NanoFab News

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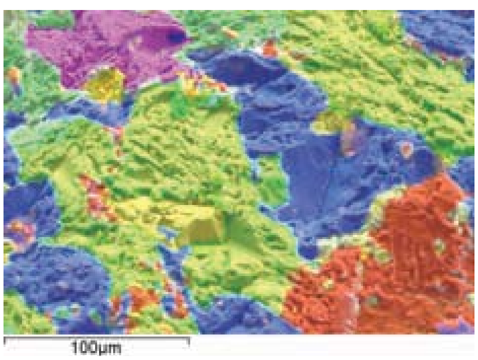
We are pleased to distribute the November 2009 issue of the *NanoFab News* from the Center for Nanoscale Science and Technology (CNST) at the National Institute of Standards and Technology in Gaithersburg, MD. This quarterly newsletter is intended to provide current and potential users of the CNST NanoFab with useful information, including news on fabrication process development, tool installations, and safety and access policies. This newsletter is for you—so if you have suggestions for improving it, please let us know.

Tool News

Oxford Instruments Energy-Dispersive Spectroscopy (EDS) Installed on the Ultra60 FESEM

The Ultra60 field emission scanning electron microscope (FESEM) can now simultaneously determine the identity and spatial distribution of all elements with an atomic number higher than boron (Z=5). Oxford Instrument's INCA X-ray microanalysis system analyzes the X-rays emitted from the sample during electron beam exposure and determines the elements from which they arose. It provides nanoscale spatial resolution and rapid qualitative analysis of samples with a spot size of several nanometers and a sampling depth of about a micrometer. With careful calibration, quantitative microanalysis is also possible. A very large detector (80 mm^2) increases X-ray collection efficiency, enabling analysis using normal imaging electron beam currents. The associated Oxford EDS INCA software package includes interpretation algorithms, guidance for tool setup, and powerful image manipulation. It also enables analysis of area, line, or point regions, as well as image processing, report generation, and project management tools. For more information, contact Mike Hernandez.



Elemental spatial distribution map on a granite sample:

■ C ■ Na
■ Al ■ Ca
■ K ■ Si
■ S ■ Fe

FEI Transmission Electron Microscope (TEM) Scheduled for Delivery in 2010

NIST recently awarded a contract to FEI Company for a Titan 60-300 FEG transmission electron microscope (TEM). This high performance analytical TEM, to be installed in a specialized laboratory space in Bldg. 216, will enable NanoFab researchers to investigate and analyze a wide range of materials and nanostructures, including organic, inorganic, and hybrid structures. The Titan 60-300 is capable of high-resolution imaging and analysis, including energy-filtered imaging and XEDS and EELS element-specific mapping in TEM and STEM modes. It also allows for data collection and analysis from multiple electron diffraction modes, including selected area, nano-beam, and convergent-beam modes. The instrument's magnification range is 51x to 1,250,000x, with a STEM resolution of 0.14 nm. For more information, contact Mike Hernandez.

Administrative News

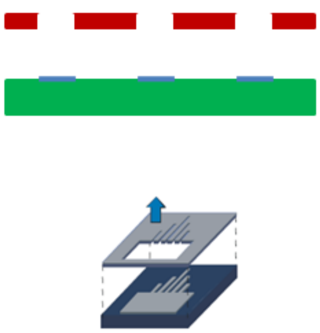
Coral Update. We have updated our equipment list in Coral so that the tool names are consistent between the web site and the Coral description.

NanoFab User's Meeting. We will hold the next NanoFab User's Meeting on December 7, 2009, from 2:00 – 4:00 pm in 215/C103. Please attend!

New Process Development

Sputter Deposition of Thin Metal Films

Metal films a few monolayers in thickness can now be deposited using the Discovery-550 sputtering tool. Film thickness is controlled using very slow deposition obtained by lowering the power, current, and pressure in a process developed by the NanoFab staff working with researchers from the University of Virginia (UVA). In their project, the UVA researchers deposited 15 bilayers, each nominally consisting of 0.3 nm of cobalt and 0.6 nm of palladium. Using X-ray reflectometry measurements conducted at UVA, the researchers confirmed that the actual thickness of the Co and Pd layers was 0.34 nm and 0.65 nm respectively. For additional information, contact Gerard Henein.



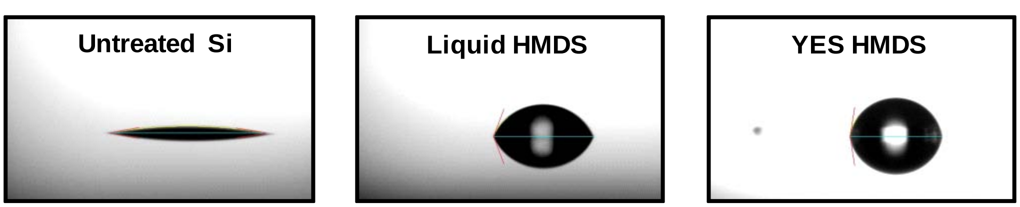
Stencil Lithography

A new stencil nanolithography process is now available in the NanoFab that uses a stencil mask rather than a polymer resist to pattern an underlying substrate. A stencil mask is made from a thin silicon nitride membrane that is patterned with electron beam lithography and then etched through. Using this structure as a free-standing stencil, lithography can be performed on chemically or thermally sensitive materials. Stencil lithography is fast, repeatable, and low-cost. If needed, the stencil can be used in high vacuum to minimize sample contamination. For more information, contact Lei Chen or Richard Kasica.

Update on HMDS Substrate Priming Oven Process

Another improvement in photolithography has been achieved with our new YES HMDS (hexamethyldisilazane) vapor priming oven. Photoresist adhesion can be significantly improved by first applying HMDS in vapor form. The YES Oven completely dehydrates the substrate and then applies a controlled vapor of HMDS. Multi-wafer throughput is possible via batch processing of cassettes. Treated wafers can be held several weeks without degradation of subsequent photoresist surface adhesion. As an example, the results below show the contact angle for a Si wafer versus HMDS treatment. For more information, contact Marc Cangemi.

CONTACT ANGLE MEASUREMENT RESULTS



The wafer contact angle increases with increasing hydrophobicity, with the greatest change achieved using YES HDMS vapor phase priming. The untreated contact angle was 10°; liquid HMDS primed contact angle was 69°; vapor HMDS contact angle was 81°.

Outreach Events

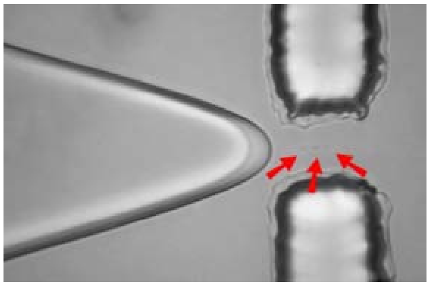
The NanoFab's outreach campaign has exhibited at twelve venues so far this year, with three remaining in 2009:

November 8 – 13	AVS 56th International Symposium & Exhibition	San Jose, CA
November 30	Mid Atlantic MEMS Alliance Symposium	Washington, DC
November 30 – Dec 4	2009 MRS Fall Meeting	Boston, MA

NanoFab Research Highlights

NIST Researchers Develop Versatile "On-Demand" Single-Molecule Drop Dispenser

NIST scientists Carlos López-Mariscal and Kristian Helmerson have fabricated custom networks of microfluidic channels for producing 1 µm-diameter droplets of water that can each carry as little as a single molecule of analyte. Squeezed into a narrow stream by a mixture of oils whose viscosity exerts pressure on it, the water enters a narrow constriction. The water's abrupt pressure drop—accompanied by a dash of detergent—breaks its surface tension, splitting it into small droplets. The droplet sizes are highly uniform and can be adjusted by varying the constriction width. Using lasers, the researchers can move two or more single-molecule-containing droplets, cause them to coalesce, and observe the reactions through optical methods. The laser beam can also be shaped to trap the liquid into droplet arrays in any desired pattern. This opens up new possibilities for single-molecule spectroscopy. For their initial reactions, the researchers are mixing different color fluorescing molecules. In the future, they envision more interesting chemical reactions, such as those between an infectious agent and an antibody, a protein and an enzyme, or a chromosome and a drug. The microfluidic devices that contain the channels are extremely low cost, and can be manufactured simply and inexpensively using fabrication technologies available at the CNST NanoFab.



The NIST "on-demand" single-molecule drop dispenser: Water flows through a microfluidic channel, roughly 35 µm wide, and enters a narrow constriction where it breaks up into droplets (just visible as indicated by the arrows).

Adapted from NIST Tech Beat 9/22/09. See, Optical Trapping of Hydrosomes, C. López-Mariscal and K. Helmerson, *Proceedings of SPIE* **7400**, 740026 (2009).