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nanoTECHNOLOGY news

from the University of Minnesota

NNIN
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Nanoscale Science, Engineering & Technology

WINTER 2015

Magnetic Dots: Energy Contours and Random Telegraph Noise

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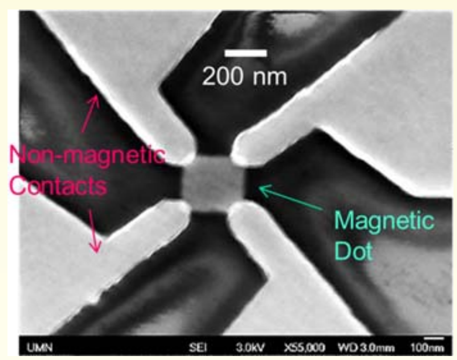
A research team from the University of Minnesota's School of Physics and Astronomy and Department of Electrical and Computer Engineering has utilized the Vistec EBPG5000+ system in the Minnesota Nano Center to make magnetic dots for fundamental studies of magnetic noise. These dots are comparable in size to the bits in magnetic hard drives and particles used in some experimental drug therapies (as small as 50 nm on a side).

By utilizing the extremely high resolution and accuracy of the EBPG5000+, the researchers were able to attach non-magnetic contacts to the dots to enable four terminal resistance measurements of individual magnetic dots. In magnetic systems the resistance depends upon the angle between the current and the magnetization, a phenomenon known as the anisotropic magnetoresistance (AMR). Therefore the magnetic state of a dot is known by its measured AMR value. By measuring the resistance of a dot varying both applied magnetic field and temperature the energy landscape and the magnetic random telegraph noise (RTN) were explored.



The magnetic dots have proven to be a highly tunable system for studying fundamental questions about noise. For example, RTN is thought to be the origin of 1/f noise, a noise phenomenon that is ubiquitous in nature but is poorly understood; to illustrate its ubiquity some systems which exhibit 1/f noise include electronic devices, music, automobile traffic, and flood levels of the Nile. The researchers are now in the process of using these dots to develop a bottom-up approach for studying the connection between RTN and 1/f noise and other noise related phenomena.

The research was supported by ONR and NSF. The energy surface measurements and the RTN have been published in *Appl. Phys. Lett*. 103, 042409 (2013); doi: 10.1063/1.4816510 and *Appl. Phys. Lett.* 104, 252408 (2014); http://dx.doi.org/10.1063/1.4884818 respectively.

ASME NEMB 2015: Minneapolis, April 19 – 22, 2015

The next ASME NanoEngineering for Medicine and Biology Conference is set for this April in Minneapolis. The NEMB 2015 technical program will be divided in six topical tracks, covering the areas of nano-imaging and nanophotonics; nano-therapeutics; nano and microfluidics; nano-to-macro multiscale modeling; nanotoxicology in public health and the environment; and biomimetic materials. Several tutorials will be presented on Sunday, April 19, as well as tours of the University of Minnesota Nano Center. Early Bird registration ends March 10 and university group discounts are available. See the conference website for complete details: http://www.asmeconferences.org/NEMB2015/

REMINDER: If your work uses the Minnesota Nano Center (formerly NFC) please add the following in the acknowledgements section of any publication: "Parts of this work were carried out in the Minnesota Nano Center which receives partial support from NSF through the NNIN program."

Nanotechnology News from the University of Minnesota is published by the University of Minnesota's Center for Nanostructure Applications and made possible by:

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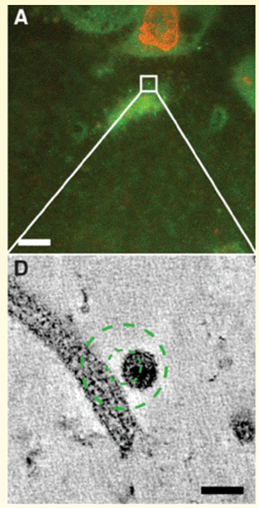
CHARFAC DIRECTOR'S MESSAGE

CharFac Director,
Greg Haugstad

In April, the CharFac and the University Imaging Center (advanced light microscopy) will hold a workshop entitled "Specimen Preparation for Biological EM and Correlative Light and Electron Microscopy". The workshop will focus on recent advances in (i) sample preparation and (ii) correlating what we image in the light microscope with the very same specimen in the electron microscope. We will show how to prepare cells and tissue samples by plunge or high pressure freezing, fix and dehydrate them at low temperature, then have them in polymerized resin using freeze-substitution using an automatic device, or rapid methods that can take place in one working day. These procedures are also well-suited for preserving fluorescence in resins for correlative studies and on-section immunolabeling. We will also highlight the FEI iCorr, a novel fluorescence microscope integrated with the Tecnai Spirit TEM at CharFac in its Moos Tower location. This instrument offers fast, in situ correlative light and electron microscopy (CLEM). CLEM also can be useful to the research of synthetic materials such as complex polymeric and organic systems that contain a hierarchy of length scales relevant to a material's processing, properties and/or performance, or materials that utilize fluorescent tagging for biomedical research. Participants should leave the workshop with practical knowledge of the latest procedures and equipment for CLEM.



Application of correlative method to HIV infected cells.

(A) fluorescence microscopy image of resin sections which merge GFP and RFP channels. The image shows HIV particles labeled with MA-EGFP on MDCK cells expressing H2B-RFP. Scale bar is 1um.

(D) An electron tomography slice of boxed area. MA-EGFP–labeled HIV particles were identified in close proximity to filopodia in the reconstruction map. Scale bar is 50nm.

Wanda Kukulski, Martin Schorb, Sonja Welsch, Andrea Picco, Marko Kaksonen, and John A.G. Briggs (2011) Correlated fluorescence and 3D electron microscopy with high sensitivity and spatial precision. J.Cell Biol. 192:111-119.

The second half of 2014 saw a strong surge in micro- to nano-scale analytical work performed by the CharFac staff for industry, particularly in the biomedical arena. There has been particularly strong activity in imaging with confocal Raman microscopy and atomic force microscopy, plus cryomicrotomy to generate cut faces of soft materials for microscopy; also, structural analysis with X-ray microdiffraction and small-angle X-ray scattering. All of this work required some amount of methods development or optimization; it thus embodies a happy confluence of interests between industrial R&D and the CharFac's need to develop "Intellectual Property" in the form of analytical methodologies. Most of this surge of work was proprietary in nature but far from routine, which is again helpful to CharFac's development of expertise that can benefit all types of users and clients, in addition to the obvious benefit of revenue to support facility costs.

If you would like to initiate discussion of CharFac methods as applied to industrial R&D or quality control, *pursuant to contracting analytical services in the CharFac*, please contact the CharFac's Associate Director for Industrial Partnerships, Dr. Klaus Wormuth (kwormuth@umn.edu). Typically this leads to a meeting or conference call with several CharFac specialists participating. As such, please recognize that discussions of analytical approaches, if not followed by actual work in the CharFac, amount to free consulting and sharing of analytical-methods IP, and thus are inappropriate. Moreover, the time required for *gratis* knowledge transfer to private entities is time taken away from many other staff responsibilities, including those that are attendant to the University's public mission.

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Greg Haugstad, Director

MNC DIRECTOR'S MESSAGE

MNC Director, Steve Campbell

We continue to work at providing new equipment for MNC. As mentioned in the last update, our proposal to the OVPR's infrastructure program to fund new equipment in PAN was successful. Our new aligner is now on the floor in PAN. The next major tool will be a high density plasma CVD system. We have hosted visits by PlasmaTherm and Oxford. The technology promises much better layers of the standard materials SiO_2, Si_3N_4, and low stress nitride. The systems are able to deposit very good films at temperatures as low as 27 °C. Residual hydrogen content is far less than in our existing system and you can get much better control of film stress. We are also planning to add a carbon source to allow us to deposit SiC, amorphous carbon and diamond-like carbon. We have also sent out wafers for them to deposit sample films that we are beginning to evaluate. We expect to make our selection by early spring and have the tool on the floor by September.

The other system on the horizon is a second ALD tool. Using funding from a new building donation from 3M and funds from a private donor, we will be able to acquire a plasma enhanced ALD tool. Our current ALD system is largely limited to oxides. Plasma systems can be used to deposit metals and nitrides in typical ALD fashion. Standard materials include TiN, Si_3N_4, and Pt. Vendor visits will begin in February. Let us know if you would like to participate.

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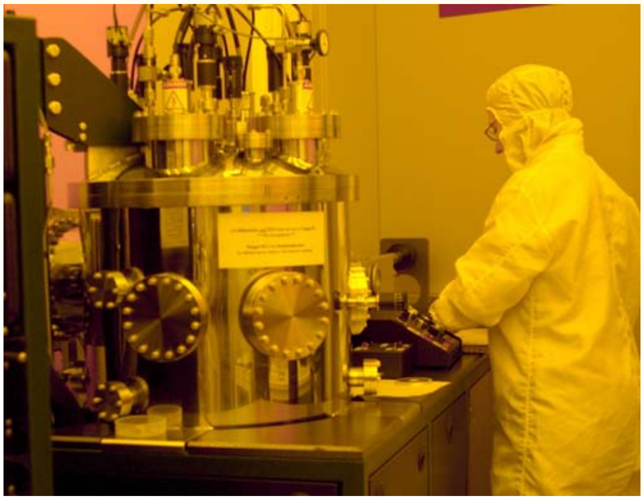
Steve Campbell, Director
Greg Cibuzar, Lab Manager

Thin Film Deposition Techniques

An important aspect of many micro- and nanofabrication processing sequences is the deposition of thin films. The films may be conductors, insulators, semiconductors or magnetic materials. At the Minnesota Nano Center we have several different process tools for deposition of a wide variety of thin films using the techniques of evaporation and sputtering. We currently have 3 different electron beam evaporation systems in our facility. Two of these evaporators, the CHA system and the Temescal system, are inside the cleanroom. The CHA is a newer tool with complete automation capability, a six pocket gun, fixturing for both planetary and lift-off deposition, and heated deposition capability. The Temescal is an older, manual operation system with a four pocket gun and lift-off fixturing. Both systems can support four to six inch wafers and smaller. Commonly deposited films include Cr, Ti, Ni, Al, Au, Pt, Pd, Ag, Mo, Cu, and Ge. MNC sputtering capabilities are centered around two AJA International systems. These tools have both RF and DC guns (2 each), load lock loading, single wafer deposition up to 8 inch diameter, and heated deposition. Common materials include Al, Al_2O_3, Au, Cr, Cu, Ge, ITO, Ni, SiO_2, Ta, Ti and W. If thin film deposition is needed for your project, consider having the work done at MNC on these excellent systems.



The AJA sputtering system at the Minnesota Nano Center.

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Published by the University of Minnesota's Minnesota Nano Center
and the National Nanotechnology Infrastructure Network.
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Minnesota Nano Center: www.mnc.umn.edu

The MNC is a state-of-the-art facility for interdisciplinary research in nanoscience and applied nanotechnology. The Center offers a comprehensive set of tools to help researchers develop new micro- and nanoscale devices, such as integrated circuits, advanced sensors, microelectromechanical systems (MEMS), and microfluidic systems. The MNC is also equipped to support nanotechnology research that spans many science and engineering fields, allowing advances in areas as diverse as cell biology, high performance materials, and biomedical device engineering.

The MNC is composed of two main facilities. Our current clean room and associated labs, formerly known as the Nanofabrication Center, are housed in Keller Hall. The Keller Lab has a 3000 square foot Class 100 clean room, and an additional 4000 square feet of labs and support areas.

In late 2013, the MNC will open a new research facility in the Physics and Nanotechnology (PN) building. The new PN Lab facility will offer a larger and more advanced clean room, with state-of-the-art tools for fabricating structures under 10 nanometers in size. The MNC will also offer two new specialized labs to support interdisciplinary research in bio-nanotechnology and nano-and micrometer-scale materials.

The National Nanotechnology Infrastructure Network: www.nnin.org

The National Nanotechnology Infrastructure Network (NNIN) is an integrated networked partnership of user facilities, supported by the National Science Foundation, serving the needs of nanoscale science, engineering and technology. The mission of the NNIN is to enable rapid advancements at the nano-scale by efficient access to nanotechnology infrastructure. The NNIN supports the Minnesota Nano Center at the University of Minnesota. As a node in NSF's National Nanotechnology Infrastructure Network (NNIN), the NFC provides access to advanced multi-user facilities to both industry and academic researchers, the latter at a subsidized rate.