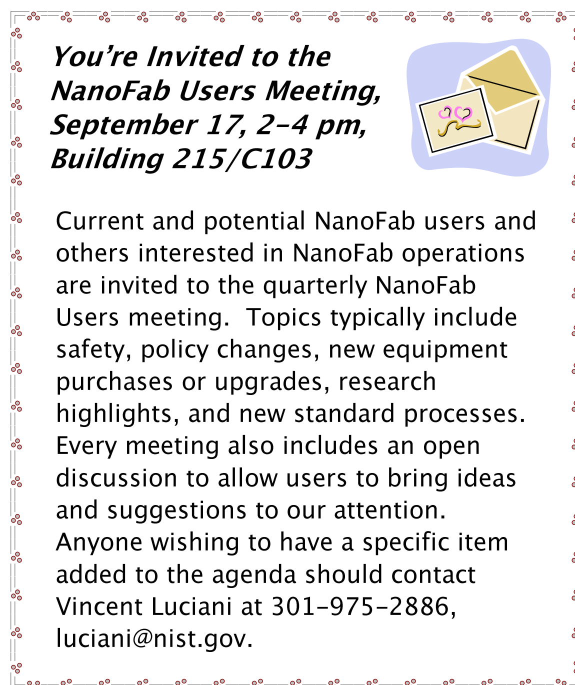
If you have publishable results from work performed in part at the NanoFab, please include the following statement in the acknowledgments section: "Research performed in part at the NIST Center for Nanoscale Science and Technology."

If your results have already been made public and were based all or in part on work done in the NanoFab, please forward them, along with the associated NanoFab Project Number(s), to NanoFab@nist.gov in the following formats:

Presentations (note those that were invited): Title of Presentation, A. A. Presenter, B. B. Author, and C. C. Author (invited, if so), Official and Complete Name of Conference or Meeting, Location City, State-or-Country, Date-of-presentation.

Patents (applications filed or issued): Title of Patent, A. A. Inventor, B. B. Inventor, and C. C. Inventor, US Patent [Application] No. XX,XXXXXX, filed/issued DATE.

Awards: Award/Honor, Month (if available) YEAR.

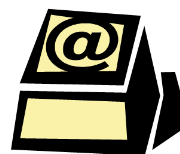


You're Invited to the NanoFab Users Meeting, September 17, 2-4 pm, Building 215/C103

Current and potential NanoFab users and others interested in NanoFab operations are invited to the quarterly NanoFab Users meeting. Topics typically include safety, policy changes, new equipment purchases or upgrades, research highlights, and new standard processes. Every meeting also includes an open discussion to allow users to bring ideas and suggestions to our attention. Anyone wishing to have a specific item added to the agenda should contact Vincent Luciani at 301-975-2886, luciani@nist.gov.

Visit our Booth at These Upcoming Meetings

Aug 3-5	**SPIE**	San Diego, CA
Oct 19-21	**AVS**	Albuquerque, NM
Nov 30-Dec 2	**MRS Fall 2010**	Boston, MA



New User Inquiry E-mail Address

The NanoFab is introducing a new e-mail address for user support. Our facility user coordinators can be reached at NanoFabuseroffice@nist.gov.