Important Dates:

- Call for User Proposals: deadline is October 23
- 2014 UEC Election: vote online October 9-30

Message from the UEC Chair

The moment we have been waiting for has arrived and it’s time to submit your exciting research projects as the new proposal call has been just announced: the deadline for submissions is October 23rd. This time around the microscopy capabilities in the Shared Research Equipment (ShaRE) User Facility have been merged with the current capabilities in the CNMS - users will be able to take full advantage of these world-class microscopy and atom probe tomography capabilities in the current CNMS proposal call. I’m delighted to report that the 2013 Neutrons and Nano User Meeting hosted by Oak Ridge National Laboratory last August 12-15 was a grand success which welcomed more than 300 attendees to tour the CNMS and SNS facilities and learn more about the science which these shared resources support. The technical program was organized by a joint sub-committee of the CNMS and SNS-HFIR User Groups that showcased plenary and invited talks in 8 technical sessions and 12 Workshops.

Your CNMS UEC representatives Vivek Prabhu, Molly Kennedy and Tony Hmelo worked with our SHUG colleagues to craft a technical program that highlighted broad areas in nanoscience from soft matter to hard matter and in areas spanning biology to battery technology, energy, and electronics.

We encourage feedback and suggestions for the content of future newsletters. We are especially interested in receiving research highlights from CNMS users that may be featured in future issues of this newsletter. Please email us any time you have an important paper that is accepted for publication.

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Check out our new website!

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2014 CNMS UEC Members:
Megan Robertson, Vivek Prabhu, Tony Hmelo, Ichiro Takeuchi, Nazanin Bassiri-Gharb, Milan Buncick, Molly Kennedy, Mick Hickner
The organizing committee worked tirelessly to solicit speakers who would showcase the collaborations that are possible between our two facilities, well illustrated by CNMS Staff member Rajeev Kumar who addressed the synthesis of well-defined polymer block copolymers, their self-assembly, and field-theoretic computer simulations with direct comparison to high-resolution neutron reflectivity results. The take away message was that the CNMS and Neutron Sciences user facilities promote scientific advancements by combining unique materials, measurement, simulation and theoretical resources. We welcomed past and current Users to discuss the proposal process and technical capabilities of the shared facilities with future academic and industry Users at two dedicated workshops.

Professor Ronald Hedden from Texas Tech commented,

As a first-time visitor to ORNL, I was most impressed by the diverse range of facilities accessible to visitors through the proposal programs. The mechanisms in place to foster collaborations with ORNL scientists at CNMS and SNS will be of great help as I begin to submit requests this fall. Collaborating with ORNL will be a great way to take advantage of unique research facilities that many universities do not have on campus.

I look forward to the continued success of future joint user meetings that highlight the exciting science enabled by the CNMS and Neutron Sciences Directorate.

Tony Hmelo
2013 CNMS UEC, Chair
Vanderbilt University

**News from CNMS**

**OPEN! CNMS Call for User Proposals: High-Impact Nanoscience Research**

The Shared Research Equipment (ShaRE) User Facility is now part of CNMS! **NEW!!**

The Center for Nanophase Materials Sciences is soliciting proposals for user-initiated nanoscience research that will make effective use of CNMS facilities and staff expertise. The CNMS nanoscience research program provides users with access to a broad range of capabilities for nanomaterials design, synthesis, characterization, and theory/modeling/simulation, in order to carry out studies that will significantly advance our understanding of nanoscale phenomena and develop functional nanomaterials systems. Access is provided at no cost to users for research that is in the public domain and intended for publication in the open literature.

The submission deadline is Wednesday, October 23, 2013. Approved projects will be granted access to CNMS facilities during the period February 1, 2014 through January 31, 2015.

The CNMS website provides detailed descriptions of specific CNMS Research Capabilities that are offered to users. Prospective users are invited and strongly encouraged to contact CNMS staff members in the respective research areas to discuss their proposal ideas and learn more about the specific capabilities of interest to them.

**2014 UEC Election**

This is also the time of year when we conduct the annual election of new members of the CNMS User Executive Committee (UEC). Online voting will be open this year from October 9 through October 30. This year users will be electing three At-Large members and two officers, the Vice Chair/Chair-Elect and Secretary, who will all serve two-year terms starting January 1, 2014. We will also be integrating ShaRE users into the CNMS User Group starting October 1, which means that ShaRE users will be eligible to vote for the CNMS UEC. Following a four-week online nomination period that closed with nominations from the floor during the annual User Meeting on August 14, there will be a total of 13 candidates on the 2014 ballot including four ShaRE users. So be sure to look for your ballot in your email on October 9!
NUFO User Science Exhibition on Capitol Hill 2013

This year NUFO’s Exhibition on Scientific User Facilities was held on June 26, 2013 on Capitol Hill. Seven members of the House and staff from more than 35 Congressional offices and committees attended the event. Representatives from several funding agencies and professional societies also joined in the exhibition. The exhibition focused on three themes in research: Energy, Health, and Innovation. The attendees learned first hand about the wide range of research and innovation undertaken at the National User Facilities. They were also able to interact directly with more than 60 users and facility representatives who traveled to Washington to participate in the exhibition. The CNMS was represented by three members of its User Executive Committee, Tony Hmelo (Vanderbilt University), Molly Kennedy (Clemson University) and Vivek Prabhu (National Institute of Standards and Technology).

Summary of the event.

CNMS Nanobio Workshop: May 23–24, 2013

The Nanofabrication Research Laboratory (NRL) and Nanobio Affiliate Laboratories (Biological and Nanoscale Systems Group, BNSG) at the Center for Nanophase Materials Sciences organized a 2-day workshop around a portion of the ‘nanobio’ work being performed at the Center. Principal Investigators with existing user projects, potential users, CNMS staff and former users were invited to participate in the workshop. Nearly 50 participants attended during the 2-day event held at the Clinch River Cabin with roughly 1:1 ratio of ORNL staff and students to ‘user’ participants.

2013B Proposal Call Results

For the 2013B Proposal Call, there were 166 proposals submitted and 103 were approved. There are also projects from prior cycles that were granted extensions bringing our active project count to 282.

Postdoctoral Opportunities at the CNMS

Visit the website for more information and links to view opportunities at ORNL.
New equipment/capabilities

The CNMS is pleased to announce the addition of a first-of-its-kind Zeiss Orion Nanofab helium-ion microscope (HIM) to the User Program. This is the first production model of the new Orion Nanofab series, and the very first to be available at a national user facility. This microscope features three primary capabilities: imaging and detailed ion-milling/patterning using He-ions, and high-rate milling using heavier Neon ions. It is located in the CNMS cleanroom to facilitate clean transfer of samples.

The new user science that will be enabled includes: the ability to image, in the manner of an SEM, at unprecedented resolution and with high surface sensitivity; and the ability to pattern through direct ion-milling and exposure of lithographic resists, down to feature sizes of about 5 nm. The instrument is complementary to a Focused Ion Beam (FIB), but capable of feature sizes 10-20 times smaller. Scientifically, the instrument will allow users to explore entirely new types of devices and engineered nanostructures that cannot be fabricated with other techniques.

CNMS Honors and Awards

The Center for Nanophase Materials Sciences' Bobby Sumpter has been selected as 2013 UT-Battelle Corporate Fellow. He leads both the Computational Chemistry & Materials Science group in the Computer Science & Mathematics Division and the Nanomaterials Theory Institute at the Center for Nanophase Materials Sciences. He has been exceptionally productive at the confluence of theory and experiment with more than 300 papers with 6,000 citations.

Congratulations Bobby!

Chengdu Liang has been elected a member of the Advisory Board of Energy & Environmental Science. Chengdu works in the Center for Nanophase Materials Sciences, where he develops lithium-sulfur and lithium-ion batteries. His research also focuses on energy conversion and storage, catalytic nanomaterials, mesoporous materials and metal and metal oxide/sulfide nanoparticles.
Beyond Silicon: Transistors without Semiconductors

Physicist Yoke Khin Yap of Michigan Technological University and his team figured out how to make virtual carpets of boron nitride nanotubes, or BNNTs, which happen to be insulators and thus highly resistant to electrical charge. Using lasers, the team then placed quantum dots (QDs) of gold as small as three nanometers across on the tops of the BNNTs, forming QDs-BNNTs. BNNTs are the perfect substrates for these quantum dots due to their small, controllable, and uniform diameters, as well as their insulating nature. BNNTs confine the size of the dots that can be deposited.

In collaboration with scientists at CNMS at Oak Ridge National Laboratory (ORNL), they fired up electrodes on both ends of the QDs-BNNTs at room temperature, and something interesting happened. Electrons jumped very precisely from gold dot to gold dot, a phenomenon known as quantum tunneling.

Their work is described in the article “Room Temperature Tunneling Behavior of Boron Nitride Nanotubes Functionalized with Gold Quantum Dots,” published online June 17 in Advanced Materials. In addition to Yap and Jaszczak, coauthors include research scientist Dongyan Zhang, postdoctoral researchers Chee Huei Lee and Jiesheng Wang, and graduate students Madhusudan A. Savaikar, Boyi Hao, and Douglas Banyai of Michigan Tech; Shengyong Qin, Kendal W. Clark and An-Ping Li of the Center for Nanophase Materials Sciences at ORNL; and Juan-Carlos Idrobo of the Materials Science and Technology Division of ORNL.

Breakthrough Energy-Dense Battery Uses Lithium and Sulfur

It was reported in Scientific America, the breakthrough work in lithium-sulfur batteries done by researchers at ORNL working on a CNMS user proposal lead by Chengdu Liang. They designed and tested a completely solid lithium-sulfur battery with about four times the energy density of comparable lithium-ion battery technology. Given the abundance of elemental sulfur, the battery can also be produced at a much lower cost.

“Our approach is a complete change from the current battery concept of two electrodes joined by a liquid electrolyte, which has been used over the last 150 to 200 years,” said Chengdu Liang, lead author of an ORNL study published in the journal Angewandte Chemie International Edition.
Research Highlights

**User Spotlight**

**Jay Zou** - Postdoctoral Researcher at National Institute of Standards and Technology (NIST)

“I am interested in nanomechanics and photonics. I employ state-of-the-art nanofabrication technology to develop next generation metrology tools. A lot of challenges emerge during development. Interestingly, I can then apply these novel tools to better understand the new phenomena, and the understanding benefits us when the challenges show up next time. The Casimir force project in CNMS is a perfect example of our approach. The collaboration with the nanofabrication group in CNMS is crucial for our Casimir force project. One key requirement of our experiment is high parallelism between two micro-machined silicon surfaces where the Casimir force will be measured. Using the advanced e-beam lithography system with proximity effect correction in CNMS, we achieved very high parallelism. I would like to mention that Dr. Kravchenko helped us a lot in the e-beam lithography. The rich experience of the staff in CNMS is at least as attractive as, if not more than, the highly advanced facilities in CNMS.”

Jie Zou received his B.S. in Physics from Peking University, China and his Ph.D. in Physics from the University of Florida. For his graduate research, he studied non-Gaussian noise and the Casimir force using micromechanical devices. Jie is currently a CNST/UMD Postdoctoral Researcher at National Institute of Standards and Technology (NIST) and he is working towards developing novel scanning force probes using cavity optomechanics.

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**Casimir Forces On A Silicon Micromechanical Chip**

**Achievement**

The Casimir force between micromachined components with nanoscale separations within a silicon chip, in the absence of external objects has been demonstrated and measured.

**Significance**

Compact and integrated actuation and detection on-chip platform is realized for the first time in measuring Casimir forces. Understanding interactions between micromachined elements in integrated chips is of great technological importance. The successful demonstration of the Casimir force between micromachined elements in such systems is a breakthrough that will help with problems of stiction and friction in micro- and nanomachinery fabricated using wafer-based technology.

**Research Details**

- **CNMS Capability**: Advanced e-beam lithography system in combination with advanced proximity correction software package.
- Magnetomotive transduction measurement technique was utilized to measure interaction forces.
- Two interacting planar surfaces are automatically aligned as a result of nanofabrication process.


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**SEM of the micromechanical structure. The separation d between suspended doubly clamped beam and the movable electrode was controllably reduced so that the Casimir force can be detected.**

Upper panel: Measured force gradient between the beam and the movable electrode as a function of separation d. The red line represents the calculated Casimir force gradients between an electrode and a beam made of silicon. The purple line includes possible contributions from patch potentials. Lower panel: Deviations of the measured force gradient from the purple line in the upper panel.
CNMS Staff Spotlight

Alex Puretzky - Senior R&D Staff member in the Nanomaterials Synthesis and Functional Assembly Group

“I’m interested in understanding both mechanisms of nanomaterial synthesis and how their synthesis conditions affect their structure and properties. I synthesize nanomaterials primarily using laser ablation and chemical vapor deposition processes, and the materials include carbon nanotubes, unusual nanoparticles such as carbon nanohorns, and most recently graphene and other 2D-nanostructures for energy applications. The core of my research at ORNL has been on applying my spectroscopy expertise for the development and application of fast optical diagnostics for in-situ studies of growth of nanostructured materials and thin films. These were first successfully applied to understand the mechanisms involved in laser ablation synthesis of thin films, then carbon nanotubes and nanowires, and now graphene and other 2D nanostructures. I’m glad to see that our expertise in this field has attracted many users to CNMS. Currently, my research at CNMS is focused on laser spectroscopic characterization of 2D nanomaterials and their functionalities. It is very exciting to work at CNMS because of new challenges coming regularly from users, new advanced equipment, and strong theoretical support.”

Dr. Alex Puretzky is a Senior R&D Staff member at the CNMS in the Nanomaterials Synthesis and Functional Assembly Group. Before joining CNMS, he worked at ORNL’s Materials Science and Technology Division and the University of Tennessee’s Department of Materials Science and Engineering as a Research Associate Professor, and he continues to maintain strong research collaborations with both. Before coming to ORNL in 1992 he was a Research Scientist at the Institute of Spectroscopy, Moscow, Russia. He received his M.S. in Physics from Moscow Institute of Physics and Technology, his Ph.D. in Physics from the Institute of Spectroscopy, and his Ph.D. in Laser Spectroscopy from the Institute of Chemical Physics, Moscow, Russia. He has published more than 200 papers in refereed journals and books.

Real-Time Optical Diagnostics of Rapid Graphene Growth

Scientific Achievement
Real-time Raman spectroscopy, optical reflectivity, and microscope videography combined with pulsed gas introduction during chemical vapor deposition (CVD) were developed to characterize rapid isothermal graphene growth and subsequent precipitation upon cooling on catalytic substrates.

Significance
The ability to observe 2D nanosheet growth at high temperatures enables growth kinetics measurements vs. processing conditions (e.g., flux, pressure, temperature, etc.) allowing fundamental growth understanding and forming the basis for remote diagnostics for advanced nanomanufacturing.

Research Details
- CNMS tunable-wavelength Raman system operating in the UV was employed to perform in situ Raman measurements at high temperatures within a specially-modified micro-CVD reactor.
- Temperature dependent shifts, bandwidths, and intensities of the graphene G and 2D Raman bands were used to verify graphene growth, and estimate the fractional precipitation during cooling (with 1-second temporal resolution).
- Optical reflectivity and videography were correlated with the Raman measurements to provide much faster diagnostics of the nucleation and growth kinetics of graphene.