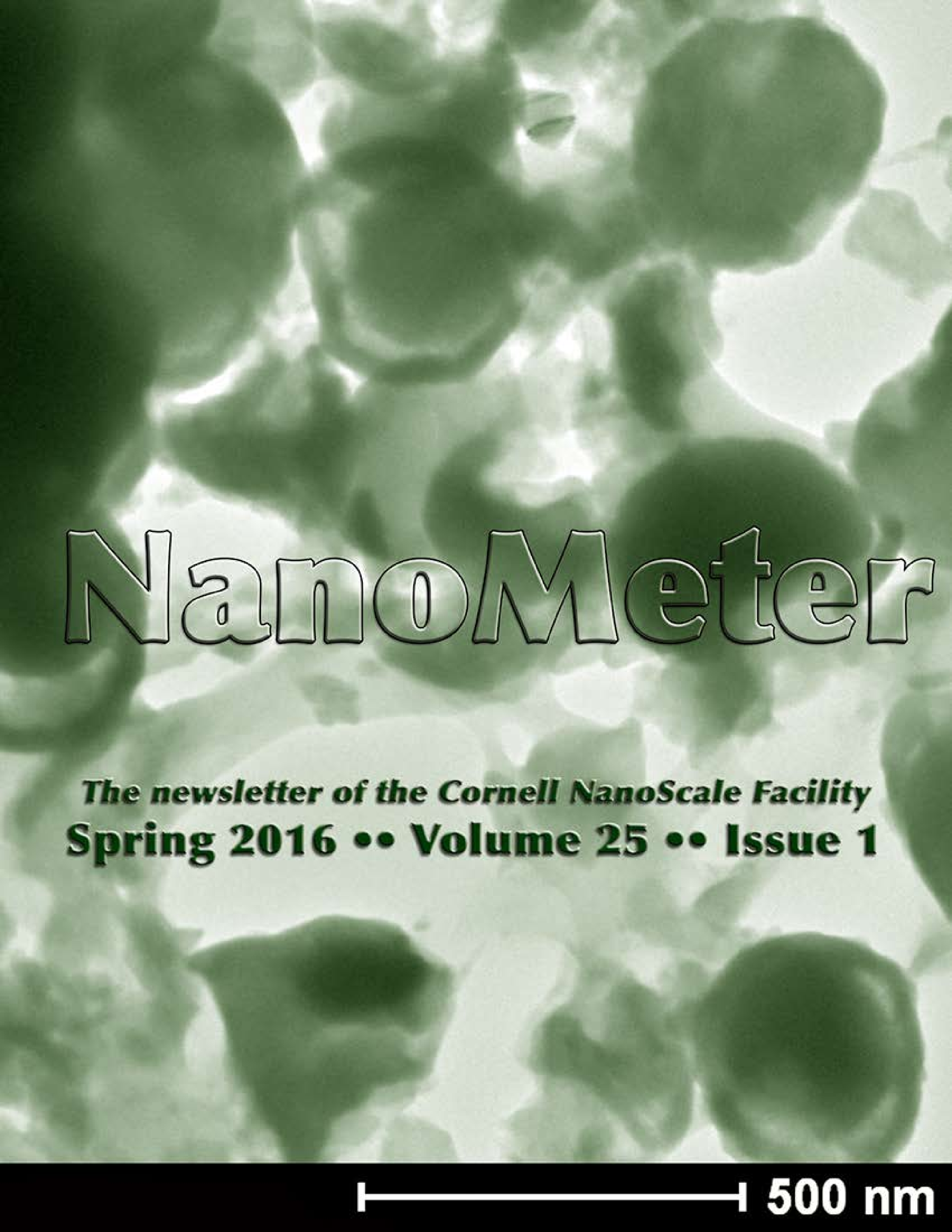

NanoMeter

The newsletter of the Cornell NanoScale Facility

Spring 2016 •• Volume 25 •• Issue 1

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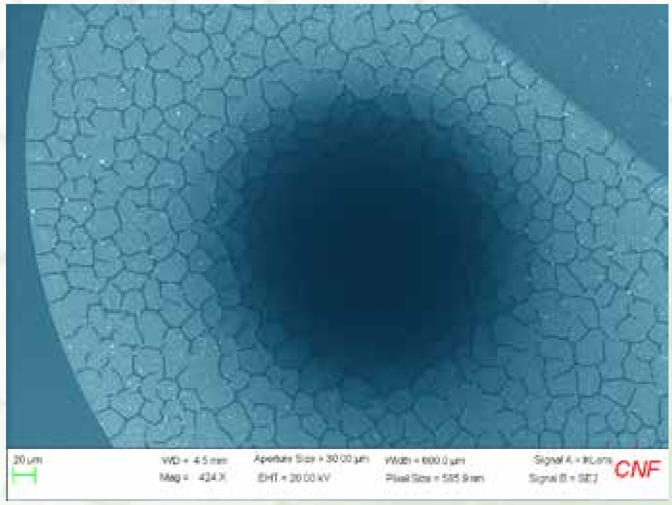

For this issue of the CNF NanoMeter: The cover image is from the article by Ryan Badman on page 11. The inside background is a research image by 2015 CNF REU Intern, Andrew King. Find Andrew's full report at http://nnin.org/reu/past-years/2015-nnin-reu-program. Article images were provided by Cornell Chronicle, the authors and or the researchers. All other photographs are credited as shown — or if uncredited, were taken by Don Tennant. The CNF NanoMeter is published twice a year and is formatted by Melanie-Claire Mallison. She welcomes your comments at mallison@cnf.cornell.edu

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Please reduce, reuse, recycle!

Welcome to the 2016 Spring Edition of the CNF NanoMeter

In this Spring 2016 edition of the NanoMeter, we are pleased to update you on the latest news from CNF. Inside you will find research highlights, a review of our annual meeting, information about student award winners, and some exciting new results from our staff.

New Equipment and Processes

CNF now has two atomic layer deposition (ALD) systems with different capabilities. The Arradiance ALD provides the new capability of making conformal coatings on nano-particles and powders, including aluminum oxide coatings of titania particles as described in more detail on page 11. We have installed a Bruker Quantax Energy Dispersive Spectroscopy (EDS) detector on our Zeiss Supra SEM. This gives the ability to do elemental analysis and mapping on wide variety of materials. A TEOS source has been added to the Oxford PECVD system to allow deposition of highly conformable SiO_2 films. The CNF Staff have also performed numerous baseline studies on amorphous silicon in the Oxford PECVD. All of our recipes are available to users!

Education and Outreach Events

As part of the activities under our new NSF funding, we have instituted a CNF Outreach Ambassador program that provides opportunities for students who are users of CNF to participate in educational outreach events. Our first big outreach event of 2016 was to host the FIRST Junior LEGO League Expo. In January we also held our 3-day short course, "Technology and Characterization at the Nanoscale (TCN)." This continues to be a great way to learn the nanofabrication landscape for students or engineers who are planning on working in the field. Our next TCN course will be in June 2016, and registration is free for up to five graduate students per (US) university from outside Cornell (see page 23).

Dan Ralph and Don Tennant

Network Update

In our last NanoMeter we announced the good news that we were selected to be part of NSF's new user facility program, the National Nanotechnology Coordinated Infrastructure (NNCI). We now know our partners in the network:

- *Mid-Atlantic Nanotechnology Hub for Research, Education and Innovation, University of Pennsylvania with partner Community College of Philadelphia*
- *Texas Nanofabrication Facility, University of Texas at Austin*
- *Northwest Nanotechnology Infrastructure, University of Washington with partner Oregon State University*
- *Southeastern Nanotechnology Infrastructure Corridor, Georgia Institute of Technology with partners North Carolina A&T State University and University of North Carolina-Greensboro*
- *Midwest Nano Infrastructure Corridor, University of Minnesota Twin Cities with partner North Dakota State University*
- *Montana Nanotechnology Facility, Montana State University with partner Carlton College*
- *Soft and Hybrid Nanotechnology Experimental Resource, Northwestern University with partner University of Chicago*
- *The Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure, Virginia Polytechnic Institute and State University*
- *North Carolina Research Triangle Nanotechnology Network, North Carolina State University with partners Duke University and University of North Carolina-Chapel Hill*
- *San Diego Nanotechnology Infrastructure, University of California, San Diego*
- *Stanford Site, Stanford University*
- *Nebraska Nanoscale Facility, University of Nebraska-Lincoln*
- *Nanotechnology Collaborative Infrastructure Southwest, Arizona State University with partners Maricopa County Community College District and Science Foundation Arizona*
- *The Kentucky Multi-scale Manufacturing and Nano Integration Node, University of Louisville with partner University of Kentucky*
- *The Center for Nanoscale Systems at Harvard University, Harvard University*

We look forward to working with this new network of facilities.

Under the NNCI, CNF will continue to serve as a national resource, to meet your research and commercialization needs. We welcome your comments as well as your suggestions for improvement.

Physicists Turn Toward Heat to Study Electron Spin

By Anne Ju Manning
Oct. 5, 2015
Cornell Chronicle

The quest to control and understand the intrinsic spin of electrons to advance nanoscale electronics is hampered by how hard it is to measure tiny, fast magnetic devices.

Applied physicists at Cornell offer a solution: using heat, instead of light, to measure magnetic systems at short length and time scales.

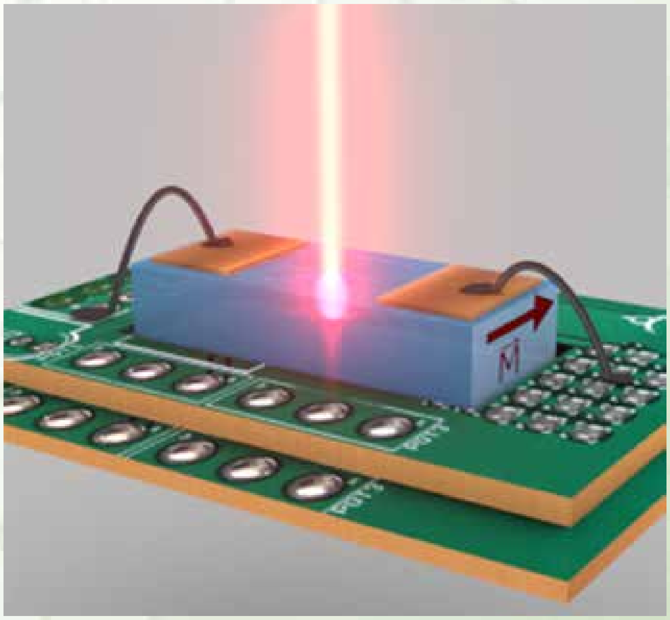
Researchers led by Greg Fuchs, assistant professor of applied and engineering physics, detail this new way to directly measure magnetic moments and how it may be used to break fundamental limits of spatial resolution that are imposed in purely optical magnetic measurements. Such a breakthrough, if perfected, could lead to a novel tabletop magnetic measurement technique and new, nanoscale electronic devices based on electrical spin, rather than charge. Their technique, which they call TRANE (Time-Resolved Anomalous Nernst Effect) microscopy, is detailed in the journal Nature Communications (Sept. 30.)

Why the interest in electron spin? In physics, electron spin is the well-established phenomenon of electrons behaving like a quantum version of a spinning top, and the angular momentum of these little tops pointing "up" or "down." An emerging field called spintronics explores the idea of using electron spin to control and store information using very low power. Technologies like nonvolatile magnetic memory could result with the broad understanding and application of electron spin. Spintronics, the subject of the 2007 Nobel Prize in Physics, is already impacting traditional electronics, which is based on the control of electron charge rather than spin.

"Direct imaging is really hard to do," Fuchs said. "Devices are tiny, and moving really fast, at gigahertz frequencies. We're talking about nanometers and picoseconds."

Scientists have been unable to directly image magnetic motion in nanoscale spintronic devices without hugely expensive x-ray sources at national facilities. In their own labs, the best they could do was infer magnetic properties from electrical measurements.

The current state of the art that is accessible to ordinary laboratories is to use optical polarization microscopy to make magnetic measurements. The technique relies on analysis of reflected light from short laser pulses to gain information about magnetization. Unfortunately, the physics of optical diffraction limit how small a laser spot can be used, which ultimately limits the resolution of the technique.



Provided by Isaiah Gray / Fuchs.

In their paper, the Cornell researchers show that by using heat, the spatial resolution of their measurements isn't limited by optical focusing, and their results suggest a method to achieve vastly improved spatial resolution. They also show that heat-based microscopy doesn't sacrifice the time resolution that they need for applications. They were able to observe that the heat diffusion time can be picoseconds, allowing them to measure magnetization in gigahertz ranges.

"This is an entirely new approach to studying magnetization, by using pulsed heating," said co-first author Jason Bartell, graduate student in the field of applied physics. "It's an exciting area to start looking at and seeing what new types of studies we can do." For instance, Bartell and colleagues will be looking at using tricks from nanophotonics, such as fabricating gold antennae to excite thermal excitations confined to nanoscale dimensions.

The paper is titled "Toward a table-top microscope for nanoscale magnetic imaging using picosecond thermal gradients" and includes co-first authorship by graduate student Darryl Ngai and authorship by Zhaoqi Leng '14. The research received support from the Air Force Office of Scientific Research, and made use of the Cornell Center for Materials Research, supported through the National Science Foundation. Devices were fabricated at the Cornell NanoScale Facility, also supported by NSF.

Creativity Leads to Measuring Ultrafast, Thin Photodetector

By Tom Fleischman
Cornell Chronicle
December 18, 2015

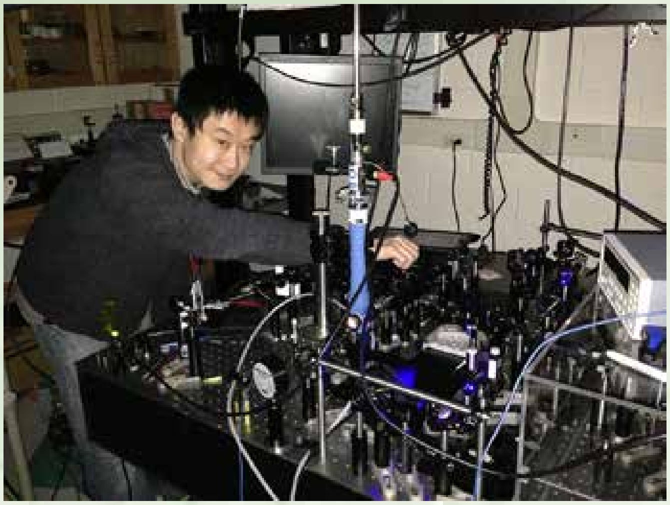
Making an incredibly fast photodetector is one thing, but actually measuring its speed is another. Graduate student Haining Wang came up with an inventive way of measuring the near-instantaneous electrical current generated using a light detector that he and a team of Cornell engineers made using an atomically thin material.

The team, headed by Farhan Rana, associate professor in the School of Electrical and Computer Engineering, measured the ultrafast response of their two-dimensional photodetector using a strobe-like process called two-pulse photovoltage correlation. The team's paper, "Ultrafast response of monolayer molybdenum disulfide photodetectors," was published in Nature Communications, November 17.

"It was very clever," Rana said of Wang's idea. "He came up with this idea of essentially hitting the device with an optical pulse [to initiate an electrical charge] and after a small delay, hitting it with the pulse again. By varying the time between the first and second pulse, and looking at the response of the device as a result, you can sort of see what the intrinsic speed of the device is."

Rana's team used a 3-atoms-thick sheet of molybdenum disulfide (MoS_2), a material Rana and others have tested previously in photodetection studies. Photodetection is used in various high-speed optoelectronic applications, including optical fiber networks.

According to Wang's experimentation, the MoS_2 photodetector had intrinsic response times as short as three picoseconds; a picosecond is one-trillionth of a second. Co-author Wang said the speed at which the MoS_2 detector responds is vastly superior to current technology, and is partly due to the extremely short distance the charges generated by light must travel before making it out of the device and into the external electrical circuit.



Provided, Haining Wang in his lab.

"State-of-the-art optical communication links work at around 10 GHz per channel, so if you make 10 channels in parallel, you have a 100 GHz optical communication link," he said. "We find that this single device can work up to 300 GHz, which is an amazing speed." Wang also said that, despite being just 3-atoms thick, MoS_2 is "extremely easy to make" and relatively inexpensive, adding to its appeal.

As with all photodetectors, however, the downside is the low quantum efficiency, which is a measure of the number of charges generated by the detector in the external circuit per incident photon. In the Rana team's work, only a small percentage of the light-generated charges — 1 to 2 percent — were able to escape the photodetector and make it into the external circuit; most recombined inside the device, producing heat. Market-available photodetector materials such as silicon and gallium arsenide, while generally much slower, have efficiencies of anywhere from 50 to 90 percent.

"That's the tradeoff of these devices. Every photodetector ever made has always had to face the efficiency-speed tradeoff," Rana said.

Further research by the group will include a discovery made by both Rana's team and a research group at the University of California, Berkeley: coating the sample with a chemical that will "basically kill the recombination completely," Rana said. "So you have to play around with these material surfaces and make sure you're attaching the right molecules and atoms to it on the outside," Rana said. The Berkeley group reported in November an efficiency of 95% using their chemically coated MoS_2 photodetector.

Rana said the photodetection technology will play a major role in emerging fields, such as LiFi — using light as a source of wireless communication. He said windows and walls could be coated with atomically thin layers of material that would interact with light and carry Internet signals.

Other co-authors include former graduate students Changjian Zhang and Weimin Chan, and Sandip Tiwari, the Charles N. Mellowes Professor of Engineering. Their research was supported by the Cornell Center for Materials Research, under a National Science Foundation grant, the Air Force Office of Scientific Research, the Office of Naval Research, as well as an NSF grant to the Cornell NanoScale Science and Technology Facility.

First Self-Assembled Superconductor Structure Created

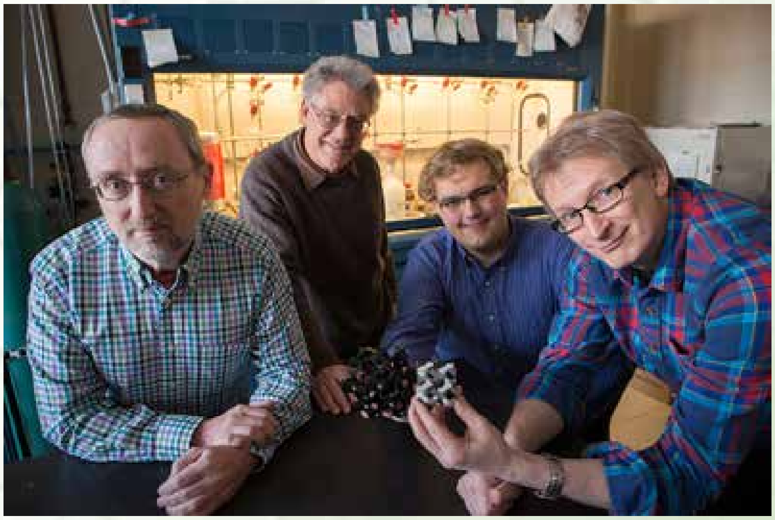
By Tom Fleischman
January 29, 2016
Cornell Chronicle

Building on nearly two decade's worth of research, a multidisciplinary team at Cornell has blazed a new trail by creating a self-assembled, three-dimensional gyroidal superconductor.

Ulrich Wiesner, the Spencer T. Olin Professor of Engineering, led the group, which included researchers in engineering, chemistry and physics.

The group's findings are detailed in a paper published in Science Advances, January 29.

Wiesner said it's the first time a superconductor, in this case niobium nitride (NbN), has self-assembled into a porous, 3-D gyroidal structure. The gyroid is a complex cubic structure based on a surface that divides space into two separate volumes that are interpenetrating and contain various spirals. Pores and the superconducting material have structural dimensions of only around 10 nanometers, which could lead to entirely novel property profiles of superconductors.



Group leader Ulrich Wiesner, right, the Spencer T. Olin Professor of Engineering, and graduate student and co-lead author Peter Beaucage, second from right, hold models of the self-assembled gyroid superconductor the group created. Also pictured are Bruce van Dover, left, professor of Materials Science and Engineering, and Sol Gruner, the John L. Wetherill Professor of Physics. Lindsay France/University Photography

Superconductivity for practical uses, such as in magnetic resonance imaging (MRI) scanners and fusion reactors, is only possible at near absolute zero (-459.67° below zero), although recent experimentation has yielded superconducting at a comparatively balmy 94° below zero.

"There's this effort in research to get superconducting at higher temperatures, so that you don't have to cool anymore," Wiesner said. "That would revolutionize everything. There's a huge impetus to get that."

Superconductivity, in which electrons flow without resistance and the resultant energy-sapping heat, is still an expensive proposition. MRIs use superconducting magnets, but the magnets constantly have to be cooled, usually with a combination of liquid helium and nitrogen.

Wiesner and frequent co-author Sol Gruner had been dreaming for over two decades about making a gyroidal superconductor in order to explore how this would affect the superconducting properties. The difficulty was in figuring out a way to synthesize the material.

The breakthrough was the decision to use NbN as the superconductor. This was born from a conversation between Wiesner and Cornell physicist James Sethna, a co-author on the paper. Wiesner recalled asking Sethna what he thought of the possibility of a gyroidal superconductor, and what material should be used.

Sethna, who was writing a paper on superconductors at the time, felt that NbN would be the best option.

Wiesner's group started by using organic block copolymers to structure direct sol-gel niobium oxide (Nb_2O_5) into three-dimensional alternating gyroid networks by solvent evaporation-induced self-assembly. Simply put, the group built two intertwined gyroidal network structures, then removed one of them by heating in air at 450°.

The team's discovery featured a bit of 'serendipity," Wiesner said. In the first attempt to achieve superconductivity, the niobium oxide (under flowing ammonia for conversion to the nitride) was heated to a temperature of 700°. After cooling the material to room temperature, it was determined that superconductivity had not been achieved. The same material was then heated to 850°, cooled and tested, and superconductivity had been achieved.

"We tried going directly to 850°, and that didn't work," Wiesner said. 'so we had to heat it to 700°, cool it and then heat it to 850° and then it worked. Only then."

Wiesner said the group is unable to explain why the heating, cooling and reheating works, but "it's something we're continuing to research," he added.

Limited previous study on mesostructured superconductors was due, in part, to a lack of suitable material for testing. The work by Wiesner's team is a first step toward more research in this area.

"Now that we have these periodically nanostructured and porous materials, we can start to ask questions about structure property relationships," he said. "Or we can fill the pores with a second material, that may be magnetic or a semiconductor, and then study the properties of these new superconducting composites with very large interfacial areas."

This latest effort is groundbreaking in terms of bringing together the organic and inorganic science communities, Wiesner said.

"We are saying to the superconducting community, "Hey, look, these organic block copolymer materials can help you generate completely new superconducting structures and composite materials, which may have completely novel properties and transition temperatures. This is worth looking into?" Wiesner said.

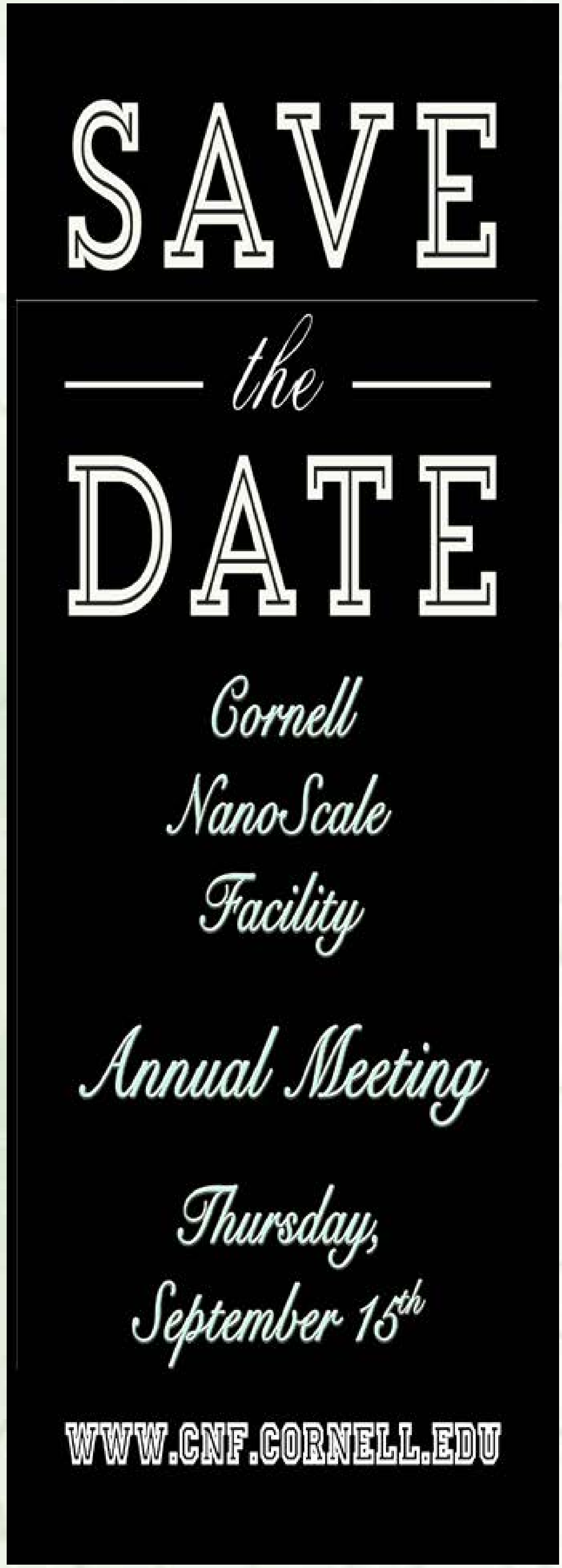
Wiesner, whose paper on laser heating-induced structures from block copolymer directed self-assembly was published in Science on July 3, noted that his team's work points to the collaborative nature of much of the research going on at Cornell. Students, grad students and professors are more identified by their fields of study and not their departments, he said.

"There is a lot of interaction among these different departments, facilitated by the field structure at Cornell," he said. "At most places, they are siloed, where at Cornell, even the administrative setup is already encouraging and facilitating interdisciplinary research."

Co-lead authors on the paper, titled "Block copolymer self-assembly directed synthesis of mesoporous gyroidal superconductors," were Spencer Robbins and Peter Beaucage, graduate students in the fields of chemistry and chemical biology, and materials science and engineering, respectively. Robbins, who graduated in January 2015, is now a materials scientist at San Francisco-based TeraPore Technologies, a startup company out of the Wiesner group.

Other team members included Francis DiSalvo, the John A. Newman Professor of Chemistry and Chemical Biology; Gruner, the John L. Wetherill Professor of Physics; and Bruce van Dover, chair of the Department of Materials Science and Engineering.

The work was supported by grants from the National Science Foundation and the U.S. Department of Energy, and it made use of the Cornell Center for Materials Research Shared Facility, the Cornell High Energy Synchrotron Source, the Cornell NanoScale Science and Technology Facility, and the Kavli Institute at Cornell for Nanoscale Science.



Cornell Looks to Make PARADIM Shift with $25M NSF Grant

By Syl Kacapyr, Cornell Chronicle
March 4, 2016

Cornell University is leading an effort that will empower scientists, engineers and entrepreneurs throughout the nation to design and create new interface materials — materials that do not exist in nature and possess unprecedented properties — thanks to a $25 million grant from the NSF.

The Platform for the Accelerated Realization, Analysis, and Discovery of Interface Materials (PARADIM) will invite users to take advantage of various facilities, data and expertise at Cornell and its partner institutions to create new materials from the bottom up, eliciting novel ways for electrons to carry information in solid-state devices and efficiently interact with magnetic, electrical and optical stimuli.

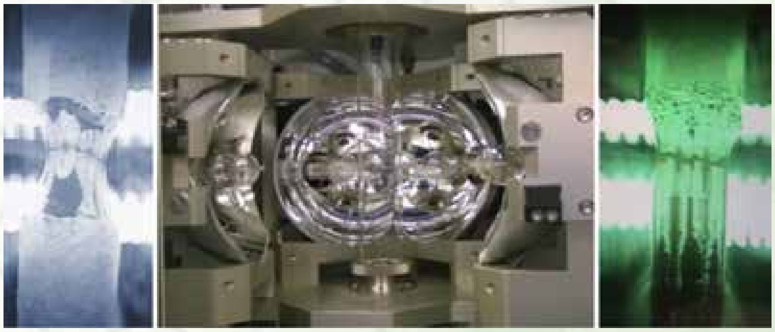


Figure 1; An optical floating zone furnace, center, is used to synthesize new materials together, including single crystals of Pr2Zr2O7, left in blue, and Yb2Ti2O7, right in green. The resulting single crystals are several millimeters in diameter and several centimeters long. Provided.

These interface materials produce properties that will impact electronics relevant to national security (quantum computation, universal memories and secure communication), clean energy (improved catalysts), national infrastructure (smart systems enabling low-power signal processing and data storage), and human welfare (miniaturized sensors for medical imaging).

"By providing users with state-of-the-art theory, synthesis and characterization capabilities, this platform marks the beginning of a new paradigm in materials discovery," said Darrell Schlom, professor of materials science and engineering and PARADIM director. Accelerating such discovery is of national importance, according to the NSF, which says the platform was inspired by the Materials Genome Initiative launched by the White House in 2011.

Empire State Development, New York state's chief economic development agency, has also committed to invest up to $377,000 annually over the next five years to support the university's model of innovation, convert concepts and ideas to the commercial sector, and generate a positive impact for both Southern Tier and New York economy.

"Cornell and its game-changing platform, PARADIM, are helping to transform high-tech business in New York state and across the nation," said Empire State Development President, CEO and Commissioner Howard Zemsky. "Opportunities offered through this platform will improve research and development, and support the innovative startups and companies that are creating the jobs of the future in the Empire State."

To balance the desire for a rich nationwide user group and the practicality of managing physical resources across different locations, PARADIM locates its Web-based theory facility at Clark Atlanta University, its bulk-crystal growth facility at Johns Hopkins University and its thin-film growth and characterization facilities at Cornell. PARADIM also leverages expertise from Princeton University as well as existing user facilities such as the Cornell NanoScale Facility, the Cornell Center for Materials Research, and the Johns Hopkins Materials Characterization and Processing Facility.

"There's no better institution to lead this platform than Cornell," said Lance Collins, dean of engineering. "Advanced materials have been a historic strength for us and our world-class centers and facilities have been drawing some of the greatest scientific minds to our campus for decades."

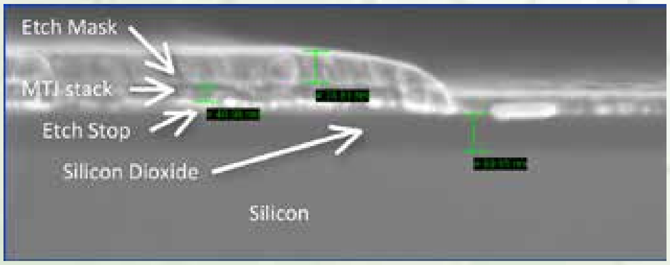
Robert Buhrman, senior vice provost for research, said in addition to taking advantage of the university's facilities, "this new materials innovation platform is particularly well supported by Cornell's highly collaborative and broadly interdisciplinary approach to materials research. We look forward to the impressive accomplishments and breakthroughs that will undoubtedly ensue," said Buhrman.

Along with training materials innovators to work effectively in teams, PARADIM will conduct free summer schools involving hands-on use of facilities to help educate its "community of practitioners" and advance the field through the cross-fertilization of ideas. PARADIM will also serve as a focal point for training the next generation of technologists who are accustomed to designing new interface materials and have the skills necessary to make them a reality.

"PARADIM is a mecca for materials discovery. We look forward to helping users realize their materials-by-design dreams," said Schlom.

New Etching Process for Magnetic RAM Developed by Cornell NanoScale Facility and Oxford Instruments Plasma Technology

For immediate release
Oxford Instruments
www.oxford-instruments.com



The Cornell NanoScale Science and Technology Facility (CNF), a leading university research facility located at Cornell University, Ithaca, NY, and Oxford Instruments Plasma Technology (OIPT), UK, have collaborated to develop a novel etching process targeted specifically at magnetic random-access memory (MRAM)-based device fabrication. These results, obtained at CNF, add a significant contribution to OIPT's large portfolio of etching processes.

MRAM is a high performance, low power, low degradation, non-volatile data storage technology that some suggest gives it the potential to become a "universal memory," able to replace SRAM, DRAM, EEPROM and flash. Etching of magnetic based materials for the development and scaling of MRAM and spintronic devices is therefore of keen interest to several leading research groups using the CNF.

Vincent J. Genova, a research staff member at CNF, explains the technology and the new process, "An element of MRAM consists of a magnetic tunnel junction (MTJ) and a CMOS transistor. One of the most challenging steps in MRAM fabrication is the etching of the MTJ stack. The stack typically contains a non-magnetic seed layer to promote proper crystalline growth (e.g., Ta), an antiferromagnet such as PtMn or IrMn, a stack of alloy pinned layers (CoFeB), a tunnelling barrier such as MgO, metals such as Ru and/or Pt, and a suitable hard mask such as TiN or Ta.

The problem is that magnetic materials have difficulty reacting with most chemically active plasma species to form volatile etch products, so users often have to resort to purely physical ion milling processes. However, ion milling suffers from low etch rates, low selectivity, undesirable sidewall redeposition especially for nanoscale features, and damage to the device structure itself.

Recently, several research groups have shown that chemical etching of Co, Fe, and Ni based alloys can be achieved using plasmas formed from methanol (CH_3OH) and argon. The new CNF/OIPT process is a result of a Design of Experiment (DOE) in which the level of CH_3OH in Ar varied, along

with variations in the ICP power, bias power, and pressure. Methanol, as the principal plasma reactant, forms volatile carbonyl compounds (e.g. $Ni(CO)_4$, $Fe(CO)_5$, and $Co_2(CO)_8$) at room temperature. This chemistry-based process avoids the disadvantages of purely physical milling.

The antiferromagnet IrMn also etches in a methanol plasma. In addition, the selectivity over common mask materials such as Al_2O_3, Ta, Ti, TaN, and TiN is high, while leaving no residue on the etched devices. We demonstrated successful etching of a 41 nm thick magnetic tunnel junction stack stopping on the tantalum under layer (see figure left). High selectivity (>10:1) over both the Ta mask and under layer is achieved through the formation of tantalum carbide in the methanol process."

CNF was pleased to announce the full facilitation of the new PlasmaPro 100 Cobra ICP etch system from Oxford Instruments Plasma Technology (OIPT) in 2015 (pictured above). This inductively coupled plasma (ICP) based RIE platform is configured for state of the art nanoscale etching vital to the research work of CNF. The system includes many extras that make for a highly flexible and powerful etch research tool. These include a wide range temperature (-150°C to +400°C) electrode, which greatly enhances the spectrum of materials that can be etched with volatile chemistries, low frequency electrode biasing and a vapour delivery system for methanol.

This advanced methanol-based etch capability for magnetic materials is an enabling process that is now available to the researchers at CNF and to the newly formed National Nanotechnology Coordinated Infrastructure Network (NNCI)

"This research work at CNF adds a significant contribution to Oxford Instruments Plasma Technology's extensive portfolio of etching processes, enabled through the use of our state of the art PlasmaPro 100 Cobra ICP etch system. We are delighted that our technology is assisting such a prestigious research centre achieve its fundamental research goals," comments David Haynes, Global Field Sales Director at Oxford Instruments Plasma Technology.

For further technical information, please contact Vincent Genova at Genova@cnf.cornell.edu or Colin Welch at colin.welch@oxinst.com.

Lynn Rathbun, laboratory manager at the Cornell NanoScale Science and Technology Facility, shows engineering students how to set up demonstrations. Lindsay France/University Photography

Graduate Students Aim to Make Nanotech Fun, Accessible for Kids

By Tom Fleischman
Cornell Chronicle
December 18, 2015

Baseball legend Joe DiMaggio was quoted as saying the reason he always gave 100 percent effort was, "There's always some kid who may be seeing me for the first time. I owe him my best."

It was that kind of thinking that got Cornell graduate student Hao Shi excited about outreach. He volunteered to take part in an event at the Cornell Center for Materials Research for high school students, at the request of his labmate, and his demonstration of the laser capture microdissection microscope he used turned out to be a revelation, both for the students and for himself.

"It was not much of an effort for me, it's really just what I do every day," said Shi, a second-year student in physics. "But afterward, all the students told me that they thought it was really cool; they couldn't stop talking about it.

"That got me thinking," he said. "I realized it was routine to me because I know how to do it, but to the high school kids, that's really cool science."

Cornell is hoping to bring more "cool science" to young students in the area with the establishment of CNF Ambassadors, a new program being run by the Cornell NanoScale Science and Technology Facility. CNF staff members Lynn Rathbun and Beth Rhoades are coordinating the effort, which so far has attracted 12 grad students to engage with area K-12 students.

Seven of the volunteers took part in orientation in mid-December in the Duffield Hall Demo Room; the rest of the participants will get their introduction to the ambassador program in January.

Rathbun said that Cornell graduate students have engaged in outreach in the past, and the new program will give greater structure to the effort and make more efficient use of the volunteer help. Initially, the student ambassadors will engage with children visiting CNF, but eventually they will give demonstrations at area schools.

"We have the resources," said Rathbun, CNF's laboratory manager. "We have lots of materials and activities that the students and staff can use, and it's a way to reach the community and get them involved in a little bit of what goes on here at Cornell and in science in general."

The ambassadors will lead school groups, 4-H activities and summer campers as well as children taking part in NanoDays, an annual weeklong festival of educational programs about nanoscale science and engineering sponsored by the National Science Foundation. The 2016 NanoDays celebration is slated for March 26-April 3.

Melanie-Claire Mallison, CNF's public relations associate, said the CNF attracts approximately 2,000 visitors a year, many of them young people. She said she's excited about the possibilities that arise when developing minds are exposed to new ideas.

Grad student Shi saw the effect his outreach had on young people who might never have been exposed to his type of work otherwise. Fellow CNF Ambassadors volunteer Ryan Badman's first exposure to outreach came at the other end of the interaction. The graduate of nearby Jordan-Elbridge High, outside of Syracuse, took a summer physics program at Syracuse University, where his father, Lee, works as an adjunct.

"That's what got me into physics," said Badman, whose work focuses on biophysics, nanofabrication and microscopy. "I think universities need to play a big role in recruiting high school kids, so I like this opportunity."

Alex Ruyack from Brewster, NY, a student in electrical and computer engineering, said that he got involved in outreach while in high school, conducting weekly science experiments for elementary schoolchildren.

"I've been involved with the Sciencenter, I've worked with the Physics Bus and have done a lot of outreach through CNF, too," he said. "It's something I've always done and always enjoyed, and I don't plan to stop doing it."

Advanced Nanoparticle Fabrication and ALD Coating Capabilities Introduced to CNF

By Ryan Badman
CNF Fellow and PhD Student in M. Wang Lab

The Fall 2015 edition of the NanoMeter announced the new availability of the Arradiance GEMStar 6 Atomic Layer Deposition (ALD) system in the main CNF cleanroom. One of the highlighted features of the Arradiance tool is its ability to conformally coat nanoparticles with various dielectric and metal films to nanometer precision. An ongoing CNF Fellow project has successfully characterized and optimized the ability of the Arradiance ALD system to conformally coat nanoparticles in a high quality and time-efficient method. The results will be fully revealed in a forthcoming Journal of Vacuum Science and Technology submission.

The nanoparticles used in the study were monodisperse (completely spherical) titania nanospheres fabricated from freely available chemicals in the Cornell Nanobiotechnology Center (NBTC). Utilizing protocols that can be readily provided to interested CNF or NBTC users, these nanospheres can be repeatedly produced to have diameters between approximately 50 nm up to several tens of microns or more, with an estimated size deviation of 5-10%. The nanosphere fabrication process takes only one hour to produce tens to hundreds of milliliters of dense nanosphere solutions. Additionally, established and tested anneal protocols in the Bard Hall anneal furnaces demonstrated the tunability of the nanosphere index of refraction to values between 1.6 and 2.7. Figure 1 displays the titania nanospheres fabricated in the study.

The nanoparticles were uniformly and conformally coated with an alumina ALD coating using a stationary crucible. Fast and slow coating recipes, and an optional rotary stage, are available depending on the quantity of nanoparticles being coated. Figure 2 is a CNF-produced example of a conformal alumina ALD coating around a titania nanosphere.

Professor Michelle Wang's research group is already using the Duffield Hall nanoparticle capabilities for biophysics research projects, and the Weisner group at Cornell was instrumental in persuading CNF to purchase the Arradiance system to meet their own nanoparticle research needs. Future studies will characterize the production of monodisperse silica and zinc oxide nanoparticles, along with ALD coatings including silica, titania, and platinum. The versatility of the Arradiance GEMStar system allows the CNF to add additional precursors in order to meet the changing needs to the diverse CNF user community. We anticipate that the new nanoparticle processing abilities will be useful to many researchers studying catalytic reactions, drug delivery, optical trapping, materials science, etc.

Images were obtained as part of the CNF Fellow study using both scanning and transmission electron microscopes in CNF and the Cornell Center for Materials Research respectively. This unique ALD nanoparticle coating capability is a tremendous asset not only to CNF, but to the entire newly created National Nanotechnology Coordinated Infrastructure (NNCI).

For more detailed information on fabricating and coating nanoparticles, please contact CNF Fellow Ryan Badman (rpb226@cornell.edu), or CNF Research Staff members Vincent Genova (genova@cnf.cornell.edu) and Xinwei Wu (wu@cnf.cornell.edu)

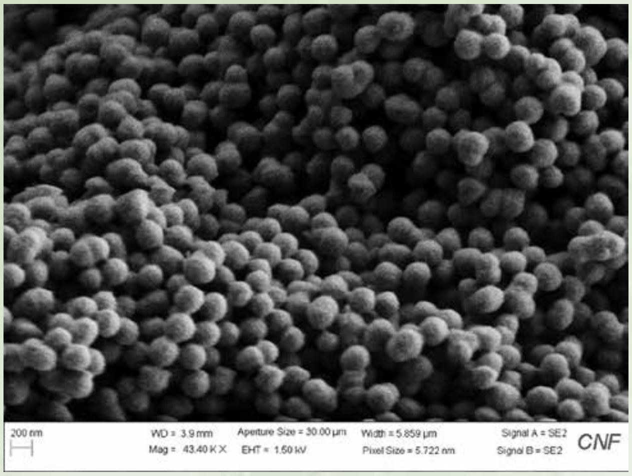


Figure 1: Titania beads chemically synthesized using CNF and NBTC facilities in Duffield Hall. These titania beads can be produced in a highly repeatable process to have indices of refraction between 1.6 and 2.7, with diameters between 50 nm and several 10's of microns. These nanospheres can be conformally cladded using the Arradiance GEMStar 6 ALD system to have 1-50 nm thick films of silica, alumina, or platinum.

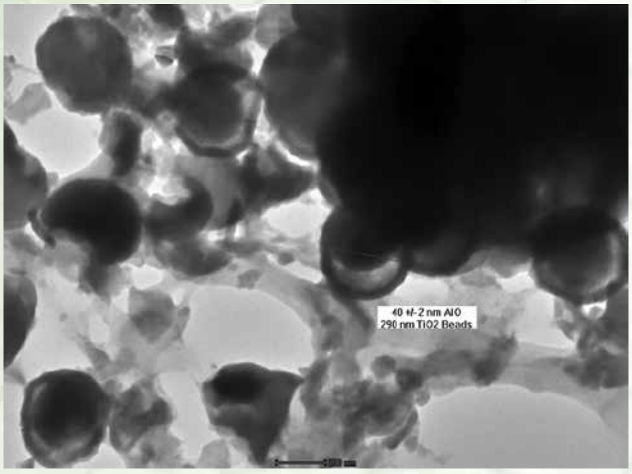


Figure 2: TEM image showing a conformal alumina ALD coating around a titania nanosphere. The alumina was deposited by the Arradiance GEMStar 6 ALD system. The black-ringed white circles are the approximately 300 nm diameter titania beads, while the black ring around the circle circumference is the conformal 40nm alumina ALD coating.

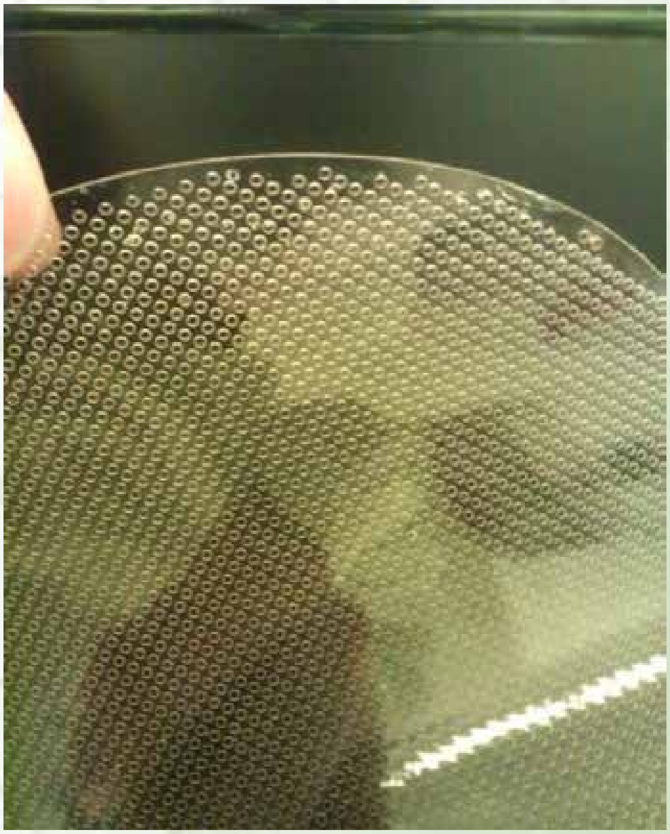
Coming Soon: Pre-Cast Photosensitive Epoxy Sheets

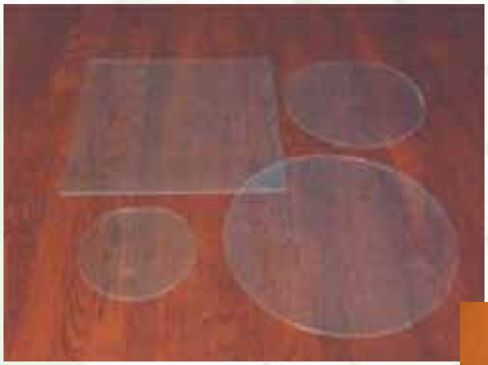
As an alternate approach to the challenge of casting thick SU-8-based features, we are currently testing a process that uses dry sheets of an SU-8 like epoxy.

Pre-cast and dried sheets of photosensitive epoxy from DJ DevCorp come in standard and uniform thicknesses of 5 to 500 microns with no edge bead. They are pre-cut to the shape of wafers or glass slides. The process is simple. Sheets are laminated onto dehydrated substrates and then exposed to UV on a contact aligner. Post-exposure bake in an oven is followed by development in our PGMEA-based developers. A final hard bake will relieve stress in thick devices.

The product has been used for MEMS, microfluidics, and packaging. We hope to have the materials and a clean room process available by the end of March.

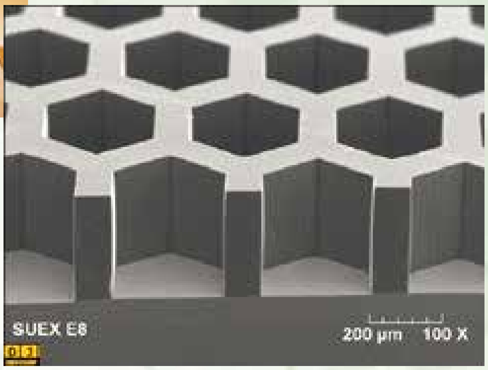
Contact Beth Rhoades if you have questions or you're interested in getting training when the process is available. In the meantime, take a look at the DJ DevCorp website for inspiration (http://www.djdevcorp.com).





Pre-cast sheets come in various sizes and shapes.

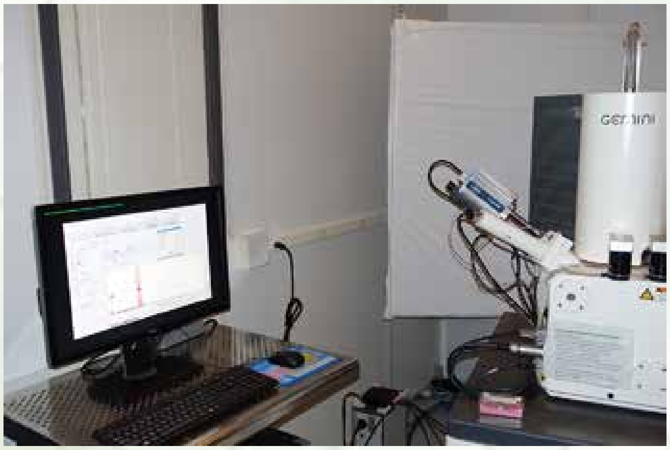
Pre-cast sheets are laminated to the substrate.



Final features.

Bruker Energy-Dispersive X-Ray Spectroscopy (EDS)

CNF has aquired a Bruker QUANTAX 200 Energy Dispersive X-ray Spectrometer (EDS) with XFlash®6 silicon drift detector. The QUANTAX 200 is a modular EDS system for qualitative and quantitative microanalysis. The system's standard-less quantification software enables manual, automatic or interactive spectra evaluation and provides reliable results for specimens with polished or irregular surfaces, thin layers and particles. The XFlash® detector is a Silicon Drift Detector (SDD), which needs no liquid nitrogen cooling, provides high throughput rates and light element detection capabilities. The QUANTAX 200 uses the scanning system of the Zeiss Supra SEM, and has line scannning with spectrum-at-every-pixel functionality and also does mapping to produce element images.



Contact Alan Bleier with questions or requests for training, bleier@cnf.cornell.edu

Specifications include:

- Energy resolution < 129 eV at Mn-Kα
- 60 mm^2 active area
- Maximum input count rate > 1,000,000 cps
- Sealed light element window, detection from Beryllium (Z=4) to Americium (Z=95)
- Vibration-free, maintenance-free, Peltier cooling
- Motorized retraction system
- ESPRIT Spectrum quantification software for spectrum acquisition and qualitative analysis, with real-time mode and comprehensive atomic database
- ESPRIT Quant, software tools for standardless quantitative spectrum analysis
- ESPRIT MultiPoint, spectrum acquisition from many user-defined points/areas in an image
- ESPRIT Line, spectral line scan with spectra data base (spectrum at every pixel)
- ESPRIT Map, digital element mapping with unlimited number of elements (regions)
- ESPRIT HyperMap, element mapping with hyper spectral database
- ESPRIT MaxSpec, maximum pixel spectrum for locating rare elements

CNF's FIRST® Junior LEGO® League Expo

The CNF hosted the tenth annual FIRST® Junior LEGO® League Expo on Saturday, January 30th, where over 20 teams presented their LEGO models for the Waste WiseSM challenge. The kids were challenged to track a piece of trash from start to finish and represent that journey in LEGO models.

The CNF has hosted the Expo for ten years, starting in the 2005-2006 NanoQuest season, where the kids were challenged to learn and understand size scales all the way down to the nanoscale. CNF staff had so much fun with the event that it was continued on through seasons covering everything from power, natural disasters, and challenges of aging. Over the years this event has hosted over 900 kids on 175 teams, coming in from Buffalo, NY, to Holmdel, NJ, and many places in between.

The Ithaca Sciencenter has generously been a part of our Expo for all ten years, providing fun activities for the kids to do while the reviewers meet to decide awards. This year we were also joined by the Tompkins County Recycling & Solid Waste Management Division, who brought their Bin It to Win It game for the kids to enjoy. The CNF has also appreciated the support of the Cornell Chapter of the Society of Women Engineers (SWE) for coming to help run the event. The Shell Corporation has also generously supported the event for the past six years.

Contact the Event Organizer, Daniel Woodie, with any questions you may have, daniel.woodie@cornell.edu.

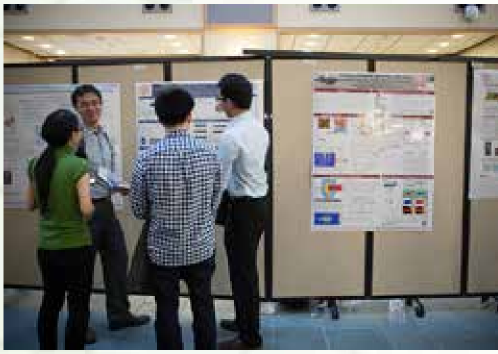
We hope to have even more teams next year for our Creatures Craze℠ challenge!

2015 CNF Annual Meeting Wrap Up

Once again, we were honored by the participation of over 150 people at our annual meeting. From Professor Karl Berggren's (MIT) talk on "*Manufacturing Below 10 Nanometers: Surprises at the Ultra-Nano*" to our corporate-sponsored poster session and awards, the meeting was an interesting and informative day of nano-research.

We thank you all for attending and hope you'll save the date for our 2016 CNF Annual Meeting — being held on Thursday, September 15th. We already have five corporate sponsors (as shown on page 2).

If your company would like to be a sponsor too, please contact Don Tennant, CNF Director of Operations, at tennant@cnf.cornell.edu



2015 CNF Annual Meeting Award Winners!

CNF Best Posters

E. Rose Agger
Mardochee Reveil
Kathryn Roach

CNF Best Paper

Dion Khodagholy

Corning Best Paper

Ved Gund

CNF Nellie Whetten Memorial Award

Kathryn McGill

Look for Kathryn McGill's profile in our next issue. For now, here is her experiement in cleanroom selfies.

The National Nanofabrication Users Network (NNUN) / National Nanotechnology Infrastructure Network (NNIN) Research Experience for Undergraduates Programs

Epilogue by Dr. Lynn Rathbun

After almost twelve years of funding, NNIN came to a close in September 2015. This is according to NSF policy where major research centers have a fixed lifespan of ten years (We got an extra 1.5 years, but that is a long story). NNIN has been replaced by a new network, the National Nanotechnology Coordinated Infrastructure — NNCI. Some former NNIN sites are also members of NNCI, but it is not a re-creation of NNIN. It is a new network with many new players and new plans.

With the end of NNIN necessarily comes the end of the NNIN REU program, which has been remarkably successful for the last 19 years (extending back to the previous network NNUN). Over that time period, we have had 1,219 outstanding participants. Our program contributed greatly to each of their careers, and likewise, their contributions greatly enhanced the research programs and environment of the NNUN/NNIN REU sites.

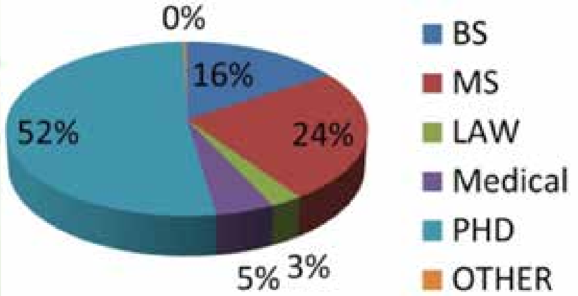
REU programs are ubiquitous now, but that was not the case in 1997 when we started this. In particular, large REU programs spanning multiple sites were unheard of. At that time, the NNUN included only five sites, but still the concept of a uniform multisite program with a single common application was novel. And I remember the day back in 1996 when I came up with the crazy idea of flying everyone to a common site for an end-of-program "research convocation" — that had never been done before! And yet it is these features, along with the quality of the research experience, which have set NNUN/NNIN REU apart from the pack. And as many interns can attest, it is those features that attracted them to the NNIN REU program.

The 2015 NNIN Interns (REU, iREG and iREU) at the final NNIN Convocation, held August 2015 at Cornell University, Ithaca, NY. Jason W. Koski / University Photography

As a 19 year program with 1,219 participants, with a consistent format over the entire period, the NNUN/NNIN REU program presents an unique opportunity to study the impact of an REU program in more than an anecdotal way. REU is an expensive undertaking, most recently costing NSF about $9000 per student. If you add that up, that is about 10M$ over 19 years for the NNUN/NNIN REU Program. But while anecdotal data on REU "impact" is widely available, actual statistically significant data on education and career outcomes has been lacking. Such information, however, is necessary to assure continued funding of the program and is highly valued by agencies such as NSF. The NNUN/NNIN REU program thus presented us with a valuable opportunity to study a large group of REU students over an extended period of time.

Starting in 2007, Nancy Healy and I began a concerted effort to track the career outcomes of past NNUN/NNIN REU participants. For this, career plans at the end of the program are pretty irrelevant — plans change; even a few years after participation is too early to get real data. So we set a mark of contacting each participant five years after completion of the program. This was long enough that participants would have completed undergraduate education and either committed and entered graduate school or entered regular employment. So we embarked on an exercise to find past participants — using email, Google, Linkedin, Facebook, and all other sorts of modern sleuthing. And it was a bit of a challenge, with foreign names, nicknames, overly common names, married names, etc. But it has become easier in recent years with the advent of more "permanent" email addresses and cell phone numbers. Each year since, we added another year to the pool at the five year horizon. In the end, we have been able to affirmatively contact 617 of the 819 students who participated between 1998 and 2010 (~75%). (It is amazing how many people, even in 2015, have no identifiable internet fingerprint!) Identified participants were emailed a request to complete a brief online survey asking about current employment, career and education path, and the retrospective impact of the NNUN/NNIN REU program.

The results are quite enlightening. The REU pie chart on the next page shows education paths for the surveyed participants. Over 50% have gone on to a Ph.D., with almost 80% going on to some form of graduate or professional school. This is aggregate data for all participants, but the data set is large enough that we can separately extract data for major demographic groups. Over 45% of women and minority participants, for example, also go on for a Ph.D., so our program has been equally as effective for this group. In addition, 50% of all participants self-identify as being



in a "nanotechnology career," and over 95% of all participants remain in a "scientific career."

Nancy and I have presented these results are several conferences. We believe it shows the significant impact that REU programs can have on career paths. And I do wish to thank the 619 participants who completed the survey instrument. Thank you!

Building upon the success of our REU program, in 2008 NNIN developed another program that has been extraordinarily successful. Our REU activities have always had excellent participants, and many of them wanted to continue with an additional nanotechnology research experience, in NNIN or elsewhere. And we realized that some student were more exceptional than others, and that after observing them over the course of the summer and the convocation, reliable identification of the most exceptional interns was easy. At the same time, we observed that one place where US student preparation was poor was in the international aspects of science. So given these observations, we decided to try to established a new international program which we called iREU, a second summer program exclusively for the most outstanding NNIN REU students from the prior year, designed to give the most exceptional students a career building experience in the global culture of research.

We applied to two different NSF programs for funding, one to the Engineering Division to send students to Germany and one to the International Division to send students to Japan. Surprisingly, both were funded, so we were faced with the challenging, but rewarding, task of setting up two new programs on two different continents. Ultimately, however, this turned out to be easy, thanks to the help of our international partners, the National Institute of Materials Science in Japan and the Forshungszentrum Jülich in Germany. The program was so successful that we supplemented the grant funding with additional funds from the NSF cooperative agreement. Later we expanded to include IMEC in Belgium, TU Delft in the Netherlands, and the Microelectronics Centre of Provence in France. This program has been extremely rewarding and successful for us, for the participants, and for our international partners. I must thank our partners here for the excellent support they have given me and our students over the past eight years. One hundred and nine select students have participated in this program since 2008.As one indication of the success of the program and its impact on participants, 30 of the 74 who have gone on to graduate school have received NSF Graduate Fellowships. We have just begun to collect quantitative data on impacts of the program on "cultural intelligence" and we have applied for separate funding to keep this program alive even after NNIN.

As we close, I want to give special recognition to Melanie-Claire Mallison, the REU Program Assistant for the entire length of the program. She processed every single one of the 8,447 applications, made about 2000 offers, processed more than 1400 acceptances (a few people always drop out), sent 10s of thousands of individual emails to applicants and participants, formatted each of the 1,358 technical reports (REU, iREU, and iREG), formatted and published each of the REU Research Accomplishments, and organized the five REU Convocations that were held at Cornell, including both the first and the last ones! And she remembers almost every one of the participants! The program would not have been successful without her.

And for the last twelve summers, I have worked closely with Dr. Nancy Healy, NNIN Education Coordinator at Georgia Tech, on REU, iREU, and other NNIN education programs. It has been a successful joint effort. And I must also acknowledge the support of the NNUN/NNIN network directors, the NNUN/NNIN site directors, the individual faculty PIs and mentors, and most of all the NNUN/NNIN site REU coordinators, all of whom are too numerous to mention. Their collective efforts have made our programs uniquely successful. These programs clearly demonstrate the success of the "network" concept, that programs can be successfully coordinated and administered uniformly across many sites, and that the result can indeed be larger than the sum of the parts.

Funding for the NNUN/NNIN program has come almost exclusively from the National Science Foundation, most recently from the NNIN Cooperative Agreement, but earlier from REU program funds. We thank Dr. Larry Goldberg, in particular, for his support of our program.

So, this brings to a close the NNUN/NNIN REU program. On behalf of myself, Melanie-Claire Mallison, Dr. Nancy Healy, and all the NNUN/NNIN REU coordinators, we thank all our interns for their participation. It has been our pleasure.

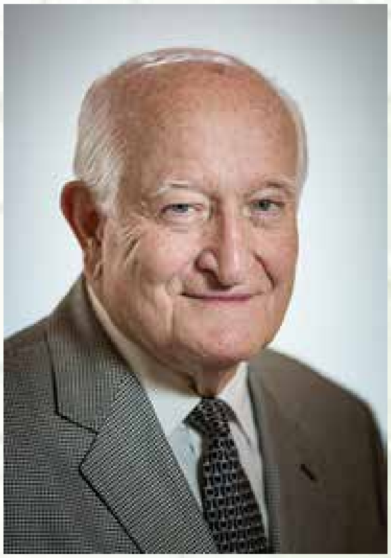
The 1997 NNUN REU staff who were still in for the 2015 NNIN! Michael Deal (Stanford), Melanie-Claire Mallison, Michael Skvarla, Denise Budinger, and Lynn Rathbun (CNF Staff). Jason W. Koski / University Photography

Nancy Healy (Georgia Tech), Inset / LinkedIn

ECE Professor Emeritus Ed Wolf named as 2015 National Academy of Inventors Fellow

School of Electrical and Computer Engineering
Tuesday, December 15, 2015

The National Academy of Inventors (NAI) has named ECE Professor Emeritus Edward Wolf to Fellow status. Election to NAI Fellow status is a high professional distinction accorded to academic inventors who have demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and welfare of society.



Photograph by Gary Hodges, Ithaca, NY.

Professor Wolf spent 15 years in the aerospace industry, first at the Rockwell International Science Center exploring thermionic energy conversion using electron field emission microscopy. He then moved to the Hughes Research Laboratories in Malibu where he led a pioneering effort in scanning electron beam diagnostics and microfabrication (key enablers later for nanotechnology). He became a senior scientist and section head of electron beam surface physics and was awarded Fellow of the IEEE for his research while at Hughes.

He joined Cornell University in 1978 as professor in the School of Electrical Engineering and first director of the National Research and Resource Facility for Submicron Structures (NRRFSS) and later National Nanofabrication Facility (NNF). Wolf's research interests included electron and ion beam processing of materials and submicron devices including advanced lithography and chemically assisted ion beam etching. He was a member of the graduate faculty of ECE, AP&E and MS&E at Cornell. In 1986, Dr. Wolf co-founded Biolistics, Inc., to develop the gene gun instrumentation and methodology. DuPont acquired Biolistics' gene gun technology rights in 1990, which were originally licensed from Cornell Research Foundation. He became professor emeritus in 1991.

He returned to Cornell University in 1995 to serve for two years as founding director of the Cornell Office for Technology Access and Business Assistance, Office of the Vice-President for Research. He served as a director (2003-2010) of Novelx, Inc., Lafayette, CA, which miniaturized the thermal field-emitter (TFE) scanning electron microscope now manufactured and sold by Keysight Technologies.

This year, 168 leaders of invention and innovation were honored with the prestigious distinction, bringing the total number of NAI Fellows to 582. Fellows represent over 190 research universities and governmental and non-profit research institutes. The 2015 Fellows account for 5,368 issued U.S. patents, bringing the collective patents held by all NAI Fellows to more than 20,000.

The NAI Fellows will be inducted on 15 April 2016, as part of the Fifth Annual Conference of the National Academy of Inventors at the United States Patent and Trademark Office (USPTO). USPTO Commissioner for Patents Andrew Hirshfeld will provide the keynote address for the induction ceremony. In honor of their outstanding accomplishments, Fellows will be presented with a special trophy, medal, and rosette pin.

The 2015 NAI Fellows will be recognized with a full page announcement in The Chronicle of Higher Education 22 Jan. 2016 issue, and in upcoming issues of Inventors Digest and NAI journal Technology and Innovation.

Those elected to the rank of NAI Fellow are named inventors on U.S. patents and were nominated by their peers for outstanding contributions to innovation in areas such as patents and licensing, innovative discovery and technology, significant impact on society, and support and enhancement of innovation.

"It is my privilege to welcome the 2015 class of outstanding academic inventors to the Academy as Fellows," said NAI President Dr. Paul R. Sanberg. "These inspiring individuals have made remarkable contributions to society through their work in research and discovery as well as in patents, licensing, and commercialization. They encourage a culture where invention and innovation is brought to the forefront and it is an honor to recognize their tremendous accomplishments with NAI Fellow status."

Complete list of NAI Fellows: http://academyofinventors.org/search-fellows.asp

Barrier-Breaking Physicist Clears Path for Solar Power

Source: Ariel Wittenberg, E&E reporter
Posted: Thursday, November 12, 2015
Governors' Wind Energy Coalition

Lidija Sekaric took over as head of the Department of Energy's Sunshot program last month. Photo courtesy of the Department of Energy.

The leader of the Department of Energy effort to drive down the cost of solar power enjoys a big challenge. When Lidija Sekaric was recruited for the SunShot initiative in 2010, she turned up her nose at the program's goal — lowering the installed cost of solar from $2 a watt to 50 cents by 2020.

"We were not ambitious enough for her," then-Director Minh Le recalled in a recent interview. "I pitch it to her that we are going to reduce costs by 75 percent, and her immediate reaction — with a straight face — was, 'Why not 25 cents per watt?'"

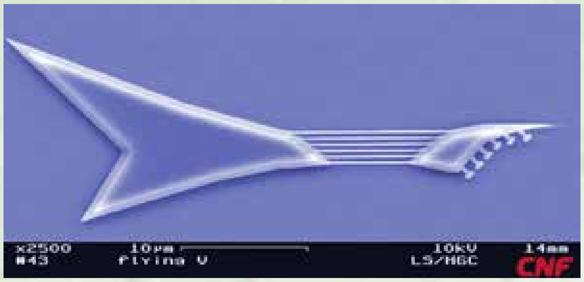
It took some coaxing, but Sekaric eventually joined SunShot, serving as Le's trusted deputy for the last four years. During that time, solar installation has fallen to 60 cents per watt. And Sekaric, considered a DOE "rising star" at the time Le recruited her, has taken over as acting SunShot director. Le has moved to a post at the Office of Management and Budget (Greenwire, Oct. 21).

"She has done a tremendous job," Le said. "I know that she will not only continue the trajectory that we laid out together, but she will also do better than that, because she has been outpacing me from the beginning."

By the time she got to DOE, Sekaric was known for pushing boundaries. A technologist-turned-policy wonk, Sekaric, 41, spent her first six years after graduate school at International Business Machines Corp. trying to find the limit of Moore's Law — which says computer processing power will double every two years — by creating the smallest possible semiconductor chips. Some of the structures she developed were only tens of atoms long. "The smaller you make something, the faster it can perform and the cheaper it is to manufacture," she said in an interview.

Sekaric's office wall is decorated with her 30 patents — most of which are for objects visible through a microscope. Her favorite patent is for a "nano-guitar" she invented while completing her Ph.D. at Cornell University. The instrument is the smallest playable guitar ever created — one string is 1/100,000 the width of a human hair — and produces music inaudible to the human ear. "It's something we made just for fun," she said, "just to test the limits." At SunShot's helm, Sekaric is still pushing limits…..

Read more at http://www.governorswindenergycoalition.org/?p=15062



Lidija's nanoguitar. Created in 2003 with Prof. Harold Craighead.

Alumni Lead Biotech Startup GeneWEAVE to Successful Acquisition

By Sherrie Negrea
Ezra Magazine,
October 2015

Two Cornell alumni who developed a diagnostic technology to detect drug-resistant bacteria while they were students have sold the startup they launched to Roche, the world's largest biotech company. Roche acquired GeneWEAVE for $425 million. The acquisition calls for Roche to pay GeneWEAVE $190 million up front and up to $235 million based on the achievement of product-related milestones. The deal was announced in August.

The company's co-founders, Jason Springs, MBA '09, and Diego Rey, Ph.D. '12, met in 2007 at Cornell after they both independently approached Wesley David Sine, faculty director of the Entrepreneurship and Innovation Institute at the Samuel Curtis Johnson Graduate School of Management. Both told him they wanted to work with another graduate student on starting a company. After Sine introduced the two entrepreneurs, they immediately began collaborating on their joint venture, eventually raising $25 million in venture capital to finance the startup.

"Unequivocally, if I had not been at Cornell, this wouldn't have happened," Springs says. "I feel very strongly about that. There's no one thing that I can point to as the pivotal thing that made it happen. It's an ecosystem or culture that allows people to do these things without burden. It takes a village to raise a company."

Read more at http://ezramagazine.cornell.edu/Update/Oct15/EU.GeneWEAVE.html

Diego Rey, Ph.D. '12, left, and Jason Springs, MBA '09, co-founders of GeneWEAVE, speak to a Johnson Graduate School of Management class in September. Photo: Jason Koski/University Photography. (Diego was a 2002 CNF REU working with Prof. Michael Spencer, and then a Cornell graduate student and CNF User.)

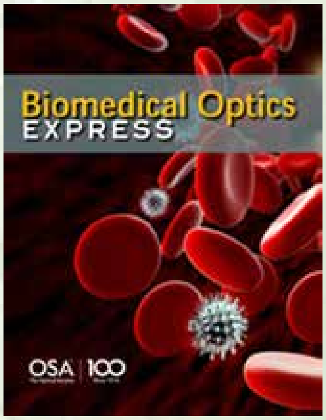
Matt Devlin, second from left, worked on "Exploration of Protein Capture Methods for Applications in Microfluidic Devices" with CNF REU PI Haiyuan Yu and Mentor Robert Fragoza, Weill Institute for Cell and Molecular Biology, Cornell University. Photograph of the 2015 CNF REU interns by Don Tennant.

2015 CNF REU Matthew Devlin

Matt Devlin, one of our 2015 CNF REU interns, and his team "Wobble" have made it onto the 2016 InVenture Prize finalist list! Georgia Tech's InVenture Prize competition is designed to encourage and support undergraduate students' interest in innovation and entrepreneurship. More than 500 students signed up for the competition. This year's six finalist teams have invented ways to make our lives safer, healthier, and a bit more fun. Team Wobble has a Facebook page!

http://www.news.gatech.edu/2016/02/09/six-finalists-competing-inventure-prize

Collaborative Publication in Biomedical Optics Express



Dear colleagues,

Today our MFM paper describing the multi-phase MFGs applied in functional neuronal imaging, that during the last few years were designed, conceived, fabricated and applied at Janelia, Rockefeller, CNF, NIST and the MBL, is finally published. Thank you all for your participation and inspiration in this project that has involved much wonderful work in optics and microscopy. The paper can be found online at the Biomedical Optics Express web page:

"Multifocus microscopy with precise color multi-phase diffractive optics applied in functional neuronal imaging;" Authors: Sara Abrahamsson, Rob Ilic, Jan Wisniewski, Brian Mehl, Liya Yu, Lei Chen, Marcelo Davanco, Laura Oudjedi, Jean-Bernard Fiche, Bassam Hajj, Xin Jin, Joan Pulupa, Christine Cho, Mustafa Mir, Mohamed El Beheiry, Xavier Darzacq, Marcelo Nollmann, Maxime Dahan, Carl Wu, Timothée Lionnet, J. Alexander Liddle, and Cornelia I. Bargmann. doi: 10.1364/BOE.7.000855

Best regards,
Sara Abrahamsson

REMINDER!
CNF User Wiki

The goal of the CNF User Wiki is to maintain up-to-date manuals, user-submitted recipes, and other information that may be helpful to the CNF community.

The wiki is only as useful as you make it. Please submit new recipes or guides using the contact form found at

https://wiki.cnfusers.cornell.edu/

Ngai Joins Z-Senz LLC

Darryl Ngai, a former CNF user in my group, has joined a new start-up — Z-Senz LLC — as Principal Physicist. Z-Senz LLC, located in Gaithersburg, Maryland, is developing novel LIDAR sensors.

Best regards,
Prof. Greg Fuchs

(Photo borrowed from LinkedIn)

Esch Awarded Lush Prize for Work in Animal-Free Testing

Wednesday, January 13, 2016
By Matt Wheeler
Syracuse University

College of Engineering and Computer Science Assistant Professor (and former CNF staff member) Mandy B. Esch has won a Lush Science Prize for 21st Century Toxicology. Lush Prizes are awarded to projects and individuals that strive to replace the use of animals in product or ingredient safety testing. Esch's team, led by Cornell's Professor Michael L. Shuler, was recognized for their development of a "Body-on-a-Chip" system that uses tissues derived from human cell sources. Their system is capable of simulating human metabolism to reveal test drugs' therapeutic actions and toxic side effects. It can play a significant role in determining the success of new pharmaceuticals without the use of animals.

The Lush Prize, hosted by Lush Cosmetics, is awarded for lobbying, public awareness, science and training that supports animal-free testing. This year's awards in London were presented by animal rights advocate Brian May, lead guitarist for the band Queen.

Shuler Wins Prize for Animal-Free Science

November 25, 2015
By Daniel Aloi
Cornell Chronicle

A research team led by Michael L. Shuler, professor of biomedical engineering, has received a Lush Prize in Science for work on developing Body-on-a-Chip systems, enabling new standards of toxicology testing without the use of animals. The prize, worth £25,000 ($37,717), recognizes and supports work in animal-free science.

Using tissues derived from human cell sources, the chip systems are capable of simulating the human metabolism by modeling the structure and function of organs. Their uses include testing new pharmaceuticals for efficacy and toxic side effects.

Shuler, the Samuel B. Eckert Professor of Engineering at Cornell, and researcher James J. Hickman of the University of Central Florida NanoScience Technology Center also received a five-year National Institutes of Health grant for the project in 2012. They are principals in Hesperos, a startup biotech research and development company.

The research team sharing in the Lush Prize also includes clinical pathologist Tracy Stokol, an associate professor in the College of Veterinary Medicine; and Mandy B. Esch of Syracuse University and Gretchen Mahler of Binghamton University, both of whom did much of this work while at Cornell.

The 2015 Lush Prizes – in the areas of science, training, public awareness and lobbying, as well as five prizes for young researchers – were announced November 20 in London. Scientists and campaigners from nine countries were recognized this year, with winners selected by an international panel of experts including members of 51 science teams and individual researchers.

Nine Cornell Faculty Named 'Most Influential' Researchers

January 27, 2016
Cornell Chronicle

Nine Cornell professors have been named to a list of the most influential scientific minds for 2015 compiled by Thomson Reuters and based on how often faculty members' research is cited. "This report is an updated listing of the elite authors officially designated as Highly Cited Researchers, based on their respective output of top-cited papers in their fields," the editors write. "Covering an 11-year period (and presenting a special subset of "hot" researchers whose very recent work has won distinction in the form of citations), it features the scientists who have won acclaim and approval within a key population: their peers."

Those cited:

- *Lynden Archer (CNF PI), professor of chemical and biomolecular engineering;*
- *Dale Bauman, emeritus professor of animal science;*
- *Lewis Cantley, professor of cancer biology in medicine;*
- *Chang Lee (CNF PI), professor of food science and technology;*
- *Johannes Lehmann, professor of soil and crop sciences;*
- *Rui Liu, professor of food science;*
- *Natalie Mahowald, professor of earth and atmospheric sciences;*
- *Mark Rubin, professor of oncology in pathology; and*
- *Mark Sorrells, professor of plant breeding genetics and a fellow, Atkinson Center for a Sustainable Future.*

Lynden Archer, above, and Chang Lee, below. Photos borrowed from their faculty pages.

Ober Named AAAS Fellow

Christopher Ober (CNF principal investigator and the Francis Norwood Bard Professor of Metallurgical Engineering, whose research focus is creating new polymeric materials and refining their properties with a fundamental understanding of their physical behavior) has been elected a 2014 fellow of the American Association for the Advancement of Science.

Volunteers from Angstron Materials Exhibit at TechFest 2016

By Colleen Costello
February 26, 2016

This is what engagement in nanotechnology education for the next generation looks like. The photo above pictures a team of volunteers from Angstron Materials, Inc. at TechFest 2016 in Dayton, OH. TechFest is a large STEM festival in the Dayton, Ohio area that was hosted on February 13th and 14th, 2016. Tech Fest has been in existence since 2003, and serves as a premier, free event for K-12 students that helps them learn about science, technology, engineering, and math. This year, Angstron Materials, Inc., one of 75 exhibitors, brought a highly interactive exhibit to the festival.

TechFest's theme this year was "Materials and Manufacturing", and so the exhibit, which featured a demonstration of graphite's electrical conductivity and molecular models kits to build graphene's chemical structure, underscored the theme and brought nanomaterial technology to life for even the youngest student. Volunteers spent the weekend interacting with many of the over 2,400 students who attended TechFest this year. At the exhibit, students also were given free copies of Nanooze, a magazine published for students to help them learn about what nanotechnology is and what it could mean to their futures. The magazine is a publication of Cornell NanoScale Science and Technology Facility and is a project of the National Nanotechnology Infrastructure Network and the NSF.

TechFest is a wonderful event held each Presidents Day weekend in Dayton, Ohio – home to Angstron Materials' headquarters. Angstron was truly honored to play a part in the education of the next generation by sharing with them experiments and knowledge about nanomaterials and the unique nanomaterial that Angstron manufactures, graphene. Thank you to all the volunteers and to our friends at Cornell NanoScale Science and Technology Facility for all their input and generous donations of the Zome building kits and Nanooze magazines!

CNF TCN

Technology & Characterization at the Nanoscale

Cornell NanoScale Science and Technology Facility

JUNE 7 - 10, 2016

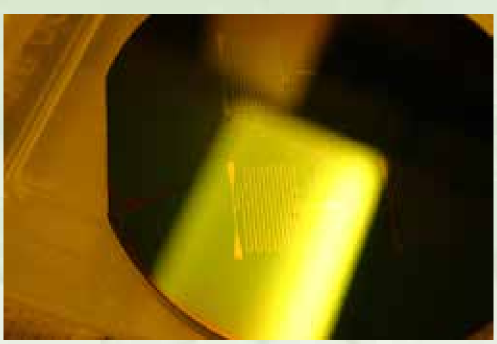
CORNELL UNIVERSITY, ITHACA, NY

This intensive 3.5 day short course offered by the Cornell NanoScale Science & Technology Facility, combines lectures and laboratory demonstrations designed to impart a broad understanding of the science and technology required to undertake research in nanoscience. TCN is an ideal way for faculty, graduate students, post docs and staff members to rapidly come up to speed in many of the technologies that users of the CNF need to employ. Members of the high tech business community will also find it an effective way to learn best practices for success in a nanofab environment. Attendance is open to the general scientific community, but class size is limited.

REGISTER TODAY!

http://www.cnf.cornell.edu/cnf_tcn_june_2016.html



Scenes from the 2016 January CNF TCN. Photographs by Sam Wright, CNF Staff.

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CNF NanoMeter •• Spring 2016 •• Volume 25 •• Issue 1

The Cornell NanoScale Science & Technology Facility (CNF) has been serving the science and engineering community since 1977.

The CNF is supported by the National Science Foundation, the New York State Office of Science, Technology & Academic Research (NYSTAR), Cornell University, Industry, and our Users.

The CNF is a member of the National Nanotechnology Coordinated Infrastructure.

To be added to our mailing list or to correct a mailing address, please send your request via email to: information@cnf.cornell.edu.

You will also find the NanoMeter in PDF on our website at: http://www.cnf.cornell.edu

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