CNST Center for Nanoscale Science & Technology
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# The CNST Quarterly

The newsletter of the NIST Center for Nanoscale Science and Technology

**June 2009 Volume 1, Issue 1**

The NIST Center for Nanoscale Science and Technology has just observed its two-year anniversary. We have made significant progress in establishing the staff and infrastructure needed to fulfill our mission; to support 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. Our new Energy Research Group is working to devise new metrology tools and processes to help the world harvest, convert and store power on the nanoscale. Our NanoFab tool set continues to grow. And we have released the first comprehensive report on our activities through December 2008. The 44-page booklet is now available in print and on the web.

This is our first CNST Quarterly Newsletter, issued to keep our colleagues and collaborators up-to-date on our latest accomplishments and activities. If you have any suggestions as to how we can better achieve our mission, please let me know. – Robert Celotta, CNST Director

## New Staff at the CNST

Rachel Cannara joined the Electron Physics Group as a new Project Leader. Rachel received her Ph.D. in Physics from the University of Wisconsin-Madison. Her research in the CNST will focus on the measurement and control of the mechanisms that govern nanoscale frictional energy dissipation, and the use of these discoveries to enable the design and operation of future nanomanufacturing systems.

Fred Sharifi joined the recently created Energy Research Group as a new Project Leader. Fred received his B. S. in Physics (magna cum laude) and Ph.D. in Condensed Matter Physics from the University of Illinois. He has approximately 40 journal publications. Fred will help establish the CNST's research program measuring nanoscale energy processes in thermoelectric and photovoltaic materials and systems.

Gregg Gallatin joined the Nanofabrication Research Group as a new Project Leader. Greg received his B.S. and Ph.D. in Physics from Penn State. He holds 12 U.S. patents and has over 60 publications. Gregg's research in the CNST will focus on the modeling and analysis of the physics of self-assembly.

Stephan Koev joined the Nanofabrication Research Group as a CNST/UMD Postdoctoral Researcher. He received his B.S. degree in Electrical Engineering from the US Naval Academy, and M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland at College Park. Stephan is working with Vladimir Aksyuk on MEMS and NEMS for integrated optical sensing and actuation and for high-throughput nearfield optical imaging.

As part of the CNST's mission to develop the next generation of nanotechnologists, the following NIST Summer Undergraduate Research Fellows are spending June and July participating in cutting-edge nanoscience research in the CNST.

Aaron Cochran, an Applied Science/Nanotechnology major at the University of Wisconsin – Stout
Nicole Messier, a Mechanical Engineering major at George Washington University
Robert Hoyt, a Physics major at Harvey Mudd College
Jason Bylsma, a Ph.D. student in Applied Physics at the University of South Florida next fall
Timothy Enright, a Chemistry major at University of the Sciences in Philadelphia
Gregory Meyer, a Mechanical Engineering major at the University of Maryland in College Park
Joshua Leibowitz, a Materials Science & Engineering major at the University of Connecticut
Christopher Hong, a Bioengineering major at Penn State University
Suehyun Cho, a Physics major at University of Maryland, College Park
Karthik Prakhya, a Physics and Electrical Engineering at the University of Massachusetts Amherst

## Honors and Awards

### Mark Stiles Named NIST Fellow

Mark Stiles is the Program Leader for Theory, Modeling, and Simulation of Nanostructures in the Electron Physics Group in the CNST. Mark enjoys an international reputation based, in part, on his seminal and ongoing contributions in the fields of magnetoresistance and spin transfer torques. His research has greatly influenced both the fundamental understanding and technological applications in each of the areas he has worked in – his publications have been cited more than 3100 times – and counting! Mark's exceptional creativity, enthusiasm, and productivity earned him the designation of NIST Fellow in May.

### Alan Band Wins Sigma Xi 2009 Award for Outstanding Support to NIST Scientific Community

In just the past two years, Alan Band has designed and fabricated a wide variety of custom electronics for the CNST, including those used in our state of the art ultralow temperature scanning tunneling microscope and another for the division's scanning electron microscope with polarization analysis (SEMPA). For his continuing excellent work (which began at NIST in 1991), the NIST Chapter of Sigma Xi Scientific Research Society recognized Band with its 2009 Award for Outstanding Service to NIST Research Scientists.

## Research Highlights

### EEEL and CNST Researchers Reveal Spin Dynamics and Mode Structure in Nanomagnet Arrays

EEEL and CNST researchers and collaborators at the University of Montana have demonstrated the ability to characterize the average magnetic properties of lithographically patterned nanomagnet arrays along with the size and shape variations within the arrays. These types of arrays form the basis for important new technologies including magnetic random access memory, high-frequency spintronic devices, bit patterned media, and biological applications. In addition to technological applications, understanding how magnetic materials behave when confined to nanoscale dimensions is a significant fundamental problem. Researchers Justin Shaw, Tom Silva, Mike Schneider and Bob McMichael used a new, high-bandwidth, magneto-optical measurement technique to detect precession of the magnetization in highly uniform arrays of nanostructures that were fabricated at NIST, Boulder, and interpreted the experimental results using the OOMMF public micromagnetic software provided by Mike

Donahue and Don Porter (ITL). The measurements yielded insight into the role of confinement on the magnetodynamic mode structure of $Ni_{80}Fe_{20}$ disks ranging in size from 200 nm down to 50 nm in diameter, and from 10 nm to 3 nm in thickness. The study demonstrated the power of magneto-optic spectroscopy for quantitatively assessing homogeneity in lithographically patterned nanomagnets.
For the complete analysis: Spin dynamics and mode structure in nanomagnet arrays: Effects of size and thickness on linewidth and damping, J. M. Shaw, T. J. Silva, M. L. Schneider, and R. D. McMichael, Phys. Rev. B 79, 184404 (2009).

**CNST, Georgia Tech Researchers Uncover New Charge Carrier Behavior in Graphene**

CNST and Georgia Tech researchers have observed significant differences in charge carrier cyclotron orbit Landau level activity on epitaxially grown graphene samples under application of scanning magnetic fields. In normal metals and two dimensional electron gases, the Landau levels present in equally spaced intervals. However, while observing graphene at 4.3 K in the CNST's cryogenic ultrahigh vacuum scanning tunneling microscope, the team discovered a completely different Landau level spectrum in which the cyclotron orbits present themselves at unequally spaced but predictable levels, which later were revealed to occur at variances as a function of the square root of the magnetic field and the Landau index. The new spectrum also displayed graphene's zero-energy state and contained information not previously available in half-integer quantum Hall effect (QHE) measurements. The findings were published in the May 15, 2009 issue of *Science*.

## New in the NanoFab

The CNST Nanofab has added new JEOL JBX-6300FX e-beam lithography system to its lineup. The JEOL's beam deflection unit employs a 19 bit DAC unit for accuracy, it scans and writes at 12 Mhz speeds, and it can handle accelerating voltages of 25, 50 and 100 kilovolts with a 2 nm minimum spot sized write target. The new system complements the Center's Vistec VB300 e-beam writer, which scans at 50 Mhz with 50 to 100 kV accelerating voltages. Both units can write to better than 25 nm stitching and overlay accuracy. The new addition adds an additional element to the CNST's advanced lithography suite that includes a laser pattern generator, nanoimprint, and focused ion beam writers.

The NanoFab has completed the electrical installation of two new Oxford Plasmalab 100 reactive ion etch systems and a new Oxford FlexALRPT atomic layer deposition system inside the cleanroom. Plumbing continues on the 12-gas system and the various tool attachments required to bring all three systems to operational status. We expect work to be completed in late summer.

## Outreach and Events

CNST Director Robert Celotta, NanoFab Manager Vincent Luciani and Nanofabrication Research Group Leader Alex Liddle are introducing the other NIST Laboratories to the capabilities of the CNST and its NanoFab. A strong bias toward collaborative work being among the CNST's prime attributes, the overview describes how NIST staff can go about collaborating with scientists in the CNST research program or make use of the NanoFab. Examples of recent nanofabrication projects are used to illustrate the CNST's capabilities. Finally, the process for becoming a NanoFab user or having a nanostructure made or measured for someone is outlined.

Several CNST staff members traveled to Marco Island, Florida where the CNST exhibited at the 53rd annual International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication. The NanoFab staff is also headed to San Francisco to July 14-16 for the annual SemiCon West event, where the CNST booth will be part of a large NIST presence on the exhibit floor. The CNST has several other future stops on the inaugural outreach tour, with the goal of building interest in research collaborations and publicizing the availability of the NanoFab.


The challenge of a dwindling petrochemical base and an increasing worldwide demand for energy motivated the CNST to co-sponsor the Nanoscale Measurement Challenges for Energy Applications Global Workshop at the College of Nanoscale Science and Engineering at the New York University at Albany, NY. The April 26-28 meeting was held in cooperation with FEI Company, The National Renewable Energy Laboratory, The Center for Sustainable Ecosystem Nanotechnologies and the ASME Nanotechnology Institute. General Electric, General Motors and Applied Materials supplied industry speakers, and academic presenters came from Stanford University, the University of California-Berkeley, Notre Dame and the Colorado School of Mines. Topics included new photovoltaic devices, new energy storage ideas, solid state lighting, and electrochemical and fuel cell energy generation. Details including abstracts are available at www.asmeconferences.org/NanoMeasurement09.

## Upcoming CNST Seminars

**July 10, 2009** **10:30 AM**
Topic: Introduction of Functionalities Into DNA Nanostructures
Speaker: Seung-Hyeon (Sarah) Ko, Department of Chemistry, Purdue University
Location: Bldg. 217, H107
Contact: Alex Liddle

**July 15, 2009** **10:30 AM**
Topic: Enablers For Probe-Based Nanomanufacturing and Nanometrology
Speaker: Harish Bhaskaran, Postdoctoral Fellow/ IBM Zurich Research Laboratory
Location: Bldg. 217, H107
Contact: Rachel Cannara

For the complete list of CNST Seminars, browse http://www.cnst.nist.gov/seminars/presentation.html

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