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# The CNST Quarterly

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Center for Nanoscale Science and Technology

**The NIST CNST operates a shared-use national nanofabrication and measurement facility, the NanoFab, complemented by a multidisciplinary research staff who share their expertise and next-generation instrumentation through collaboration.**

**Inside this issue:**



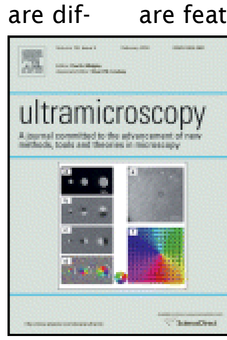
## From the Director, *Robert Celotta*

Since being established in May 2007, the CNST has grown rapidly, with over 500 scientists now participating in CNST-supported research. Research participants come from more than two dozen companies, a dozen national laboratories, 70 universities, and from institutions in 30 States and 13 countries. Currently, 10% of our research participants come from industry, with this fraction growing rapidly, and another 10% come from other government labs. The remaining participants are equally divided between NIST and academic researchers. We look forward to further growth in our research participants as we continue supporting nanotechnology from discovery to production.

CNST Center for Nanoscale Science & Technology

## Research Highlight: *Measuring the Three Dimensional Nanostructure of Magnetic Vortices*

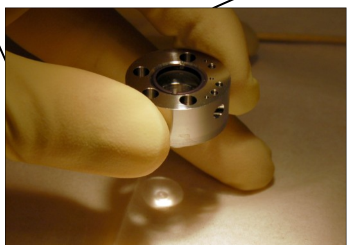
Researchers in the CNST have shown that scanning electron microscopy with polarization analysis (SEMPA) can be used to image the three-dimensional structure of a magnetic vortex—one of the smallest magnetic structures in ferromagnetic materials. A magnetic vortex is a common feature in thin ferromagnetic films that have been patterned into nanostructures, such as a disc, and consists of an in-plane magnetization swirl surrounding an out-of-plane magnetic core. Although potentially important for magnetic memory and storage applications, vortices are difficult to image because they are small, with a core only 10 nm to 20 nm wide, and inherently three-dimensional. Conventional imaging techniques have been able to image only a single component of the magnetization vector or have simply detected the presence of a core without resolving it. The CNST researchers have demonstrated that the unique measurement capabilities of SEMPA can be used to obtain a complete three-dimensional image of the magnetic vortex nanostructure. The ability to image the vortices is an important requirement for understanding how various nanoscale magneto-electronic devices work, such as those used for magnetic information storage or programmable logic. The results are described in the February 2010 issue of Ultramicroscopy, and are featured on the journal's cover;




see, Simultaneous Measurement of Magnetic Vortex Polarity and Chirality Using Scanning Electron Microscopy with Polarization Analysis (SEMPA), S.-H. Chung, D. T. Pierce, and J. Unguris, Ultramicroscopy **110**, 177-181 (2010).

## Research Highlight: *A Novel Transparent Faraday Cup*

CNST researchers Brenton Knuffman, Adam Steele, and Jabez McClelland have invented an innovative way to observe ion currents while simultaneously optically probing the ion source. This innovation was developed during a project to develop high-brightness, low-emittance ion sources based on magneto-optical atom traps for focused ion beam applications. In an atom trap used as an ion source, the optical signal gives information about the number of trapped atoms, while measurement of the current indicates the number of ions extracted. Ordinarily, ion currents are monitored by placing a metal Faraday cup in their path. In many circumstances, the bulky and opaque Faraday cup prevents optical monitoring of the ion source. In the new design, the rear of the Faraday cup is replaced with an optically transparent window or lens which is coated with a transparent conductor, such as indium tin oxide. Because the window is conductive, the ion current can be efficiently collected without charge accumulation, while its transparency allows direct optical access. The use of a transparent Faraday cup improves control, opens up the possibility of using feedback to stabilize the ion current, and allows the ion source to be monitored from multiple directions. This invention will be useful for improving the researchers' magneto-optical trap-based ion source (MOTIS), in addition to other applications where both current collection and optical access are desired. A US Patent application has been filed for the invention (U.S. Patent Application number 12/691,256).



Prototype of the integrated Faraday cup and optical objective.

**Coming soon – the NanoFab will be staffed and open until midnight Monday through Friday.**

## Expanded NanoFab Hours Coming Soon

Usage of the CNST NanoFab continues to grow, with over 80-user-hours on average per day. To address the increasing demand for access, beginning this summer we will extend NanoFab business hours to 7 am to midnight, Monday through Friday. Users will enjoy NanoFab staff support and be able to book equipment time just as during the current business hours (7 am – 7 pm). The facility will be open to all users who have evening access to the NIST campus.


## New E-beam Evaporator and RIE Systems Available in the NanoFab

A second vacuum e-beam evaporator has been installed in the NanoFab cleanroom.

A second Denton Vacuum E-beam Evaporator has been installed in the cleanroom, and is now available for general use. The e-beam evaporator is the most heavily used tool in the NanoFab, and this new system adds some welcome relief for users needing to deposit metals and metal oxides. For the last month, NanoFab staff have been developing and installing a full suite of baseline processes. Deposition recipes are available for the following materials: Ag, Al, Au, Co, Cr, Cu, Fe, Pt, Ti, W, Si, $Al_2O_3$, $SiO_2$ and $TiO_2$.

The two new Oxford Plasmalab System 100 Reactive Ion Etching systems are now available for use. These systems allow plasma etching and deposition processes for compound semiconductor, optoelectronics, photonics, MEMS, and microfluidics applications. They allow selective etching under variable temperatures on planar surfaces ranging from fragments to 8-inch wafers. The first etcher will be used for III-V materials and metals, while the second will be used for Si, silicon oxides, and silicon nitrides.

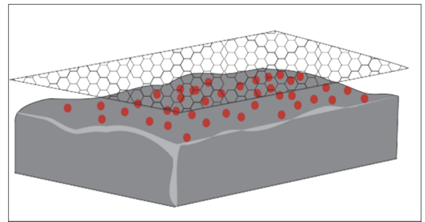
## Postdoctoral Researchers Win NIST Sigma Xi Poster Awards

Three CNST Postdoctoral Researchers won awards at the Sigma Xi Scientific Research Society 17th Annual NIST Postdoctoral Poster Presentation Competition.. Shaffique Adam and Adam Steele, both in the Electron Physics Group, were awarded the "Most Outstanding" and "Runner-up" prizes, respectively, in the Physics category. Sarah Ko, from the Nanofabrication Research Group, won the "Runner-up" award in the Materials category, which had the largest number of entrants.

Shaffique described his research with Mark Stiles on "Effective Medium Theory for Carrier Transport in Graphene."

Adam's poster, "A Focused Chromium Ion Beam," reported on his work with Jabez McClelland, in collaboration with CNST Postdoctoral Researcher Brenton Knuffman.

Sarah was recognized for her project with Alex Liddle, "2-D Assembly of Quantum Dots Directed By DNA Origami on Lithographical Patterns."



Model of impurities in graphene, from Shaffique Adam's winning poster.

## The CNST Welcomes New Postdoctoral and Visiting Researchers

*Han-Jong Chia* is a CNST/UMD Postdoctoral Researcher working with Bob McMichael in the Electron Physics Group to develop a ferromagnetic resonance force microscope for measuring the dynamic properties of magnetic nanostructures. Han-Jong has a Ph.D. in Physics from the University of Texas at Austin.

*Raymond Kallaher* is a CNST Postdoctoral Researcher working with Fred Sharifi in the Energy Research Group developing measurement techniques for characterizing high efficiency nanostructured thermoelectric materials. Ray has a Ph.D. in Physics from Florida State University and postdoctoral research experience at the Virginia Polytechnic Institute.


*Myung-Gyu Kang* is a CNST/UMD Postdoctoral Researcher working with Fred Sharifi developing techniques to measure the properties of carbon nanotube-based field emitters and nanoscale defects in photovoltaic devices. Myung-Gyu has a Ph.D. in Electrical Engineering from the University of Michigan.

*Tomohiro Matsui* is a CNST Visiting Fellow and Assistant Professor of Physics at the University of Tokyo. Prof. Matsui has extensive experience developing transport measurement techniques based on ultra-low temperature scanning tunneling microscopy, and is working with Joe Stroscio in the Electron Physics Group to characterize the electronic properties of graphene.

*Stefano Mazzucco* is a CNST/UMD Postdoctoral Researcher working with Renu Sharma in the Nanofabrication Research Group developing a Raman spectrometer to be integrated with an environmental TEM, and studying the effects of compositional heterogeneity in catalyst nanoparticles. Stefano has a Ph.D. in Physics from Paris-Sud XI University, France.

*Dmitry Ruzmetov* is a CNST/UMD Postdoctoral Researcher working with Alec Talin in the Energy Research Group to fabricate nanowire-based batteries and characterize their micro-structural and electrical properties. Dmitry has a Ph.D. in Physics from Indiana University.

*Joachim Welker* is a Visiting Graduate Student Researcher working with Joe Stroscio. Joachim is a Ph.D. candidate studying with Prof. Franz Giessibl at the University of Regensburg, Germany. Joachim is collaborating with Joe on the addition of atomic force microscopy capabilities to the CNST's cryogenic scanning probe microscopy systems.

**CNST research is creating the next generation of nanoscale measurement instruments, available through collaboration.**

***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.***

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***Supporting the development of nanotechnology from discovery to production.***

CNST Center for Nanoscale Science & Technology

www.nist.gov/cnst

The NIST Center for Nanoscale Science and Technology supports the development of nanotechnology through research on measurement and fabrication methods, standards and technology, and by operating a state-of-the-art nanofabrication facility, the NanoFab. The Center promotes innovation by using a multidisciplinary approach to research, maintaining a staff of the highest caliber, and leveraging our efforts by collaborating with others.

If you would like to subscribe to this newsletter, please send a blank e-mail to listproc@nist.gov with "Subscribe cnst_news your name" in the e-mail body.

## Upcoming CNST Seminars

Seminars are held in Bldg. 217, Rm. H107, unless otherwise noted.

**Si Wire-Array Photovoltaics And Hydrogen-Producing Photoelectrodes**
Shannon Boettcher, Assistant Professor of Chemistry, University of Oregon
Monday, May 3, 2010, 10:30 am.

**Magnetic And Mechanical Responses Of Functional Multiphase Materials**
Brian Pate, Adjunct Assistant Professor, Central Michigan University
Friday, May 7, 2010, 10:30 am


Process Engineer Eileen Sparks staffs the CNST exhibit booth.

## Visit our Booth at these Upcoming Meeting Exhibits

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| April 21 – 23 | SBIR National Conference | Hartford, CT |
| May 4 – 6 | BIO International Convention | Chicago, IL |
| June 22 – 23 | Nanotech Conference & Expo | Anaheim, CA |