NanoMeter

The newsletter of the
Cornell NanoScale Science
& Technology Facility
(CNF)

Winter 2011
Volume 20
Issue # 2

In This Issue....

Welcome to the 2011 Winter Edition of the CNF NanoMeter

This issue will highlight some recent developments in the Laboratory, as well as examples of outstanding science and engineering being done by CNF users.

This year has also been a very busy one for the installation of new equipment at CNF. The following new tools are now in place and available to users. Additional details about many of these tools are given within this edition of the NanoMeter. Please see the CNF web site for the names of the staff members to contact for training.

- **SÜSS Gamma Automatic Spin/Spray Coat/Develop Tool: automated photoresist and wet processing system designed to meet needs for clean, reliable and high throughput wafer spinning, baking, developing, and spray coating of conformal resists, on 100 mm to 200 mm wafers. Together with the Heidelberg Mask Writer and ASML DUV (248 nm stepper), the Gamma tool gives the CNF the capability for highly reliable and high-throughput DUV lithography.**
- **FirstNano Graphene and Carbon Nanotube Growth Furnace: chemical vapor deposition growth on substrates up to 4 inches in diameter.**
- **Primaxx Vapor Phase HF Etching Tool: designed to make MEMS devices and other released structures without the need for critical point drying.**
- **Improved Facilities for Spinning and Baking SU8 and PDMS: expanding our capabilities for microfluidics users.**
- **AJA Sputter Deposition System: a 5-target, single-wafer system designed to eliminate processing bottlenecks associated with CNF's existing sputter system.**
- **Improved optical microscopes, cameras, and software: installed throughout the lab, and designed to provide a more consistent software interface.**

To help bring the CNF community rapidly up to speed on new nanofabrication technologies, CNF staff members have begun hosting workshops, often in collaboration with our tool vendors. This edition of the NanoMeter includes a report about the SÜSS MicroTec Workshop held at CNF in September and the GenISys BEAMing in November. Microfluidics workshops are now also held regularly in collaboration with NBTC. Suggestions for additional future workshops are welcome.

In staff news, our Lab Use/Safety Manager Dan Woodie has decided to leave the CNF to take a new position coordinating safety activities for the Engineering College. We want to thank Dan for eleven years of outstanding service to CNF, and we wish him well in his new position. Because of Dan's departure, there has been some shuffling of staff responsibilities within the CNF. Daron Westly has agreed to serve as the new Lab Use Manager and Phil Infante is the new Lab Safety Manager. To help cover Dan's tool responsibilities and to assist with the growth of the user population, we have begun the process to hire two new technical staff members.

Please note the dates for upcoming events on the back page and check our web site often for news updates. Most importantly, please continue to give us your recommendations for how to improve CNF.

Daniel Ralph
Lester B. Knight Director, CNF

Donald Tennant
CNF Director of Operations

An Assist from a Former Staff Member!

Former staff member Daniel McCollister has assumed a six-month appointment as a Research Support Specialist. Daniel has had a host of experiences since he last served at Cornell NanoScale Facility and he likes the changes he sees. Dan is "thrilled to have the opportunity to join this lab's great staff."

Dan will help operate several tools and pitch in where needed as we transition some of the responsibilities among staff members and seek a new staff member to fill in for the departing Dan Woodie.

Dan McCollister

Dan Woodie

The Dans

CNF Fall Golf Classic 2011

To celebrate the end of summer and coming fall (and mourn the end of golf season) several of the more modestly talented of us decided to enjoy one last golf outing together. Meeting at Mark Twain golf course in Elmira, NY, we enjoyed 18 beautiful holes watching all the nature this scenic course provides. It would have been more helpful watching the golf ball, but oh well. The score was only an afterthought as the primary reason was simply for some staff and users to get together and enjoy life outside of the lab.

We will be hosting another golf outing at the start of the next golf season to celebrate the end of winter and the start of the spring so watch your email for information. All are welcome!

In fact, this golf outing was the first time Daron's wife was on a golf course. Yajaira now has been out three more times, has her own clubs, and is a member at Hillendale golf club.

If you have ever thought of golfing, our spring outing is the perfect event! You just need to make it through the winter....

CNF's own Garry Bordonaro. All the precision you would expect from a photolith guy....

David Sessoms on the green.

Measuring Wavefront Aberrations of Hard X-Ray Optics

Compiled by Photonics Spectra Staff
ARGONNE, Ill.

Wavefront aberrations produced by imperfect hard x-ray optics can distort and broaden the focused spot of high-brightness x-ray beams. But a new method enables optimized positioning of existing optics along with quantitative feedback that can guide improved fabrication procedures for future optics.

The technique was described in a report by scientists conducting research at national laboratories, including the US Department of Energy's Advanced Photon Source at Argonne. They were from the University of Rochester, Cornell University, and the Brookhaven and Argonne labs. The work was performed, in part, at the Cornell NanoScale Science & Technology Facility.

The ability to accurately measure these aberrations is critical to realizing the full potential of bright x-ray sources to investigate materials at the nanoscale, the scientists said. Currently, however, the most widely used method of x-ray optics performance characterization is a series of knife-edge scans at different distances from the optic. From these measurements, scientists can extract the optimal focal spot size and distance but can't gather direct information on the aberrations in a timely fashion. The research team has developed a new phase retrieval method to determine the aberration of hard x-ray optics. Known as transverse translational diversity, or TTD, the technique has been successfully used in x-ray imaging applications.

In TTD, the x-ray field of the focusing optic is perturbed with a known object placed at a variety of transverse positions. At each position, the corresponding diffraction intensity pattern is measured, with resulting data enabling more robust resolution of the ambiguities typically present in phase retrieval data. The ambiguities are especially severe for the one-dimensional case of conventional phase retrieval. Computer algorithms then quickly produce the x-ray wavefront aberration, and scientists can optimize the alignment of the existing optic on-line or improve the manufacturing of future optics.

The researchers deliberately introduced an aberration into their focusing setup to test the method. They rotated a one-dimensional focusing kinoform x-ray optic away from its optimal position and, because the aberrations created by the rotation could be accurately predicted, the researchers could evaluate the accuracy of their wavefront measurement. The new method's findings are detailed in the March 15, 2011, issue of Applied Physics Letters (doi: 10.1063/1.3558914).

Along with providing quantitative information on the wavefront aberrations produced by imperfect x-ray optics, the method can measure using arbitrary x-ray wavelengths, can take direct measurements rather than extrapolated ones, and can facilitate the alignment of samples. Using computer-based propagation methods, they predicted the field at all other distances and determined where the best focus occurs, and what its size and profile is.

Lastly, the method allows the perturbing object to be located far from the focus, which optimizes the focusing optic without disturbing sensitive samples or their environments located at the x-ray-beam focus.

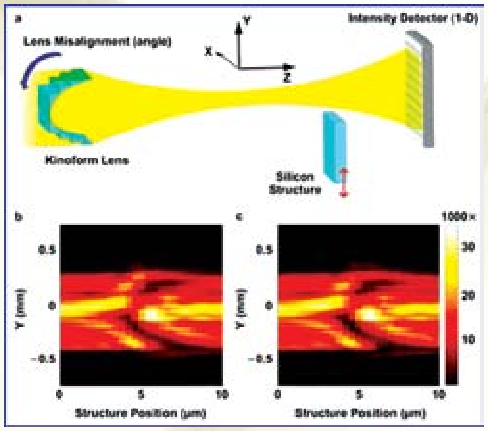


Figure 1: (a) The experimental setup. (b) Measured intensity vs. structure position for a lens angular misalignment of θ = 0.14°. (c) Computed far-field intensity vs. structure position for the reconstructed beam. Images courtesy of Manuel Guizar-Sicairos et al, © American Institute of Physics.

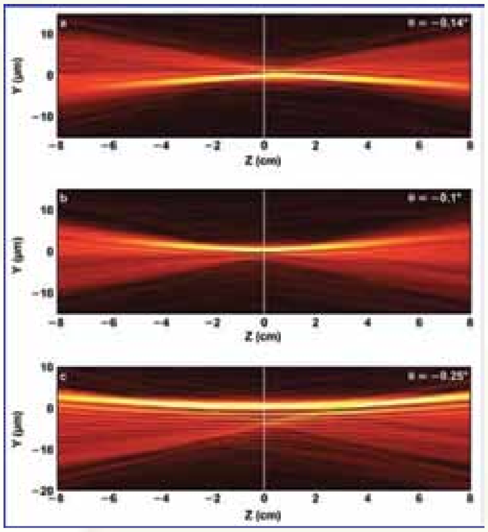


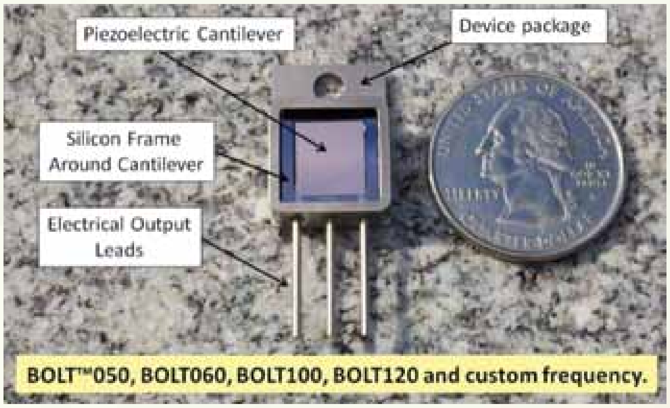
Figure 2: Through-focus amplitude of reconstructed beams for different lens angular misalignments. The white dashed lines indicate the plane of reconstruction.

MicroGen's BOLT™ MEMS Energy Harvester Combines with Infinite Power Solutions' THINERGY® MEC to Create Self-Powered Wireless Sensor Node

MicroGen demonstrates missing-link to efficient and reliable vibrational energy harvesting solutions

Chicago, Il (PRWEB) June 21, 2011

MicroGen Systems, Inc., of Ithaca, NY, and Infinite Power Solutions, Inc. (IPS; www.infinitepowersolutions.com) of Littleton, CO, recently demonstrated a complete Wireless Sensor Network (WSN) solution powered by their combined products. At the recent Sensors Expo and Tradeshow 2011 (www.sensorsexpo.com) held in Rosemont, IL, MicroGen's MEMS-based piezoelectric vibrational energy harvester (PZEH) micro-power generator product, called the BOLT™ 060, combined with the THINERGY® IPS-EVALEH-01 Energy Harvesting Evaluation Kit from IPS to power-up a complete wireless sensor board.



The actual demonstration was completed at MicroGen's booth on an electro-mechanical shaker to simulate a typical industrial vibration environment. The IPS-EVAL-EH-01 was easily connected to the MicroGen BOLT060 micro-power generator and vibrated at a frequency of 60 Hz and an acceleration amplitude of 0.7 g ($g = 9.8\ m/s^2$). The BOLT devices are 1.0 cm^2 silicon-based chips or less that produce power levels up to 200 mW. These are the first commercial MEMS-based PZEH to be demonstrated at low relevant frequency and acceleration levels.

The IPS-EVAL-EH-01 is a universal energy harvesting evaluation kit that accepts energy from a variety of energy harvesting transducers (both AC and DC charge sources), and efficiently stores the energy in a THINERGY® MEC101 solid-state micro-energy cell (MEC), a unique type of thin-film battery the size of a postage stamp. The THINERGY MEC101 is a near loss-less energy storage device able to accept charge currents less than 1 µA making it ideal for energy harvesting applications. For this demonstration, the ez430-RF2500 wireless temperature sensor demo from Texas Instruments' (www.ti.com) was used as the load, which features an integrated MSP430 microcontroller and CC2500 2.4 GHz radio transceiver to transmit temperature data.

MicroGen's founder, President and CTO, Robert Andosca stated, "Our BOLT micro-power generator products are the first of their kind to be sold into the emerging energy harvesting market. These products will help eliminate the need to constantly replace dead batteries in wireless sensor nodes/networks, which is very cost prohibitive in terms of labor." He added, "MicroGen has now demonstrated that efficient and cost-effective solutions can be offered to accelerate the deployment of self-powered WSNs."

Tim Bradow, VP Marketing for IPS added, "We are delighted to work with MicroGen and to provide them with the most efficient and easy to use energy storage solution available for their low power energy harvesters. Together we provide a low cost, compact, vibration harvesting power supply solution that can operate reliably and maintenance-free for decades."

MicroGen's MEMS-based PZEH family of products called BOLT™ is intended to enable low power electronic devices, such as wireless sensor nodes for WSN applications. A custom BOLT product can be fabricated for any target frequency between 30 and 1,500 Hz. There are no other commercially available MEMS-based PZEH products on the market today.

MicroGen is a self-funded startup that also benefits from the support provided by The University of Vermont (www.uvm.edu), Cornell University's Energy Materials Center (www.emc2.cornell.edu) and New York State Foundation for Science, Technology and Innovation (www.nystar.state.ny.us), the Cleantech Center (www.thecleantechcenter.com), High Tech Rochester (www.htr.org), NY State Energy Research and Development Authority (www.nyserda.org), and the National Aeronautics and Space Administration (www.nasa.gov). This work was performed at the Cornell NanoScale Facility (www.cnf.cornell.edu), a member of the National Nanotechnology Infrastructure Network, which is supported by the National Science Foundation (Grant ECS-0335765).

MicroGen Systems, Inc. Cornell Tech Park, Langmuir Lab, 95 Brown Road, Suite 120, MS 1014, Ithaca, NY 14850. Contact Michael Perrotta, mperrotta@microgensystems.com or http://www.microgensystems.com

Artificial Tissue Grafts with Microchannels Promote Skin Growth in Severe Wounds

By Anne Ju
Cornell Chronicle

Victims of third-degree burns and other traumatic injuries endure pain, disfigurement, invasive surgeries, and a long time waiting for skin to grow back. The improved tissue grafts designed by Cornell scientists that promote vascular growth could hasten healing, encourage healthy skin to invade the wounded area and reduce the need for surgeries.

These so-called "dermal templates" were engineered in the lab of Abraham Stroock, associate professor of chemical and biomolecular engineering at Cornell and member of the Kavli Institute at Cornell for Nanoscale Science, in collaboration with Dr. Jason A. Spector, assistant professor of surgery at Weill Cornell Medical College, and an interdisciplinary team of Ithaca and Weill scientists. The research was published online May 6 in the journal Biomaterials.

The biomaterials are composed of experimental tissue scaffolds that are about the size of a dime and have the consistency of tofu. They are made of a material called type 1 collagen, which is a well-regulated biomaterial used often in surgeries and other biomedical applications. The templates were fabricated with tools at the Cornell NanoScale Science & Technology Facility to contain networks of micro-channels that promote and direct growth of healthy tissue into wound sites.

"The challenge was how to promote vascular growth and to keep this newly forming tissue alive and healthy as it heals and becomes integrated into the host," Stroock said.

The grafts promote the ingrowth of a vascular system — the network of vessels that carry blood and circulate fluid through the body — to the wounded area by providing a template for growth of both the tissue (dermis, the deepest layer of skin), and the vessels. Type I collagen is biocompatible and contains no living cells itself, reducing concerns about immune system response and rejection of the template.

A key finding of the study is that the healing process responds strongly to the geometry of the microchannels within the collagen. Healthy tissue and vessels can be guided to grow toward the wound in an organized and rapid manner.

Dermal templates are not new; the Johnson & Johnson product Integra®, for example, is widely used for burns and other deep wounds, Spector said, but it falls short in its ability to encourage growth of healthy tissue because it lacks the microchannels designed by the Cornell researchers.

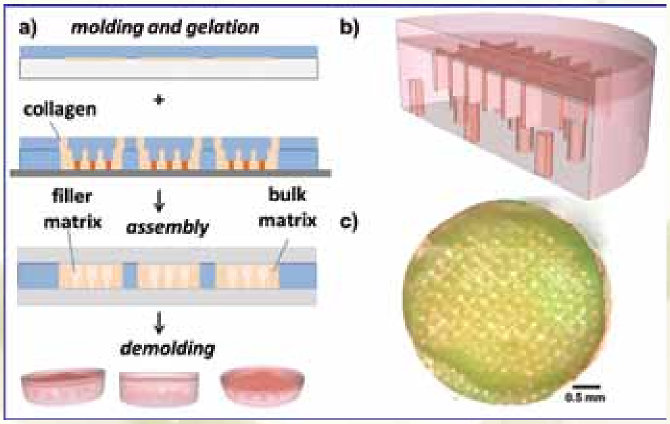


Figure 1: Microstructured tissue template (MTT). a) Schematic diagram of fabrication of MTT. b) Schematic cross-sectional view of MTT. c) Fluorescence micrograph of MTT. Pore structure was filled with red-fluorescent microbeads.

"They can take a long time to incorporate into the person you're putting them in," Spector said. "When you're putting a piece of material on a patient and the wound is acellular, it has a big risk for infection and requires lots of dressing changes and care. Ideally you want to have a product or material that gets vascularized very rapidly."

In the clinic, Spector continued, patients often need significant reconstructive surgery to repair injuries with exposed vital structures like bone, tendon or orthopedic hardware. The experimental templates are specifically designed to improve vascularization over these "barren" areas, perhaps one day eliminating the need for such invasive surgeries and reducing the patient's discomfort and healing time.

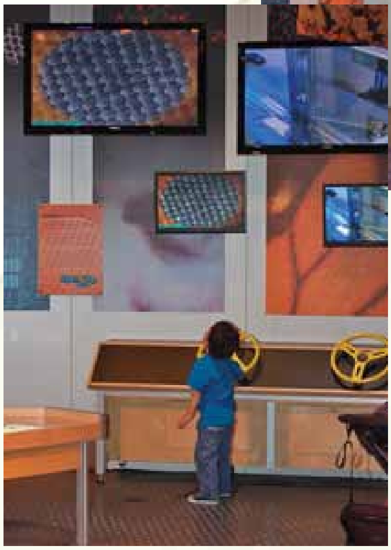
Eventually, the scientists may try to improve their tissue grafts by, for example, reinforcing them with polymer meshes that could also act as a wound covering, Spector said.

Other collaborators include first author Ying Zheng, a former postdoctoral associate in Stroock's lab; Dr. Peter W. Henderson, chief research fellow at Weill Cornell's Laboratory for Bioregenerative Medicine and Surgery; graduate student Nak Won Choi; and Lawrence J. Bonassar, associate professor of biomedical engineering.

The work was supported by the Morgan Fund for Tissue Engineering and the New York State Office of Science, Technology and Academic Research.

Itsy-Bitsy, Teenie-Weenie: Disneyland Exhibit Goes Nano

The new Nanooze Lab at California's Disneyland allows guests to explore the very, very small.



By Susan Lang
October 17, 2011

To help visitors understand the vast world of the wee, the new Nanooze Lab at Disneyland, in Anaheim, CA, allows guests to "touch a molecule" and zoom into the nanometer scale world of atoms and molecules.

Using microscopes, they can see everyday objects magnified more than 100 times and share them on a large video display or with magnifying glasses, explore butterfly wings and other objects from nature.

Sponsored by Cornell and the National Science Foundation, the Nanooze Lab opened in September for one year. It also includes a live show where guests can hear about the wonders of nanotechnology — and even get to make nanometer-scale material.

"What is the smallest thing you an think of? It might be a bug, a cell, an atom, a quark, but it isn't," said Prof. Batt, Cornell's Liberty Hyde Bailey Professor of Food Science and founder of Nanooze. "Everything starts off with some common object, and we give guests a chance to explore and play, going down to the nanoscale."

The Nanooze exhibit is part of the overall Nanooze media enterprise that includes a website — with games, articles, a blog and Q&A section — and a magazine for children. All Nanooze issues can be downloaded for free.

A series of print issues of Nanooze, focusing on chemistry, will be distributed to more 100,000 students in the United States this coming year.

A similar long-term exhibit called *Take a Nanooze Break* opened in 2010 at the Innoventions pavilion at Epcot theme park at Walt Disney World, Lake Buena Vista, FL.

The CNF and the National Nanotechnology Infrastructure Network also provided support for the exhibits, and the displays were built by the Cornell Department of Theatre, Film and Dances's former painter Andy Mansfield, now head of Tamarack Design, and Steve Brookhouse, former assistant technical director.

For more information about Nanooze, visit: http://www.nanooze.org/

SÜSS MicroTec Announces Collaboration in Nano Research with Cornell University

Garching, Germany, 11 January 2011

SÜSS MicroTec, a leading supplier of equipment and process solutions for the semiconductor industry and related markets, announced a strategic collaboration with the Cornell NanoScale Science & Technology Facility (CNF), a university nanofab based in North America. As part of the cooperation, CNF staff will perform research using SÜSS lithography equipment, including enhanced contact aligner tool sets and a Gamma spray coater. The research and development facilities at CNF, which hosts up to 700 users annually, will also serve SÜSS MicroTec as a support lab for research applications and customer demonstrations. The new equipment is expected to become available to users early in 2011.

The lithography equipment to be installed at CNF includes two specialized mask aligner toolsets for the SÜSS MA/BA6 aligner: Substrate Conformal Imprinting Lithography (SCIL), a technology developed by SÜSS MicroTec in conjunction with Philips Research, that provides an

inexpensive means of defining features of 10 nm or less with high reproducibility by using a full-size imprint stamp and MO Exposure Optics, a patented technique developed by SÜSS MicroTec's daughter company SÜSS MicroOptics. This unique illumination technology extends the performance of standard lithography processes. The Gamma lithography coater cluster will be used to support all resist processing operations at CNF. It includes facilities for development, baking, and coating, including the SÜSS spray coat module for high aspect ratio structures.

According to Don Tennant, Director of Operations at Cornell NanoScale Facility, "The Gamma system manufactured by SÜSS MicroTec will bring to CNF the high end performance coat bake and develop capability that is really needed. Its stable, reproducible results and its process flexibility are a great match to the needs of our users. This agreement will also provide us with an opportunity to explore the exciting new technology that SÜSS MicroTec has developed both for the Gamma system and for the MA/BA6 platform. We are anxious to learn what these advancements can do to enhance the efforts of our users."

"We are very pleased to have the CNF, a recognized pioneer in nanotechnology research, as our partner," commented Frank Averdung, President and CEO of SÜSS MicroTec AG. "We are looking forward to using their state-of-the-art research facilities for further developing our technologies. We are happy to offer our North American customers the option to have their application processes set up and tested in this environment."

Sub-Millisecond Heating of Chemically Amplified Photoresists for DUV and EUV Lithography

Byungki Jung, Christopher K. Ober, and Michael O. Thompson, Materials Science & Engineering, Cornell

Chemically amplified resists (CARs) continue to be developed to achieve sub-22 nm lithography in both 193i and EUV platforms, with key challenges in resolution, sensitivity and line width roughness (LWR). In this work, we explore the use of transient laser heating to address these challenges by shifting the time/temperature regime for the post-exposure bake (PEB) process from tens of seconds at 90-130°C to sub-millisecond times at temperatures of 250-450°C. Using commercially available resist systems, patterns can be generated using laser PEB (l-PEB) as shown in Figure 1.

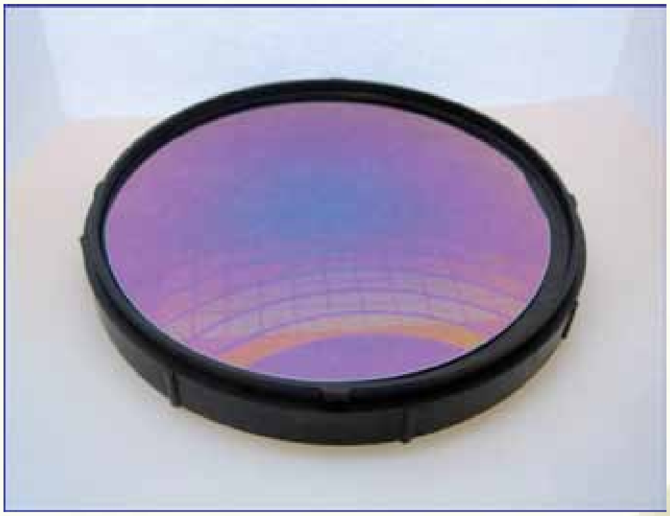


Figure 1: Latent image generated after sub-millisecond post-exposure bake using a line-focused laser source. Bands represent heating at varying powers / temperatures.

The concept of l-PEB is to induce maximum resist deprotection using very high PEB temperatures while simultaneously minimizing deleterious acid diffusion at submillisecond PEB durations. This concept is demonstrated in Figure 2, where dose required to generate comparable resolution is a factor of two less when using l-PEB while reducing the line width roughness (LWR) by 28% (30.9 nm for hot plate and 22.2 nm for l-PEB).

This group investigated the use of this material by syringe-dispensing their photoresist in the SUSS MicroTec Gamma System. The motorized syringe dispense kit on the Gamma's spin coater module is an ideal dispense system for applications where only small resist amounts are available, used or needed. It provides a fully programmable dispense volume and speed, as well as for material suckback volume and speed.

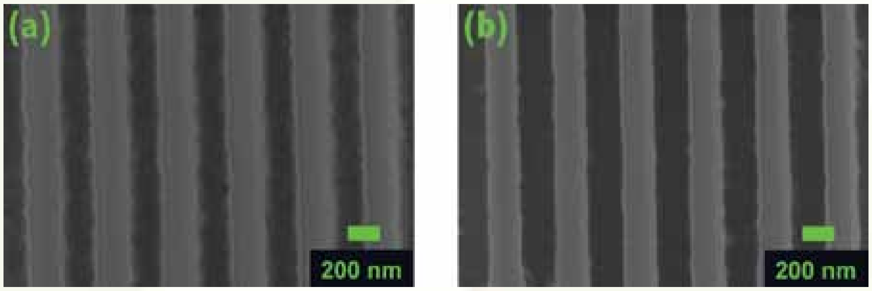


Figure 2: Patterns generated under Cornell ASML 248 nm exposures using a) hot plate PEB and b) laser PEB. Dose required for these comparable SEM images were 10.8 mJ/cm² for laser PEB and 20.0 mJ/cm² for hot plate PEB. PEB temperatures and durations were 20W (~295°C) for 500 ?s (laser) and 115°C for 60 seconds (hot plate).

SÜSS MicroTec Wafer Bonding and Lithography Workshop at Cornell University

By Noah Clay, CNF Staff

On September 14th, SÜSS MicroTec and CNF held an all-day workshop in Duffield Hall. Registration was open to the Cornell community, the NNIN and general public. Attendance was full, with nearly fifty-percent of the attendees hailing from outside of the Cornell community.

The workshop was segmented into two sessions, with technical presentations from 9AM through 2PM, followed by live demonstrations of equipment for the remainder of the day. Applications engineers from SÜSS MicroTec discussed advancements in wafer bonding, nanoimprinting, resist spray coating, source mask optimization and selective plasma treatments of substrate surfaces. Equipment demonstrations consisted of several thirty-minute sessions of spray-coating photoresist on the Gamma Cluster Tool, SCIL nanoimprinting on the MA-6 mask aligner, and wafer bonding on the SB-8e system. Also presenting at the workshop was an applications engineer from GenISys, who discussed and demonstrated their new simulation package, LayoutLAB. As noted in the previous issue of The NanoMeter (page 19), LayoutLAB allows for simulation of contact and proximity exposure conditions on the SÜSS MA-6 with a variety of illumination filter plates (IFPs).

Acknowledgements — Two of our CNF Fellows, Wei-Min Chan and Melina Blees, were instrumental in the success of the nanoimprint demonstrations. In the days leading up to the workshop, their collective fabrication efforts greatly contributed to the positive experience of the workshop attendees. In addition, we express great gratitude to Melanie-Claire Mallison for all the coordination with SÜSS MicroTec, as well as orchestrating yet another successful event at CNF. Lastly, we are very grateful to the SÜSS MicroTec team, particularly Emyr Edwards, for sponsoring the day's events and enlightening the technical community on the company's latest developments.

By Emyr Edwards, SÜSS MicroTec staff

As part of SÜSS MicroTec's ongoing collaboration with Cornell NanoScale Science & Technology Facility (CNF), on September 14th, SÜSS MicroTec presented a *Wafer Bonding and Lithography Workshop*. CNF graciously hosted the workshop. Over 35 attendees saw presentations of innovative SÜSS MicroTec technologies such as SELECT selective plasma activation, MO Exposure Optics, SCIL Conformal Wafer-scale Nano Imprinting, Spray Coating, Permanent Bonding and Temporary Bonding. These advanced technologies were also demonstrated live by SÜSS MicroTec and CNF staff using the SÜSS MicroTec equipment that is installed at CNF.

Click here to download the presentations. https://suss.picturepark.com/Website/Mailing.aspx?Action=browseMailings&MailingId=82&PW=5ea874ef-767c-4364-ae4b-8549588074ee&UserId=84








GenISys BEAMeeting Hosted by CNF

On November 9, 2011, the CNF and GenISys GMBH conducted a "BEAMeeting" for users of software made by GenISys.

Layout BEAMER is used to convert computer aided design (CAD) files to the file formats used by the two JEOL electron beam lithography systems at CNF. Layout LAB is used to plan exposures with the SÜSS MicroTec MO Exposure Optics in the SÜSS MA-6 contact aligner.

GenISys was represented by Ulrich Hofmann, president of the company, and Gerald Lopez, field applications engineer. Approximately twenty CNF users from Cornell, Syracuse and Rochester, and several CNF and other NNIN site staff members attended the meeting.

Attendees learned about proximity effect correction (PEC) and process correction for high resolution HSQ lithography; generation of point spread functions for proximity effect correction using both proprietary and freely available Monte Carlo simulation codes; use of PEC to fabricate grating couplers for optical devices; multi-pass e-beam exposure to improve field stitching, CD uniformity and edge roughness; and 3D e-beam lithography processing. Use of Layout LAB to optimize source masks for the SÜSS MicroTec MO Exposure Optics was also presented.

A hands-on workshop with the software on PC workstations followed the presentations. Users learned several techniques in Layout BEAMER that went beyond the basic file conversion functions. These included manual placement of fields to avoid stitching errors, controlling the order in which fields are exposed, splitting patterns into coarse and fine features, and how to fine tune the algorithm used to convert circular features.

The CNF users and staff and GenISys staff found the meeting to be highly successful and there are plans to have a longer hands-on workshop in the near future.

Michael Skvarla interviewed on Science Cabaret on Air

Ithaca's Science Cabaret was inspired by the Cafe Scientifique movement, which started in Europe in the late 1990's and has spread rapidly. Cafes Scientifiques are informal talks in bars, cafes and other public venues that give like-minded people a chance to discuss current and sometimes controversial topics in science. *Science Cabaret on Air* is a weekly radio broadcast that interviews scientists from all disciplines in the local area. These are broadcast on WICB 91.7 every Sunday at 7:00 p.m. The podcasts from all shows can be heard at the following link: http://sciencecabaret.podomatic.com/

Our own Mike Skvarla was invited to give an interview about the Societal and Ethical Issues in Nanotechnology (SEI) program sponsored by the NNIN. As stated from the SEI website "A fundamental objective of the federal SEI initiative is to develop national self-awareness and self-reflection regarding the impact of nanotechnology research." More information can be found at: http://sei.nnin.org/

Mike's podcast can be heard at the following link. Have a listen! http://sciencecabaret.podomatic.com/entry/2011-09-12T07_14_27-07_00

NanoDays in Puerto Rico

By Yajaira Sierra-Sastre

It was a typical sunny day of September in the southeast coast of Puerto Rico and the temperature was already reaching 103°F at the early hours of the morning. The smell molecules of "arroz con pollo y habichuelas" (rice with chicken and beans) coming from the cafeteria were already filling the hallways and the classrooms of the Enrique Huyke Elementary School; a school located only 300 meters from the Caribbean waters that bathe the coast of the town of Arroyo. A total of 117 students were anxiously waiting for the arrival of a special guest that morning, a nanoscientist from the United States.

But this scientist didn't look like a foreigner from "el otro lado del charco" (the other side of the pond, or properly named the Atlantic Ocean). She spoke Spanish just like everyone else in the room and spent some time sharing childhood experiences growing up in the same "pueblito" (small town). Very promptly, it was made clear to everyone that nanoscientists are — or can be — people like you and me, and them.

Only 4% of the students had heard the word *nanotechnology* prior to that day, so it was necessary to first become familiar with the units of measurements from centimeters to millimeters, from millimeters to micrometers, and from micrometers to nanometers. I was really amazed by the ability of the students to quickly grasp an understanding of the very small scales by using as a reference a 100 micrometer-thick, black Caribbean strand of hair. Certainly, when it comes to thinking small, it seems to be easier when things appeal to our senses, experiences, and surroundings [1].

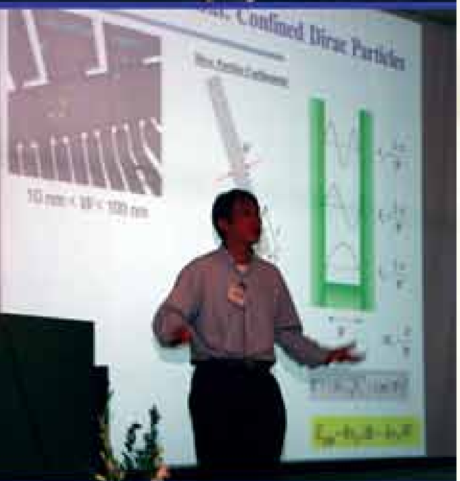
We played the game "Guess that Smell" and explored how our noses act as nanosensors to detect molecules of different sizes and shapes. We investigated the magnetic properties of ferrofluids and magnetite (which we have in abundance in the black sands of the beach next door) and learned how their difference in behavior is due to size. Finally, we investigated the hydrophobic properties of pants made from nano fabric and ordinary fabric and laughed about the joy nanotechnology would bring to parents — and teachers — if the school uniforms would be forever free of stains and stinky smells.

After all was said and done, I am confident there is "plenty of room" and opportunities in my community to spark the enthusiasm of the little ones in discovering the pleasures of finding things out. If after reading this story you get enthusiastic and would like to either contribute to this community or participate in a science outreach within a U.S. territory, but with a "pizca" (pinch) of international seasoning, don't hesitate to contact me or perhaps join me in my next trip to Puerto Rico!

Acknowledgements:
Yajaira Sierra-Sastre would like to thank the CNF for providing the NanoDays activities for this outreach event and would like to thank Mr. Roberto Morales-Pérez (science teacher) and Mrs. Odalis Collazo-Alayón (school director) for their hospitality.

You can reach Yajaira via email: ys253@cornell.edu.

References:
[1] Batt, C. A. Nature Nanotechnology 3, 121-122 (2008).



2011 CNF Annual Meeting

Our 34th annual meeting was held on Thursday, September 15th, here on Cornell University campus. We had over 200 participants, who enjoyed a day of discovery, education, comradery, and really excellent food!

Our keynote speaker was Dr. Philip Kim, Professor of Physics at Columbia University, who presented his talk "Toward Graphene Quantum Electronics." Dr. Kim was followed by sixteen presentations given by CNF users, chosen to highlight their exciting research results. But many more users are doing great work at the CNF, so we also had over fifty users present posters during the Poster Session & Corporate Soiree!

We are indebted to our twenty-four corporate sponsors, listed on the next page. Their dedication and support of our program is greatly appreciated. Because of our corporate sponsor generosity, we were able to give out eight awards to our hard-working and much deserving users. The awards are listed on the next page, along with a photograph of our winners.

More information and more photographs of the 2011 CNF Annual Meeting can be found at http://www.cnf.cornell.edu/cnf_2011am.html. Note that we will be celebrating our thirty-fifth anniversary next year! Information is on the back page — plan to join us in July 2012! We already have seven sponsors!

2011 CNF Annual Meeting Corporate Sponsors

**• Applied Materials • ASML • Corning • First Nano •
• GLOBALFOUNDRIES • Heidelberg • Hitachi •
• JEOL • JENOPTIK • KAUST • Kionix •
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2011 CNF Annual Meeting Award Winners!

Sponsored by First Nano, GLOBALFOUNDRIES, Pacific BioSciences, XACTIX, and Bob Scruton

Best Presentation Awards:

- **Byungki Jung • Carlos Ruiz-Vargas**

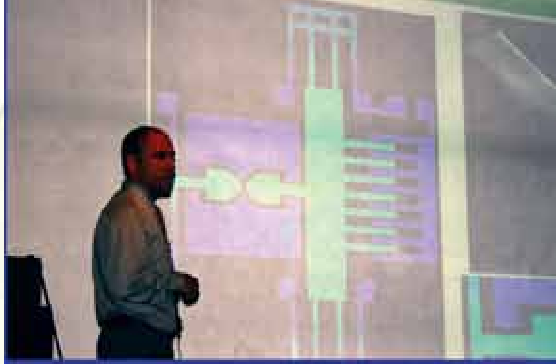
Best Poster Awards:

- **Kwame Amponsah • Vlad Oncescu • Casey Kraning-Rush**
- **Alexander Ruyack & Samantha Roberts**

Nellie Yeh-Poh Lin Whetten Memorial Awards:

- **Melina Blees • Jonilyn Longenecker**

University Photography



2011 CNF Whetten Memorial Award Winner Profile: Melina Blees

Melina Blees is a fifth-year graduate student in the physics department at Cornell University and has been a CNF Fellow since the spring of 2011. She is one of two recipients of this year's Nellie Yeh-Poh Lin Whetten Award. The Whetten Award recognizes outstanding female graduate students who show spirit and commitment to professional excellence as well as professional and personal courtesy.

University Photography

Melina received her bachelor's degree in physics from Carleton College in Northfield, Minnesota, in 2007. She attended Research Experience for Undergraduates (REU) programs at the University of Minnesota, where she studied liquid crystal films, and at the University of California at Davis, where she studied magnetic tunnel junction devices. In 2008, she joined Professor Paul McEuen's research group in Cornell's Department of Physics. The group studies graphene and carbon nanotubes, and Melina's most recent project focuses on folding graphene into three-dimensional shapes – graphene origami.

As scientists and engineers move into the truly nanoscale regime, three-dimensional structures and especially moving parts have become increasingly difficult to create and control. Graphene offers unparalleled in-plane strength and low out-of-plane bending energy, so it is an ideal material for nanoscale structures and hinges. New growth techniques have made it possible to grow atomically-thin graphene over arbitrarily large areas, and these membranes can be transferred across substrates and integrated with existing lithographic techniques to create arrays of identical structures. In one proposed application, a thin strip of graphene would act as an ideal hinge in a more complex device, folding with very little energy cost but maintaining its great strength. Such nanometer-scale sheet hinges could replace the fragile and relatively large silicon-based hinges that enable moving parts in today's microscale structures (Figure 1).

In order to fold graphene in a controlled way, Melina works in solution. She fires a laser up through a transparent substrate to heat single- or multi-layered graphene, and the heat nucleates a vapor bubble. Graphene refers to sit at the bubble-water interface to reduce the surface energy of the system, so it wraps around the bubble to form a three-dimensional structure (Figure 2). When the bubble dissolves away the graphene structure collapses, but reinforcing panels of another material could provide a permanent framework, as in Figure 1 (b, c). At the moment, Melina is focusing on controlling the adhesion of graphene to the surface using surfactants and sacrificial layers; the next step will be the addition of small SU-8 "handles" on the graphene which can be controlled with an optical trap, allowing for manual assembly of more complex structures.

In addition to nanoscale graphene sculpture, Melina continues to explore macroscale artwork and graphics design. Her interests include metalworking (Figure 3), book cover design, and painting. She has taken a number of classes in Cornell's Department of Art and Architecture, and especially enjoyed printmaking — a form of art that closely parallels many of the processes in nanofabrication. Most recently, she has been working with Jim Tyler in the Risley letterpress studio to learn Gutenberg-style typesetting and printing. She also swing dances, volunteers as the travel coordinator for the annual Light In Winter festival, and borrows far more books from the library than she actually has time to read.

Melina is extremely grateful to everyone she's worked with — her advisor, labmates, and the CNF users and staff — for their generous support and enthusiasm.

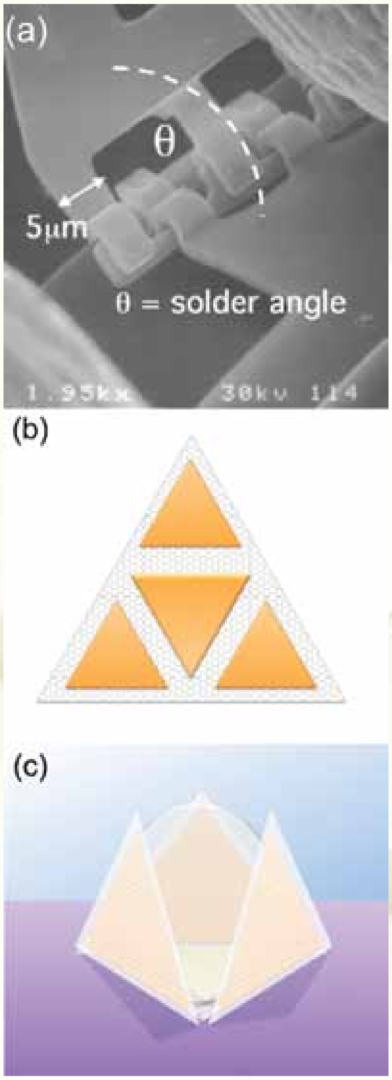


Figure 1: (a) A microscale silicon hinge, from R. Linderman et al., Sensors and Actuators A (2001). (b) A proposed metallic structure with graphene sheet hinges in its lithography-friendly two-dimensional fabrication state, and (c) folding around a bubble in solution.

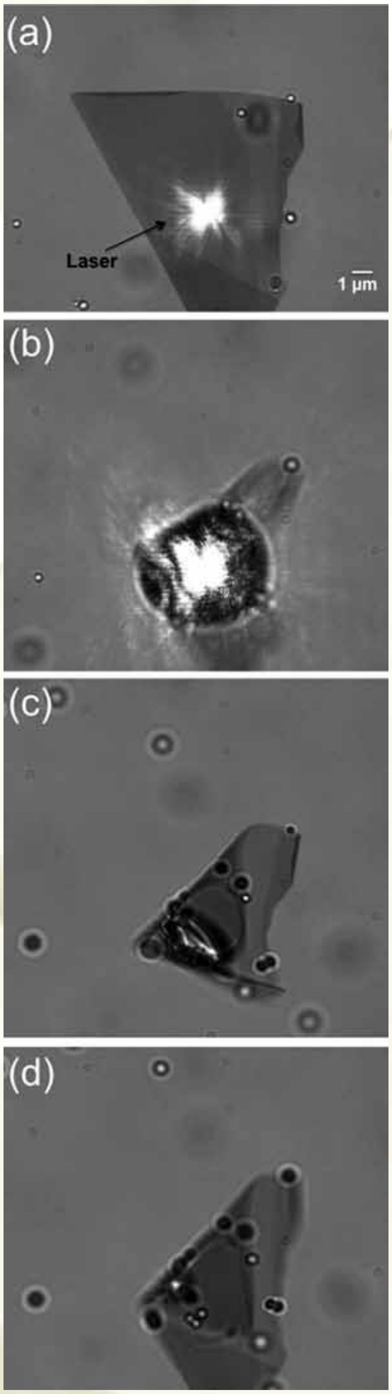


Figure 2: Multilayer graphene flake in water. (a) Graphene is struck with a laser; (b) the heat causes a bubble to nucleate, and the graphene folds around the bubble. (c) When the laser is turned off, the bubble starts to dissolve back into solution and the graphene begins to collapse. (d) The graphene remains partially folded but lies flat on the surface.

Figure 3, left: Skeleton of Archaeopteryx lithographica, made from silver and brass, 6 cm tall.

The Nellie Yeh-Poh Lin Whetten Memorial Award

"This award is given in fond memory of Nellie Whetten, a CNF staff member from 1984 to 1987, who died March 24, 1989.

This award recognizes outstanding young women in science and engineering whose research was conducted in the CNF, and whose work and professional lives exemplify Nellie's commitment to scientific excellence, interdisciplinary collaboration, professional and personal courtesy, and exuberance for life."

In the words of her husband, Dr. Timothy Whetten, "The award should remind us to find out what it is like for people different from us to live and work in the same community. For men, to try to appreciate what it is like to be a woman scientist. For Caucasians, to try to feel what it is to be Asian or Black. For members of racial minorities and women, to try to understand what it is like to be a White male. And finally, the award should stimulate each of us to reach out and encourage women scientists who, like Nellie Yeh-Poh, have the brilliance, stubbornness, and cheerfulness, to succeed."

(From the Whetten Award plaque in the CNF main office, which lists all the Whetten Award winners since 1978.)

2011 CNF Whetten Memorial Award Winner Profile: Jonilyn Longenecker

Jonilyn Longenecker, a fifth year graduate student in the Department of Chemistry and Chemical Biology at Cornell University, is one of the recipients of the 2011 CNF Nellie Yeh-Poh Lin Whetten Award.

Jonilyn received her bachelor's degree in Chemistry from Juniata College in Huntingdon, Pennsylvania. While an undergraduate, she conducted molecular modeling studies to aid in the development of alternative antibacterial agents, and also participated in a Research Experience for Undergraduates at the University of Hawaii at Manoa where she studied astrochemistry-related reaction dynamics and achieved the first infrared spectroscopic detection of the monobridged diboranyl radical. In the fall of 2007, Jonilyn joined Cornell's Department of Chemistry and Chemical Biology, where she currently works on magnetic resonance force microscopy (MRFM) in Professor John Marohn's research group.

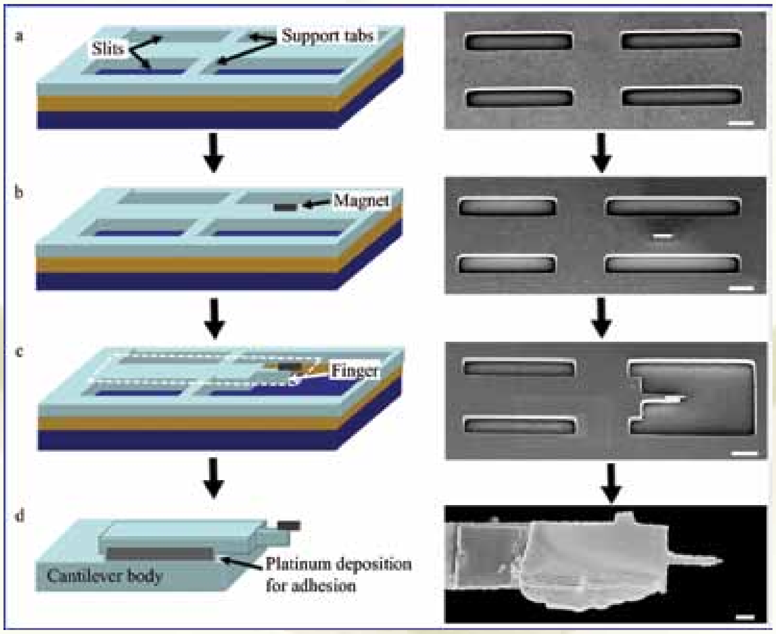


Figure 1: Process flow schematics (left) and the corresponding SEM images (right) at key steps in the process used to fabricate overhanging magnet-tipped silicon chips and attach the chips to cantilevers. The magnet-tipped chips are fabricated by (a) etch slit definition and chip release, (b) magnet deposition, and (c) definition of the silicon leading-edge finger. To attach the chip to a cantilever, the portion of the chip inside the dashed line in the schematic in panel (c) is moved and attached to the leading edge of the cantilever, resulting in the magnet-tipped chip-on-cantilever shown in panel (d). All scale bars are 2 µm.

Jonilyn's research focuses on developing nano-magnet-tipped ultrasensitive cantilevers for application in MRFM. There is a critical need for a technique capable of non-invasive high resolution imaging of single copies of delicate biomolecules and as-fabricated semiconductors and spintronics devices. MRFM, which is a non-invasive, scanned-probe magnetic resonance technique, has the potential to fill this important niche. MRFM uses custom, attonewton-sensitivity cantilevers to detect electron spin resonance (ESR) and nuclear magnetic resonance (NMR).

Recently, 4 nm resolution imaging of a virus has been achieved by Dr. Dan Rugar's team at IBM Almaden Research Center using MRFM, demonstrating that the capabilities of the technique can be comparable to current state-of-the-art single molecule imaging. However, the 4 nm resolution image was achieved using a sample-on-cantilever geometry, meaning that the sample was prepared on the leading edge of a cantilever and scanned over a stationary magnet.

In order to realize the full potential of studying functional devices and macromolecules using MRFM, Jonilyn has focused on the development of cantilevers utilizing an alternative geometry: affixing a small magnetic particle directly onto the cantilever, which enables complex systems to be prepared and studied on a nearby surface without rigid spatial constraints. The challenge in developing nanomagnet-tipped cantilevers lies in process integration; the magnets are easily damaged at the high temperatures required for steps in the fabrication of the cantilevers.

To bypass these fabrication incompatibilities, Jonilyn utilized a dual-beam focused ion beam (FIB) system to develop a novel method for attaching a nanomagnet to the leading edge of a cantilever.

The process, as detailed in Figure 1, involves; (1) fabricating overhanging nickel and cobalt magnetic tips on shortened mock cantilevers, (2) using FIB milling and deposition to cut the mock cantilever (and attached tip) free from the substrate, and then (3) attaching the released structure to a full-length, high-sensitivity cantilever. The nanomagnets are defined using electron beam lithography, and the magnetic material is deposited by electron gun evaporation.

The quality of the nanomagnets is critically important in MRFM in order to achieve maximum resolution. Jonilyn has worked to extensively characterize the elemental composition, morphology, and magnetization of the nanomagnets in order to determine the extent of magnet damage. She has imaged the crystalline grain structure of a nickel nanorod using scanning transmission electron microscopy and determined that the magnets were free from contaminant elements and that the leading edge of the nanomagnets were tapered using electron energy loss spectroscopy (Figure 2).

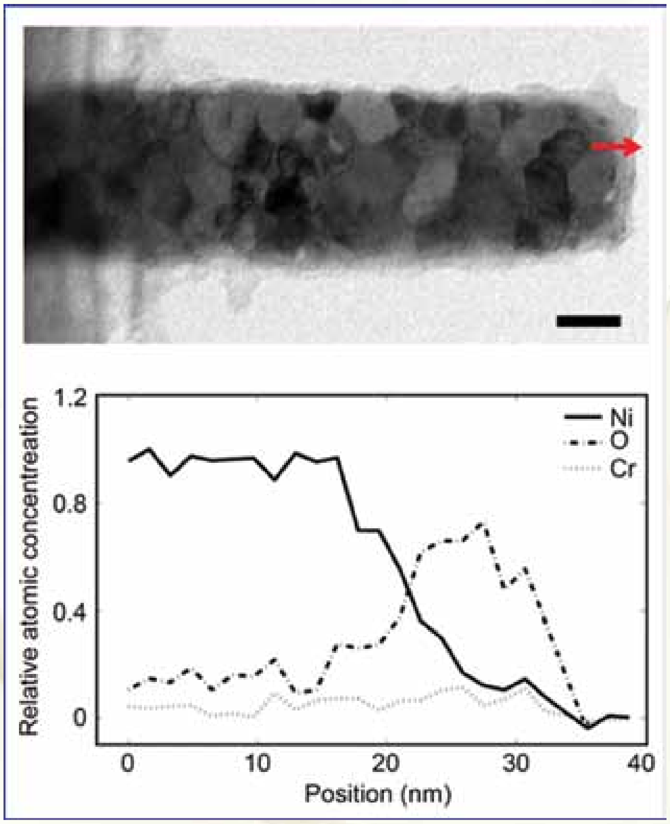


Figure 2: (Top) Bright-field scanning transmission electron microscopy (STEM) image of a nickel nanorod (scale bar = 50 nm). (Bottom) Elemental mapping of an overhanging nickel nanorod by electron energy loss spectroscopy (EELS). The arrow in the STEM image indicates the scan direction of the EELS data.

She also obtained results using superconducting quantum interference device magnetometry that indicate that the magnets are nearly fully magnetized and should produce field gradients large enough to be successfully used in high-resolution NMR-MRFM and single spin ESR-MRFM.

Jonilyn is excited to utilize her magnet-tipped cantilevers in MRFM experiments. Along with her coworker Dr. Lei Chen, Jonilyn is currently designing and constructing a custom MRFM instrument in which her nanomagnet-tipped cantilevers will be used. The instrument will have three dimensions of scanning and will be operated at 4 K and high vacuum.

In addition to her Ph.D. research, Jonilyn worked as a Cornell NanoScale Facility Fellow from 2009-2011. She primarily characterized thermal and plasma tantalum-based atomic layer deposition (ALD) processes and fabricated metal-insulator-metal (MIM) capacitor devices to test dielectric properties of ALD films.

Jonilyn also enjoys teaching and learning about science and nanotechnology in community and global settings. She is an active science education volunteer who has worked with students, teachers, and families in Ithaca. She also had the opportunity in to participate in the 2010 International Winter School for Graduate Students sponsored by the National Nanotechnology Infrastructure Network and held at the Indian Institute for Science in Bangalore, India. As part of the program, she travelled to Dharmasthala and interacted with many local residents to understand how they have been influenced by technological advancements. Jonilyn's picture was taken at the Hoysalaswara temple en route between Bangalore and Dharmasthala.

University Photography

Photograph Credits

Cover Image: Byungki Jung, Christopher K. Ober, and Michael O. Thompson. See page 8.

Background Image: Reyu Sakakibara, Jeevak Parpia, and Robert A. Barton Jr. See page 18.

Research images are the property of the person/group in the article.

All other photographs were taken by CNF Staff unless otherwise noted on the picture.

Monday, 1 August 2011

Dear Melanie,

This is a just a heads up to let you know I am still alive, and that after a hiatus into the workforce I have (finally) decided to attend graduate school after all. I have been accepted into a Ph.D.-by-research program at the University of New South Wales in Sydney, Australia. I can hardly believe I am writing this, but it is with the School of Photovoltaic and Renewable Energy Engineering, which has developed many of the best solar cells in the world for about 30 years running. In short, it is basically my dream school.

Ironically, I will be researching phononic band gaps in hot carrier solar cells, just as I researched photonic crystals in peacock feathers at CNF, an experience I honestly never really expected to directly use again; it's funny sometimes the curve balls life throws your way.

I have decided that this graduate research tact is the best possibility I have, because it will serve me the best in my pursuit of powerful and effective renewable energy solutions, and in so doing, allow me the greatest positive impact I can have upon the world.

Doubtless, both on paper and in real-life, the practical experience at CNF helped me get where I am, and will continue to help me in the future. My sincere thanks to you and the NNIN REU program for the unique opportunity I was granted, and to all the CNF staff who collectively "babied" me along into becoming what I would term a "real" research scientist.

I will be forever in your debt; with my whole heart, thank you.

Your friend always,
Suntrana (Tran) Smyth
2007 CNF REU Intern
and 2007 Intel Fellow

This issue's background image was borrowed, with permission, from one of our 2011 CNF REU reports. "Graphene Resonators for Mass and Charge Sensing," by Reyu Sakakibara, Chemical Biology, University of California, Berkeley; Principal Investigator: Professor Jeevak Parpia, Department of Physics, Cornell University; Mentor: Robert A. Barton Jr., Department of Applied and Engineering Physics, Cornell University. The image is an SEM image of a completed device with suspended graphene. The image was also used on the cover of the Journal of Vacuum Science & Technology B, above. Read Reyu's full REU report online at http://www.nnin.org/nnin_2011reu.html.

IEEE Transactions on Biomedical Engr., V.58, No. 11, Nov.2011; pgs 3197-3205

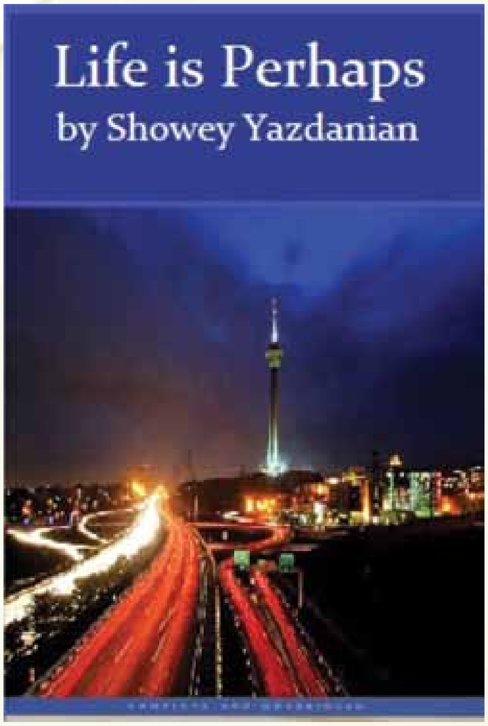
A Hermetic Wireless Subretinal Neurostimulator for Vision Prostheses

Shawn K. Kelly*, Member, IEEE, Douglas B. Shire, Member, IEEE, Jinghua Chen, Patrick Doyle, Marcus D. Gingerich, Stuart F. Cogan, Member, IEEE, William A. Drohan, Member, IEEE, Sonny Behan, Luke Theogarajan, John L. Wyatt, Senior Member, IEEE, and Joseph F. Rizzo, III

Abstract: A miniaturized, hermetically encased, wirelessly operated retinal prosthesis has been developed for preclinical studies in the Yucatan minipig, and includes several design improvements over our previously reported device. The prosthesis attaches conformally to the outside of the eye and electrically drives a microfabricated thin-film polyimide array of sputtered iridium oxide film electrodes. This array is implanted into the subretinal space using a customized ab externo surgical technique. The implanted device includes a hermetic titanium case containing a 15-channel stimulator chip and discrete circuit components. Feedthroughs in the case connect the stimulator chip to secondary power and data receiving coils on the eye and to the electrode array under the retina. Long-term in vitro pulse testing of the electrodes projected a lifetime consistent with typical devices in industry. The final assembly was tested in vitro to verify wireless operation of the system in physiological saline using a custom RF transmitter and primary coils. Stimulation pulse strength, duration, and frequency were programmed wirelessly from a Peripheral Component Interconnect eXtensions for Instrumentation (PXI) computer. Operation of the retinal implant has been verified in two pigs for up to five and a half months by detecting stimulus artifacts generated by the implanted device.

Where are they now?

Showkat "Showey" Yazdanian



By Daron Westly

If you had just finished writing your dissertation, what's the first thing you would want to do? Why, you would probably want to write some more! *Probably not.* But that's what Showey Yazdanian decided to do.

Of course, she's been writing her entire life, producing her first work when she was in the third grade entitled "A Tree." This is in sharp contrast to the last work she produced here at Cornell with the Marohn group — entitled "Scanned Probe Microscopy Studies of Thin Organic Films Using Cantilever Frequency Noise." In between Showey has also published in The Ithaca Journal, the Manchester Evening News and The Lawyer's Weekly, and freelanced exclusively for the Toronto Star from 2003 - 2007. Did I mention she has a law degree?

Showey is now a sessional professor in the physics department at the University of Guelph in Toronto. She still occasional comes through Ithaca and meets with friends on her way to New York City. She has recently published her first full length work of fiction entitled *Life is Perhaps*. This work includes seven interlinked stories that are mostly "tragi-comdic," as she describes them "turning a humourous lens on the experiences of Iranian immigrants who have been uprooted from home and grafted onto foreign soil." The book can be purchased from her website or from Amazon and is also available as an e-book. To get an idea of her humor I would highly recommend visiting her website at http://showey.net/.

We always enjoy hearing about what our former users are doing. Please keep in touch with us as you move on to life outside of the lab.

NNIN ON THE ROAD

In October, the National Nanotechnology Infrastructure Network (NNIN) sponsored a booth at the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) Southeast Regional Meeting. Here's a photograph of our primo spot at the meeting!

With fourteen member universities in the NNIN, spread out across the United States, we often have someone close to an important regional meeting or nano-tech conference. Contact Dr. Nancy Healy (nancy.healy@mirc.gatech.edu) if you are holding an event you think we might be interested in attending!

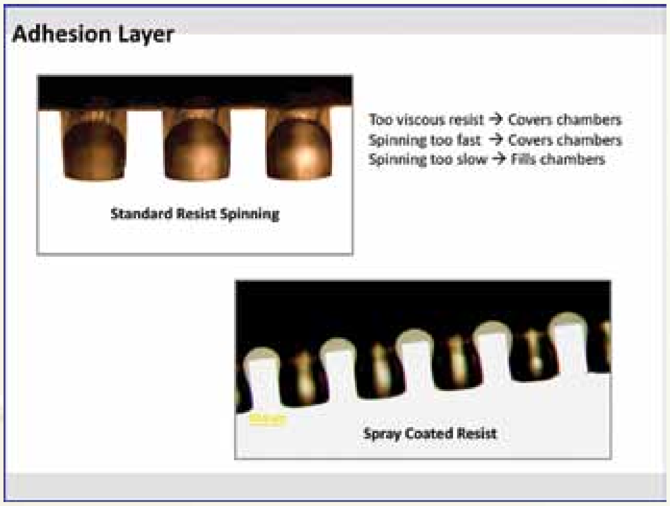
New System Adds to CNF Sputter Deposition Capabilities

The new AJA Orion8 sputter deposition tool will substantially expand our metal and dielectric deposition capacity. The system is a load-locked single wafer DC and RF sputter tool.

The AJA will add five sources to complement our existing CVC three target system managed by Jerry Drumheller. Jerry and Rob Ilic have been working hard to characterize and prepare the tool for the user community.

We expect it to be ready within a month for training!

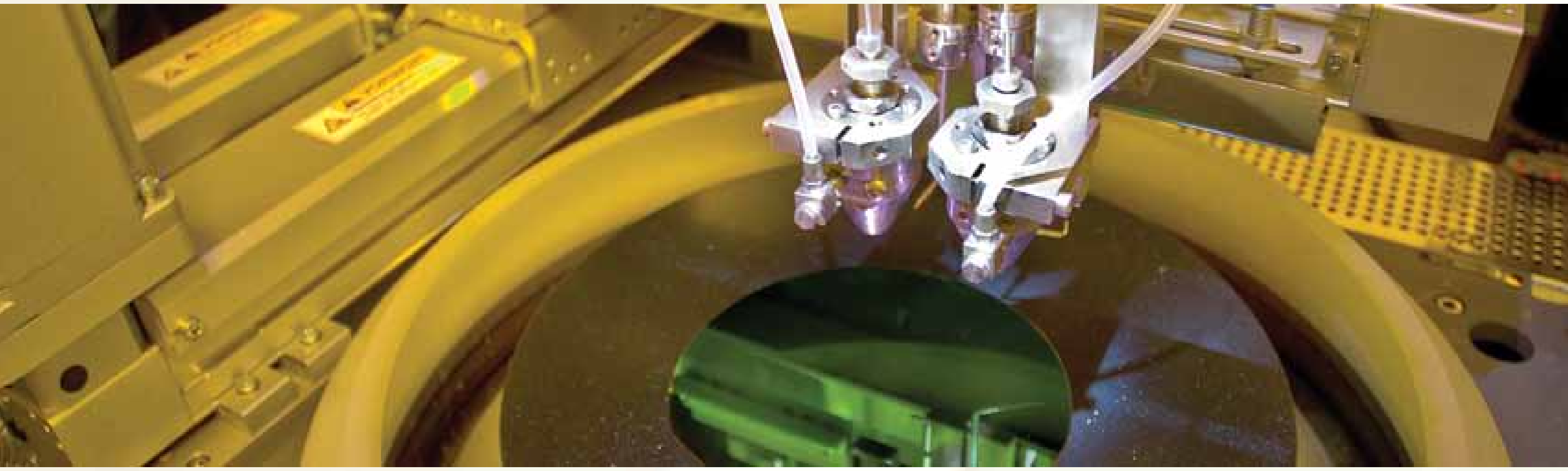
Spray Coating Photoresist



Carlos Ruiz-Vargas, a Chemistry Department graduate student in Professor Jiwoong Park's group, is interested in the fabrication and characterization of graphene nanodevices to investigate atomic interfaces. For one of his projects, spray coating photoresist on devices with the SUSS MicroTec Gamma System has given good results.

Carlos requires deposition of photoresist on the tops of pillars, but little or no resist in the trenches between the pillars. The photoresist is to be used as a thin layer of "glue" for transferring graphene membranes and subsequently suspending them.

As can be seen in the photos, conventional spin coating of photoresist results in resist pooling between the pillars, while optimizing spray coating parameters results in deposition of resist only on uppermost regions of the wafer.



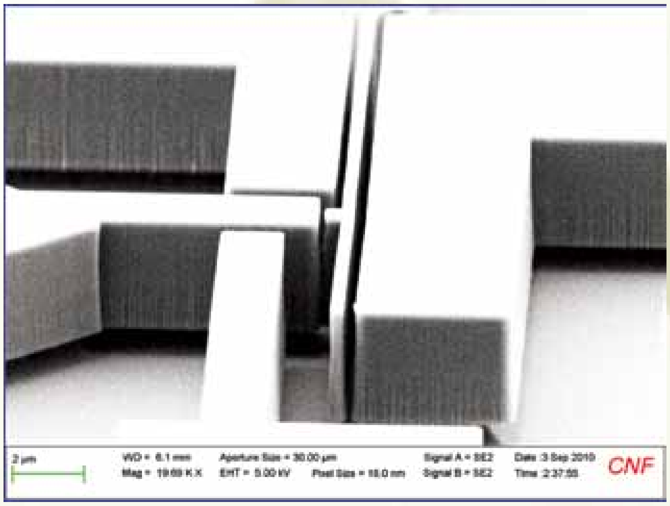
SÜSS DSM8

CNF has completed the installation of a SÜSS DSM8 Manual Front-to-Back Alignment Verification System. We expect this tool to assist users of the MA/BA6, the EV620, the SB8e, and the PAS5500/300C, which are all used in front-to-back wafer processing.

From the SÜSS MicroTec brochure:

> **The SÜSS DSM8 is the ideal tool for verifying alignment for front-to-bottomside exposed or bonded wafers or substrates from 2″ up to 200 mm. The straightforward measurement process requires no special training. Reliability, precision and speed make the SÜSS DSM8 the tool of choice for both the R&D and production environment.**
>
> - **Intuitive and easy to use through step-by-step assistance**
> - **Measurement results independent of operators skill**
> - **Compact design – small footprints and benefits**
> - **Accuracy: 0.5 µm (3σ)**
> - **Accuracy for thick materials: 0.5 µm + 0.1 µm per mm wafer thickness (3σ)**

Primaxx Update



The recently installed Primaxx µEtch vapor HF system is a valuable addition to the CNF. The system provides a single step release process of MEMS structures without stiction or the use of critical point drying. The dry release process allows for highly selective and uniform etching of silicon dioxide (SiO_2). Undercut etch rates as high as 0.25 µm/min can be obtained along with high selectivity to materials such as single crystal silicon, amorphous silicon, Al, TiW, Al_2O_3, and SiC. In addition, high selectivity to both LPCVD low stress SiN and LPCVD stoichiometric SiN has been demonstrated with figures as high 80:1 and 10:1 respectively.

The figure at left illustrates the successful release silicon beams 25 µm in length and 500 nm in width from an SOI with a 2 µm thick buried oxide layer.

For additional information or training on the Primaxx system, please contact Vince Genova at Genova@cnf.cornell.edu.

CNF Fellow, Melina Blees (Physics Department; profile, page 14), has been working on the SÜSS MicroTec SCIL (substrate conformal imprint lithography) system, which is enabled by the MA-6 mask aligner. Melina is a graduate student in Professor Paul McEuen's group, and is interested in using single-layer graphene to build three-dimensional "origami" and strong, truly nanoscale hinges. To do this, she needs good control over the adhesion of graphene to its substrate, which can be achieved by reducing the contact area using nanopatterned substrates. These patterns should be between 10-100 nm in scale but still inexpensive and easily reproducible, which makes SÜSS's substrate conformal imprint lithography process an ideal tool for Melina's purposes.

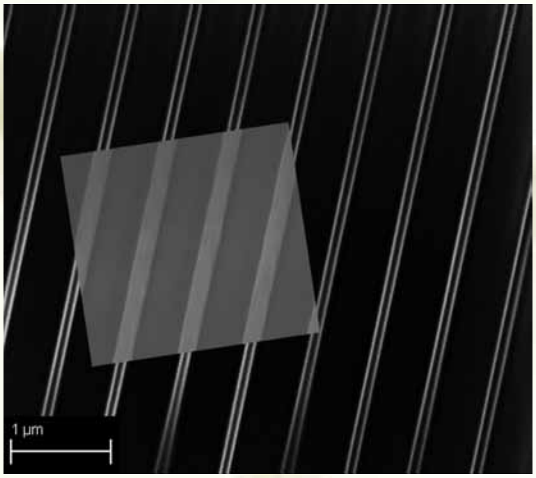


Figure 1, above: Separating a SCIL mask from its silicon master wafer.

Figure 2, right: Array of lines in UV-cured resist after imprint lithography. Inset: Original etched silicon wafer from which the imprint mask was made.

Welcome to the CNF Fellows Program!

Abdurrahman Gumus, PhD. Student, Electrical and Computer Engineering. Advisor: Prof. David Erickson

My research objective is to develop self-reliant, self-powered micro- and nanosystems for autonomous biophysical monitoring. These systems will be applied to the understanding of avian flight biology through the development of "Lab-on-a-Bird" devices. The approach taken will be to intertwine a number of micro- and nanotechnologies (including biosensors, microfluidics, drug delivery, and energy harvesters) with the living animal and will enable in-vivo real-time dynamic measurements of the physiological state of birds while they move in their natural habitat.

National Nanotechnology Infrastructure Network Research Experience for Undergraduates (NNIN REU) Program

The 2011 NNIN REU Interns at the network-wide convocation at Georgia Tech in August. Photograph by Christopher Julian.

This past summer, the network hired 85 undergraduate students to "play" in our member labs and cleanrooms — twelve interns came to the CNF.

As our new NNIN director, Prof. Roger Howe noted, "*For many of the students, the NNIN REU is their first experience when the answer, or even the existence of an answer, is not yet known.*" We are always impressed by the youthful enthusiasm of our undergraduate researchers! They dive into the unknown with a vigor and dedication that is grand to see.

We hosted a successful second-year International Research Experience for Undergraduates (NNIN iREU) Program, which has proven popular not only with our interns, but also with our international partners! Sixteen of our 2010 interns signed on again and took part in research in Belgium, France, Germany, and the Netherlands.

As if these two programs were not enough, we also hosted four Japanese graduate students at our United States sites, where they experienced a rare and wonderful opportunity for international research.

We welcome corporate involvement! If you are interested in sponsoring one or more of our interns, please contact Dr. Lynn Rathbun, our NNIN REU Program Manager, at rathbun@cnf.cornell.edu.

The NNIN REU Program has become so popular that for the 2011 program, we received over one thousand "hits" to our online application, and 856 undergraduate students successfully completed their application by the deadline!

Find more NNIN REU Program information, and research reports from past programs at http://www.nnin.org/nnin_reu

The 2011 CNF REU Interns. Photograph by Christopher Julian.

Cornell NanoScale Facility
250 Duffield Hall
Ithaca NY 14853-2700

CNF NanoMeter V20, #2

information@cnf.cornell.edu
http://www.cnf.cornell.edu
1-607-255-2329

Your Comments Are Welcome!

Save The Date!

We will be celebrating our 35th anniversary in 2012.
Please plan to join us on Thursday, July 19th for
our annual meeting and special observation of this milestone!

As it becomes available, we'll add information on our
invited speakers, corporate sponsors, and schedule:
http://www.cnf.cornell.edu/cnf_35th2012am.html

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.

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The CNF NanoMeter on our web site in PDF, http://www.cnf.cornell.edu