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NanoMeter

Newsletter of the Cornell NanoScale Facility

Spring 2019
Volume 28
Issue 1

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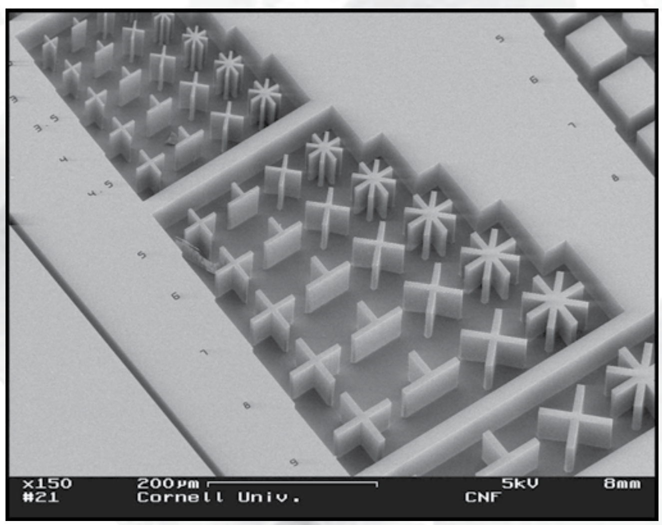
Photography Credits

Our cover ruler was fabricated by John Treichler, who said — "I made a couple hundred 5 mm rulers. The decimal point did not resolve on the thousandths but they are usable." The ruler makes for great cover art!

The background for this issue harkens back to our NNF years. Just one of the many device images in our archives.



The photographs in this book were primarily provided by the author(s), but also by University Photography or CNF Staff. The NanoMeter is formatted by Melanie-Claire Mallison, and is printed on 30% post-consumer content paper using soy-based inks.

Please reduce, reuse, and recycle!

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REGISTER NOW!

CNF TCN

Short Course

June 4, 2019 - June 7, 2019

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.

The CNF TCN is an ideal way for faculty, 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 and is not limited to CNF users or Cornell students. It is suitable for both new and experienced researchers interested in nanoscale science. An emphasis will be placed on CNF laboratory resources, however, the concepts and techniques discussed are generally applicable to research in this field and do not require use of CNF.

PLEASE NOTE #1: The short course augments but does not replace the three part training required to become a user of our facility, nor does it replace tool trainings. To become a CNF user, one must follow the instructions under the "Getting Started" link online (www.cnf.cornell.edu).

PLEASE NOTE #2: Thanks to funding from the National Science Foundation, this course is free for graduate students from U.S. institutions outside Cornell, up to five students per external university. (Travel and lodging are not included.) Students who wish to attend the course for free should contact Rebecca Vliet PRIOR to registering to ensure complimentary registration is available (vliet@cnf.cornell.edu).

COST

Academic Rate (including students and faculty) and Government Rate: $425. Industrial Rate: $850. As noted above, the course fee will be reimbursed for up to five research graduate students per university for grads from U.S. institutions outside Cornell University.

OVERVIEW of COURSE

- Tuesday, Day 1: Registration & Orientation (5:30p-7:30p)
- Wednesday, Day 2: Introduction & Microfluidic Systems (8:45a-4:00p)
- Thursday, Day 3: MEMS Cantilever Fabrication (8:45a-4:00p)
- Friday, Day 4: Nanoelectrode Fabrication (8:45a-4:00p)

REGISTRATION

http://cnf.cornell.edu/cnf_tcn_june_2019.html

5kV

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Director's Column

Chris has given me the honor of writing this, my last Director's Column, solo. I am therefore happy to introduce the latest edition of the NanoMeter.

As you will read, we continue to make progress on our strategic plan and have added a new initiative — quantum information — to our focus going forward. Large scale funding opportunities among agencies and industry make researchers in quantum prime customers for the National Nanotechnology Coordinated Infrastructure (NNCI) facilities like CNF.

In this spirit we have co-authored a proposal with our colleagues in NNCI for ACCELNET, which, if funded, will provide an opportunity to link international networks around quantum information. To advance our capabilities in biotech and advanced nanophotonics packaging, we submitted an MRI proposal for a two-photon sub-micron 3-D printer and are awaiting the results of that NSF competition.

We also have on order a Finetech flip chip bonder that will aid our users doing chip level packaging, chip stacking, and foundry CMOS post processing. These are all examples of our new focus in heterointegration.

As part of our reinvigorated effort in nanobiotechnology, we held a workshop on "Revisiting Nanobiotechnology at Cornell: Themes and Opportunities" on January 25, 2019, that was jointly sponsored by CNF and the Cornell Biotech Institute. This was well attended and has led to new connections among faculty in engineering and life sciences. We thank our colleagues for working together so closely on this event.

Finally, our initiative to garner capabilities for fabrication and characterization in 2D materials, will be enhanced by our just announced plan to acquire the first-ever Darius Nanoprobe station from Xallent, a Cornell startup company that spawned from work at CNF (see page 16).

So you can see we are thinking about and acting on our vision!

At this year's SPIE Conference in San Jose, I had the pleasure of presenting a paper titled, *The Evolution of the Cornell NanoScale Facility and Synergies with the Semiconductor Industry*. In researching the historical information for this paper I was able to draw from material that appeared in presentations from Ed Wolf, Bob Buhrman, and our wonderful Annual Meeting Keynote speaker and author, Cyrus Mody.

It was somehow fitting that, as my last invited talk as CNF Director of Operations, I finally came to appreciate the full and critical role that CNF has played in establishing leading edge fabrication facilities across the US and the climate that helped create the prototype for microstructure fabrication facilities — NRRFSS.

The shift of funding models from military to civilian sources in the 1960s created an opportunity for the National Science Foundation to become involved in standing up and operating such open facilities. In the decades that followed, this has both been a boon for faculty driven research and for commercialization efforts via numerous startup companies.

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Your CNF can now boast of nearly $2B in economic impact over its 44 year history! Much of that impact is due to the ability to continuously renew its instrumentation, acquire leading edge capabilities, and its model of retaining expert staff members whose experience help our users to achieve their goals.

On a personal note, let me say that my time (13 years!) at CNF has been an extremely rewarding and enriching experience. When I started at CNF in 2006, I smiled walking in to work every day for a month. It was very special to be able to come back to my alma mater after so many years and feel I had something to give back.

I am so grateful for the support that has been provided by our staff, alumni, faculty, user community, vendor community, Cornell administration, and corporate benefactors. Helping to lead CNF through this period has been an honor and a privilege. I encourage all of you to continue to stay in contact with the staff and leadership at CNF, to engage with them to create new opportunities (mark your calendar for the Annual Meeting, September 12, 2019), and to help make CNF even better.

As always, we love to hear from you and welcome your comments. But this time send your thoughts to Chris Ober!

All the Best,

Don

CNF Director of Operations, 2006-2019

See the Director of Operations job description posting on page 17.

Cornell, Air Force to Study 'Disruptive Material' in New Center

By Syl Kacapyr
Cornell Chronicle
March 19, 2019

The AFRL-Cornell Center for Epitaxial Solutions leadership team holds a plaque commemorating the opening of the center March 7 at Cornell. From left: associate professors Mike Thompson and Farhan Rana, and professors Debdeep Jena, David Muller, and Huili Grace Xing. Tom Hoebbel/Provided.

A new center established by Cornell and the Air Force Research Laboratory (AFRL) aims to discover the atomic secrets of beta-gallium oxide (β-Ga_2O_3), a promising new material that has piqued the interest of engineers for its potential to allow electronic devices to handle dramatically more power.

Sixteen members of the AFRL joined researchers at Cornell on March 7 during a daylong kickoff event for the AFRL-Cornell Center for Epitaxial Solutions (ACCESS). The center is made possible by a three-year, $3 million grant from AFRL with additional funds from Cornell and an option for a two-year extension.

"The way β-Ga_2O_3 atoms are arranged is really unique; it's the only semiconductor material that shows this structure," said Mike Thompson, associate professor of materials science and engineering and director of the center. "It's shown potential to be a key disruptive material for high-powered electronics."

Silicon has long been the go-to semiconductor material for electronic devices, but with the emergence of electric vehicles, renewable energy sources and 5G communications networks comes a need for a material that can handle higher voltages, higher power densities and higher frequencies. And if β-Ga_2O_3 proves to have the performance that is predicted, it will enable a wide range of new devices and applications.

"It's a new frontier in terms of just how hard you can drive a device and understanding where our current models break down for devices we use today," said Gregg Jessen, AFRL fellow and principal electronics engineer, adding that applications could include compact power supplies for new types of radar systems, communications technologies and sensors.

"Cornell has a long history of being experts in compound semiconductors and has expertise where we don't, so our skill sets complement each other," added Jessen.

Some of the earliest research on the value of β-Ga_2O_3 as a semiconductor has been conducted by Huili Grace Xing and Debdeep (DJ) Jena, both professors of materials science and engineering and of electrical and computer engineering. Recent samples of the material synthesized by their research group produced some unanticipated results, according to David Muller, professor of applied and engineering physics who analyzed the samples' atomic structures with his state-of-the-art microscope.

"Like people, what makes a material interesting is its defects, and we've already seen some exciting defect structures in the materials Grace and DJ have grown," said Muller, who is also a member of the center's technical team. Discoveries have included new

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materials and atomic structures when the β-Ga_2O_3 is mixed with other elements such as tin or aluminum.

The research will continue under the center, where engineers will focus on developing growth and processing methodologies for high-quality β-Ga_2O_3, as well as developing a fundamental understanding of the material's properties.

Rounding out the technical team is Darrell Schlom, professor of materials science and engineering, who will focus on synthesis of the material, and Farhan Rana, professor of electrical and computer engineering, who will focus on understanding atomic defects through optical probes.

The center also includes an exchange program between Cornell and the AFRL in Dayton, Ohio. AFRL researchers visiting Cornell will be able to access facilities associated with the center, including the Cornell NanoScale Science and Technology Facility; the Cornell Center for Materials Research; the Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials; and the Cornell High Energy Synchrotron Source.

Meanwhile, Cornell students involved in the center will spend a year in Dayton, where they will have the opportunity to apply their education to new research challenges at the AFRL.

"The value of these types of centers is immeasurable to the College of Engineering for a number of reasons," said David Erickson, associate dean for research and graduate studies. "They allow us to develop deep partnerships to give our students real-world experience, to marshal our resources to meet national needs, and allow us to dedicate our science to solve important problems."

Engineers Create 'Lifelike' Material with Artificial Metabolism

By Matt Hayes
Cornell Chronicle
April 10, 2019

As a genetic material, deoxyribonucleic acid (DNA) is responsible for all known life, but DNA is also a polymer. Tapping into the unique nature of the molecule, Cornell engineers have created simple machines constructed of biomaterials with properties of living things. Using what they call DASH (DNA-based assembly and synthesis of hierarchical) materials, Cornell engineers constructed a DNA material with capabilities of metabolism, in addition to self-assembly and organization — three key traits of life.

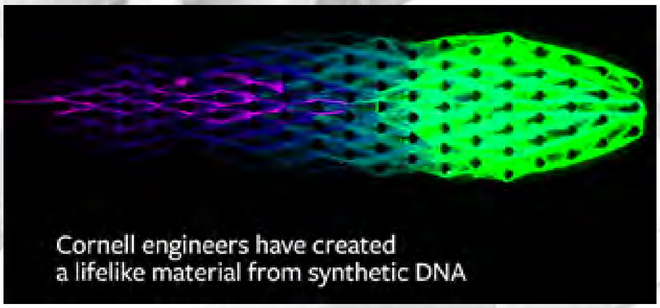

Figure 1: Cornell professor of biological and environmental engineering Dan Luo and research associate Shogo Hamada have created a DNA material capable of metabolism, in addition to self-assembly and organization. John Munson/Cornell University.

"We are introducing a brand-new, lifelike material concept powered by its very own artificial metabolism. We are not making something that's alive, but we are creating materials that are much more lifelike than have ever been seen before," said Dan Luo, professor of biological and environmental engineering in the College of Agriculture and Life Sciences. The paper, "Dynamic DNA Material with Emergent Locomotion Behavior Powered by Artificial Metabolism," was published April 10 in Science Robotics.

For any living organism to maintain itself, there must be a system to manage change. New cells must be generated; old cells and waste must be swept away. Biosynthesis and biodegradation are key elements of self-sustainability and require metabolism to maintain its form and functions.

Through this system, DNA molecules are synthesized and assembled into patterns in a hierarchical way, resulting in something that can perpetuate a dynamic, autonomous process of growth and decay.

Using DASH, the Cornell engineers created a biomaterial that can autonomously emerge from its nanoscale building blocks and arrange itself — first into polymers and eventually mesoscale shapes.

Starting from a 55-nucleotide base seed sequence, the DNA molecules were multiplied hundreds of thousands times, creating chains of repeating DNA a few millimeters in size. The reaction solution was then injected in a microfluidic device that provided a liquid flow of energy and the necessary building blocks for biosynthesis. As the flow washed over the material, the DNA synthesized its own new strands, with the front end of the material growing and the tail end degrading in optimized balance. In this way, it made its own locomotion, creeping forward, against the flow, in a way similar to how slime molds move.

The locomotive ability allowed the researchers to pit sets of the material against one another in competitive races. Due to randomness in the environment, one body would eventually gain an advantage over the other, allowing one to cross a finish line first.

"The designs are still primitive, but they showed a new route to create dynamic machines from biomolecules. We are at a first step of building lifelike robots by artificial metabolism," said Shogo Hamada, lecturer and research associate in the Luo lab, and lead and co-corresponding author of the paper. "Even from a simple design, we were able to create sophisticated behaviors like racing. Artificial metabolism could open a new frontier in robotics."

The engineers are currently exploring ways to have the material recognize stimuli and autonomously be able to seek it out in the case of light or food, or avoid it if it's harmful. The programmed metabolism embedded into DNA materials is the key innovation. The DNA contains the set of instructions for metabolism and autonomous regeneration. After that, it's on its own.

"Everything from its ability to move and compete, all those processes are self-contained. There's no external interference," Luo said. "Life began billions of years ago from perhaps just a few of these kinds of molecules. This might be the same effect."

The material the team created can last for two cycles of synthesis and degradation before it expires. Longevity can likely be extended, according to the researchers, opening the possibility for more "generations" of the material as it self-replicates. "Ultimately, the system may lead to lifelike self-reproducing machines," Hamada said. "More excitingly, the use of DNA gives the whole system a self-evolutionary possibility," Luo added. "That is huge."

Theoretically, it could be designed so that subsequent generations emerge within seconds. Reproduction at this hyper pace would take advantage of DNA's natural mutational properties and speed the evolutionary process, according to Luo.

In the future, the system could be used as a biosensor to detect the presence of any DNA and RNA. The concept also could be used to create a dynamic template for making proteins without living cells.

The work was funded in part by the NSF and supported by the Kavli Institute at Cornell for Nanoscale Science. Work was performed in part at the Cornell NanoScale Facility. Collaborators include Jenny Sabin, the Arthur L. and Isabel B. Wiesenberger Professor in Architecture, and researchers form Shanghai Jiaotong University and the Chinese Academy of Sciences. There is a patent pending with the Center for Technology Licensing.

Nanobots That Can Do Just about Anything

Paul L. McEuen, Physics, College of Arts and Sciences, Cornell University

"Imagine something as small as a piece of dust, but it has … solar panels on it to power it … computation on board to carry out a task … do some sensing."

Paul McEuen, Physics, finds the miniscule endlessly fascinating. The tagline for his lab sums up the essence of his interest in the nanoworld: "Anything, as long as it's small." There are no barriers to McEuen's curiosity, and everything is fair game — just as long as it's no bigger than the size of a single cell and preferably far smaller.

These days, he's turned his attention to nanomachines.

"Back in the 1950s Richard Feynman, a famous physicist, gave an important speech to other scientists where he said, 'Why don't you make things really small? Why don't you make tiny electronics, miniature machines?'" McEuen says. "People went on to make electronics tiny, but nobody really did much with nanomachines. My group, though, has been really interested in them for a while. Recently, we took that interest to the next level and tried to actually build the tiny machines that Feynman envisioned."

In creating their nanomachines, McEuen and his collaborators built on their earlier work with graphene (a resilient material only one or two atoms thick with interesting optical and electrical properties) and carbon nanotubes (graphene rolled into a tiny cylinder with a width of about 10 atoms across). The researchers manipulated graphene in a number of ways, studying its physical properties as they did so.

"We were the first to make a vibrating one-atom-thick graphene sheet that was, in essence, a drum," McEuen says. "We also made the world's first nanotube guitar. We used a nanotube as a guitar string and plucked it to make it vibrate."

Since the nanotube guitar string vibrates at megahertz frequencies — much higher than the human ear can hear — the researchers had to figure out how to measure it. They reported their results in a paper forthcoming in the journal Nature. "We not only heard it," McEuen says with satisfaction, "but we played the Cornell alma mater on it."

"We had things that know how to bend. We had electronic devices that can carry out tasks. We could shoot light at little voltaic cells to drive the legs. So we combined them."

For McEuen, playing a tune on a guitar string the width of a strand of DNA is par for the course. He made his reputation manipulating graphene sheets, carbon nanotubes, and other materials, creating some of the smallest electronic or mechanical systems ever invented.

"We had a couple of aims," he says. "On the technological side, we wanted to help the electronics industry make transistors smaller. That was an attempt to fulfill Moore's Law, which says electronics will shrink every year. In the meantime, on the physics side, scientists had never studied the behavior of electrons inside tiny materials like these. So we spent a lot of time doing fundamental physics of how electrons behave in one dimension, in the case of the nanotube, and in two dimensions, in the case of the graphene sheet."

Now, the mechanical side of tiny has taken center stage. "On the electronics side, nothing nanoscientists have come up with has displaced silicon transistors," McEuen says. "They're still the best at what they do. But with these nanomachines, there isn't any other competition. We're doing things that have never been done before." The researchers use the existing technology of the semiconductor world for their tiny robots. "Little semiconductor devices know how to communicate, how to compute, how to sense certain kinds of things," McEuen explains. "So we can just hijack that and use it for our machine. Imagine something as small as a piece of dust, but it has a set of solar panels on it to power it; it's got computation on board to carry out a task, maybe do some sensing; and it's got a light-emitting diode to blink out information to you."

The resulting proto machines — everything from voltage and microfluidic sensors to thermometers — are approximately the width of a human hair. McEuen even has a photo of one, resting on the chest of the infinitesimal Abraham Lincoln that sits within one of the windows of the Lincoln Memorial etched on the back of a penny. The nanobots are so small, they could be injected with a needle, which may open up all kinds of medical uses in the future.

"You can put these anywhere," McEuen says. "One day, one of these little machines might be used to record the voltage when a neuron fires in the brain. So instead of putting a wire in your skull, like they do now, they could implant this and leave it. And it turns out when something is as small as these nanomachines, your body doesn't realize they're there. It doesn't make scar tissue."

The researchers fabricated the first nanomachines at the Cornell NanoScale Science and Technology Facility, but McEuen envisions a future where the same commercial foundries that make computer chips will also make tiny machines. As a result, the machines will be cheap, perhaps less than a penny to make, even as their computing capacity becomes extremely sophisticated. "One of the reasons to make it so small is because it's so cheap," he says. "There's a lot of up-front costs to developing the technology, but once we have it figure out, they'll be ubiquitous, even disposable."

Applying Origami Techniques to Nanomachines — For Movement

Once the researchers had created some working nanomachines, they moved on to the next step — making them mobile. To do that, they turned to techniques used in origami, which they had pioneered in graphene. By punching offset cuts in the two-dimensional graphene, they were able to fold and bend it, creating three-dimensional springs, pyramids, and spirals. They took graphene and other flexible materials and bonded them with a second, more rigid, material into a bimorph. By making the more rigid material contract, McEuen and his collaborators made the flexible material bend and twitch. "We're building a tool box for our little robots," he explains. "We are learning how to make things fold."

Eventually the scientists settled on using voltage to make the bimorph bend. "Now the job was to put these things together," McEuen says. "We had things that know how to bend. We had electronic devices that can carry out tasks. We could shoot light at little voltaic cells to drive the legs. So we combined them." In one of McEuen's videos, multiple nanobots twitch and move in pond water, while a single-celled paramecium — gigantic in comparison — swims past. "There goes a paramecium!" McEuen points out with relish.

Radical Collaboration

In his quest to make these cell-sized smart phones, McEuen has joined with a variety of collaborators at Cornell, including Alyosha C. Molnar, electrical and computer engineering, Chris Xu, applied and engineering physics, and Itai Cohen, physics.

"I think almost every grant I have is a collaborative grant," McEuen says. "My group and I enjoy finding someone who's really good at doing something and working with them rather than trying to figure out everything ourselves. That's one of the reasons I came to Cornell. I knew it had a very collaborative environment."

"We had things that know how to bend. We had electronic devices that can carry out tasks. We could shoot light at little voltaic cells to drive the legs. So we combined them."

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Nanoscale Guitar String 'Executes a Complex Dance'

A nano-sized guitar string vibrates and crackles in an unexpectedly organized and intricate way, according to researchers who devised a way to listen to a nanoscale guitar for the first time — and then played the Cornell alma mater on it.

By Melanie Lefkowitz
Cornell Chronicle
February 4, 2019

Cornell researchers created the first nanoguitar (Figure 1) more than 20 years ago, but until now researchers could only assess its motion retroactively, using a method that averaged its vibrations over time. In a new study, Paul McEuen, the John A. Newman Professor of Physical Science, and his colleagues developed a set of microtweezers capable of lifting the string, called a nanotube, and holding it near a device that can measure it. Their findings are described in "Real-Time Vibrations of a Carbon Nanotube" published in Nature, January 21.

"We created a better technique for measuring, and it revealed a new world of complex and interesting behavior," said McEuen, who is also director of the Kavli Institute at Cornell for Nanoscale Science. "It was one thing to do an average measurement and listen over long periods of time, but it was another thing to listen to it instantaneously and hear every small change in its vibration."

McEuen collaborated on the work with Michal Lipson, formerly a professor of electrical engineering at Cornell and now at Columbia. First authors are Arthur W. Barnard, Ph.D. '15, now at Stanford, and Mian Zhang, Ph.D. '15, now at Harvard. Former Cornell postdoctoral associate Gustavo Wiederhecker, now of Universidade Estadual de Campinas in Brazil, also contributed to the study, which advances the understanding of how materials behave at the scale of a nanometer — one billionth of a meter.

"What happens when you make a guitar so small that it's basically being battered around by intrinsic noisiness of the microscale world?" McEuen said. "It's a fundamental curiosity question — how do these work? As we continue to make little mechanical systems that are smaller and smaller, how are they different from their macroscale counterparts?"

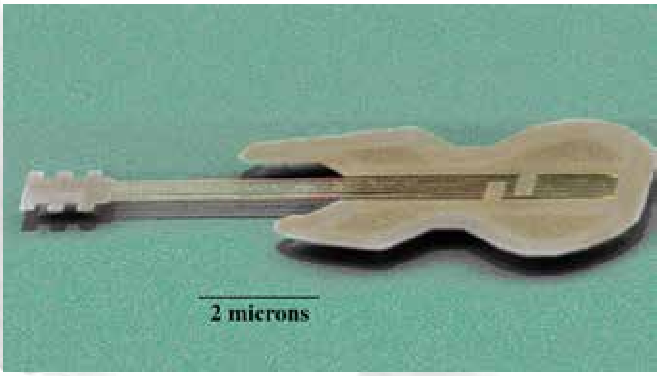


Figure 1: In 1997, this was the smallest guitar in the world, about the size of a human blood cell, created to illustrate new technology for nano-sized electromechanical devices. The "nanoguitar" — made for fun by Dustin Carr and Harold Craighead — was just one of several structures that Cornell researchers believed were the world's smallest silicon mechanical devices made at the CNF. http://news.cornell.edu/stories/1997/07/worlds-smallest-silicon-mechanical-devices-are-made-cornell

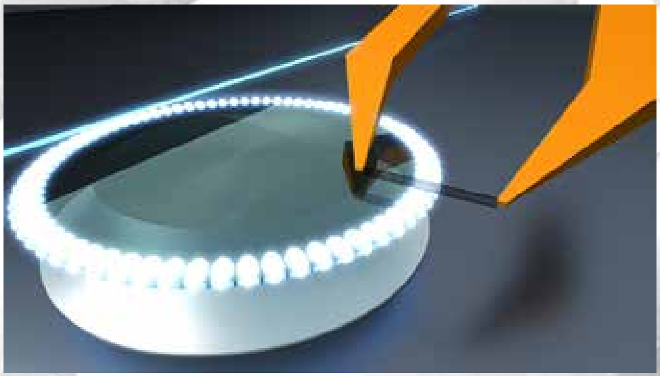


Figure 2: A schematic showing a carbon nanotube positioned with a pair of microtweezers. Provided by McEuen Group.

The nanotube is so small — the width of a strand of DNA — that it doesn't absorb enough light to be measured with most methods. An optical resonator developed by Lipson's lab can shoot light past a nano-sized object thousands of times, causing the object to absorb enough light to measure it. Until now, however, no way had been developed to use the optical resonator with the nanotube.

To solve this, McEuen and colleagues designed a set of electrically connected gold microtweezers that can pick up the nanotube and carry it to the optical resonator.

"There's a glow around the edge of the resonator, and when we put the nanotube on the edge of that glow, it starts to absorb some of that light," he said. "When the nanotube moves closer or farther away from the resonator because it is wiggling and vibrating, it will change the amount of light that's being absorbed and, hence, detected."

The vibration of the nanotube is far too high-pitched to be audible, but the researchers could hear its sound by slowing it down 500 to 1,000 times. Using the old, retroactive method, researchers found that the nanotube's tone was impure and jumbled — "like a tone that's being played through a noisy radio," McEuen said. Now that they could listen in real time, they learned that the crackling sounds were far more organized than they'd believed, consisting of vibrations transferring to other vibrations before returning to their original form.

"We thought that they were just very noisy, but what we found is that they're really executing a complex dance," he said. "There's a lot of order going on in what people had previously thought of a disorderly system."

In related unpublished work, the group also played the Cornell alma mater on the nanotube guitar by using the tweezers to stretch the nanotube to change its frequency of vibration, stretching and relaxing it to get each note right.

The work was supported by NSF and CCMR, and was performed in part at the Cornell NanoScale Facility.

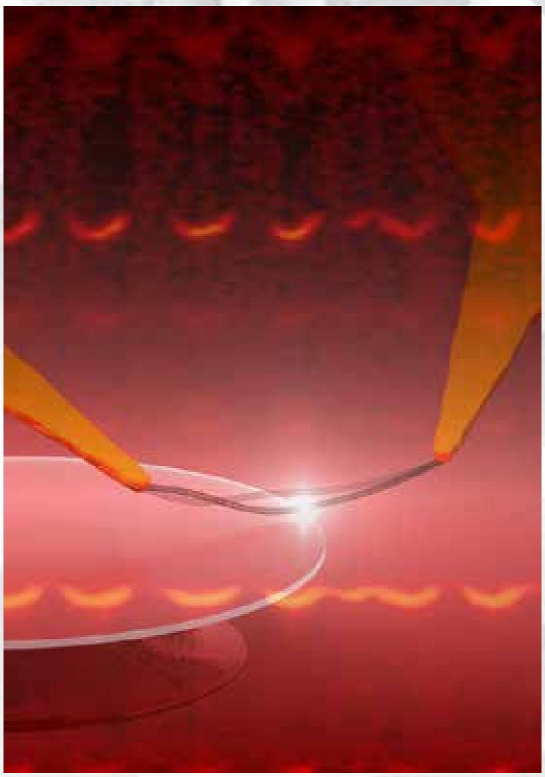


Figure 3: Using microtweezers, researchers were able to measure the nanotube's vibrations in real time. Provided by McEuen Group.

http://cornelluniversity.tumblr.com/post/182581594312/a-nanosized-guitar-string-vibrates-and-crackles

Polka Dot Pattern Upends Superfluid Hypothesis

By Matt Hayes
Cornell Chronicle
April 18, 2019

Exotic behaviors emerge in atoms when cooled to near absolute zero, a temperature so cold that atoms cease their jittery movement. By bringing the isotope helium-3 to the brink of that threshold and confining it to a tiny space, Cornell researchers discovered that a surprising polka dot pattern spontaneously appeared in the superfluid.

"We found clear evidence of a pattern emerging, essentially out of the blue. Systems are not supposed to do that," said Jeevak Parpia, M.S. '77, Ph.D. '79, professor of physics who specializes in low-temperature physics.

The work was described in the paper "Evidence for a Spatially Modulated Superfluid Phase of ^{3}He Under Confinement," published in February in Physical Review Letters. Parpia collaborated with researchers at Royal Holloway, University of London, (led by physics professor John Saunders and researcher Lev Levitin) where the experiments were conducted using special confinement chambers constructed at Cornell.

Superfluids are exotic quantum systems that behave in a unified manner, without resistance or viscosity. When cooled to a few degrees above absolute zero, liquid helium-3 (^{3}He, an isotope composed of two protons and a single neutron) surrenders its random motion in favor of coordinated movement. The material can be described as a single wave function with specific properties to it.

The superfluid state of liquid helium has been a hot topic of research since its discovery in the early 1970s at Cornell. The work earned Cornell physicists David Lee, Robert C. Richardson and Douglas Osheroff, M.S. '71, Ph.D. '73, the 1996 Nobel Prize and ignited decades of research to better understand quantum physics.

Two phases of superfluid ^{3}He (A phase, B phase) are known to exist. In the early 2000s at Northwestern University, theoretical physicists James Sauls and Anton Vorontsov proposed that the B phase would arrange in a striped pattern of plus and minus orientations in equal ratio when confined to a nearly two-dimensional space.

Testing the hypothesis was stymied due to the difficulty of engineering a confinement device barely a micron — one millionth of a meter — in height. The Cornell researchers designed and built special magnetic resonance chambers at the Cornell NanoScale Science and Technology Facility (CNF), with dimensions of 1 cm in length and width, and 1.1 µm in height, creating a nearly flat cavity to conduct their experiments.

By confining the superfluid, physicists found that the superfluid state diverged into positive and negative domains, with the positive domain appearing at four times the concentration of the negative. The findings ruled out the striped pattern, suggesting instead an either regular or disordered array of island domains — in other words, polka dots.

The appearance of a spontaneous pattern is evidence of a broken symmetry, an unusual occurrence. "Usually such patterns impose a significant cost in energy, but the polka dot appears to lower its energy cost enough to compensate," Parpia said. He said the findings could one day help inform principles used for quantum computing.

"To create a chamber with uniform height extending that large of a distance is remarkable. It's hard to come up with schemes maintaining that profile," he said.

The chamber was designed by Robert Bennett while working as a postdoctoral research associate and created by Nikolay Zhelev, M.S. '13, Ph.D. '16.

"Superfluids are remarkable materials, and we continue to be surprised by their richness and unexpected behavior when we confine them in smaller and smaller systems," Parpia said. "Discoveries of these exotic forms of matter in a system that we can control with great precision give us knowledge that can be applied to more practical electronic systems."

The research was performed in part at the CNF, and supported by grants from the Engineering and Physical Sciences Research Council in the U.K., the NSF and the European Microkelvin Platform.

PRAXIS CENTER

for Venture Development

Emmanuel P. Giannelis, vice provost for research and vice president for technology transfer, intellectual property and research policy, left, and Robert Scharf '77, director of the PRAXIS Center and an entrepreneur-in-residence at Cornell Engineering, cut the ribbon for the PRAXIS Center for Venture Development. Lindsay France/Cornell Brand Communications

New Cornell Center to Give Engineering Startups a Boost

By Matt Hayes
Cornell Chronicle
March 25, 2019

The word "praxis" is drawn from the Greek language; it implies action, or getting things done. It's a concept informing and animating a new center aimed at fostering New York State startup companies in engineering, digital technology and physical sciences.

The PRAXIS Center for Venture Development hosted a grand opening and ribbon-cutting ceremony on March 21 in Duffield Hall. The center will help clients accelerate research and development of their technologies and products. One of the primary goals will be facilitation of clients' progress toward securing significant outside investment and achieving self-sufficiency, all while supporting business development in New York State.

"There's an amazing ecosystem of knowledge, instrumentation and experience in so many disciplines at Cornell," said Robert Scharf '77, director of the PRAXIS Center and an entrepreneur-in-residence at Cornell Engineering. "Somewhere within walking distances on campus there is an expert in your topic of interest. This is a tremendous asset that we can harness to benefit entrepreneurs in New York."

The PRAXIS Center, housed in Duffield Hall and funded by Cornell's Research Division, takes as a model Cornell's Kevin McGovern Family Center for Venture Development in the Life Sciences in Weill Hall. The McGovern Center incubator, which opened in 2011, has helped scores of budding entrepreneurs take their ideas from the back of a napkin to the marketplace.

"There is a strong entrepreneurial spirit at Cornell, especially among our students and young faculty. Resources like PRAXIS and the McGovern Center encourage and support a startup mentality with enormous potential for growth," said Emmanuel P. Giannelis, vice provost for research and vice president for technology transfer, intellectual property and research policy. "At Cornell, we are committed to fostering entrepreneurship by translating knowledge into real world applications."

In achieving its goal of supporting Cornell startups, the PRAXIS Center contributes to the university's land-grant mission by supporting local, regional and state economic development and job creation in science, technology, engineering and math (STEM) fields. Giannelis said the center will entice more venture capital to the region so that entrepreneurs won't have to go to larger cities in order to grow.

Prospective clients are already working on a range of projects, from crypto-currency and next-generation robotics to ultrasonic sensors with applications in the emerging field of digital agriculture.

That entrepreneurial mentality is aided by the center's close proximity to three major National Science Foundation-supported research and development laboratories — the Cornell NanoScale Science and Technology Facility (CNF), Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials (PARADIM), and portions of the Cornell Center for Materials Research (CCMR).

200 µm

This puts the PRAXIS Center in a unique position, according to Amit Lal, the Robert M. Scharf '77 Professor of Electrical and Computer Engineering and a prospective PRAXIS client.

"It's kind of amazing," Lal said. "I don't think there's another place where you have a cleanroom like CNF and a business incubator so close to it. It's quite a unique thing."

The incubator model creates the potential for synergies among diverse companies, according to Giannelis. Prospective clients are being considered for a range of ideas that might foster collaboration. Plus there is access to people like Scharf — a retired executive with 12 patents, whose 2003 startup, Protokraft, was acquired by Moog Inc. in 2012 for $17.5 million.

"The PRAXIS Center is not just a space; it's not just the infrastructure," Giannelis said. "There's also the human element, with mentorship from experienced entrepreneurs that form an integral part to helping young businesses become successful."

https://pcvd.cornell.edu/

Fine-Tuning Photons to Capture Fleeting Electron Motions

By Melanie Lefkowitz
Cornell Chronicle
April 1, 2019

Cornell researchers have discovered a way to accelerate photons using four orders of magnitude less energy than existing methods, paving the way for ultraviolet lasers that can capture processes lasting a quintillionth of a second.

Photon acceleration boosts the energy of a photon, allowing physicists to fine-tune the color of laser beams, making them useful for various functions. Traditionally, photon acceleration has required extreme-intensity laser pulses and gas plasmas.

A team led by Gennady Shvets, professor of applied and engineering physics, used an ultrathin nanostructure known as a metasurface to accelerate photons to the same output level achieved using gas plasmas, but using a fraction of the energy.

"People would use ultrahigh power lasers to strip off electrons from gas molecules to accelerate photons," Shvets said, "but this process is too violent to be practical."

"We've built an analog of what's happening at these big lasers, but at a tabletop setting," said Maxim Shcherbakov, a postdoctoral associate in Shvets' lab and first author of "Photon Acceleration and Tunable Broadband Harmonics Generation in Nonlinear Time-Dependent Metasurfaces," which published March 22 in Nature Communications. "We can apply less power to the system and the photons get accelerated at the same level."

Now, the researchers hope to build on this finding to generate some of the world's shortest laser pulses, which would produce bursts of light as short as a few attoseconds — one quintillionth of a second. "These will help to study basic condensed matter phenomena in many different settings and materials; there are numerous applications of such ultra-short pulses," Shcherbakov said.

For example, a super-short burst of light could create snapshots of the movement of an electron inside an atom, or in the process of hopping from one atom to another in a crystal lattice. "Currently people generate attosecond pulses by using large gas chambers and very powerful lasers. We want to change those by a process with a very small footprint, and requiring very low laser energy," he said.

Photons — particles representing a quantum of light — generally have a certain color, corresponding to the amount of energy they contain. Photons are important tools in transferring information, such as over the internet, but their colors — and energy levels — are very difficult to change.

One way to change photons' energy is through harmonics, in which several photons can combine to form a single photon with a higher energy. Previously, researchers were only able to combine discrete photons, but Shvets and colleagues discovered that metasurfaces make it possible to combine three photons to create one with 3.1 times the energy.

"This makes the process much easier and more tunable, so you can actually fine-tune the final color of your laser beam with this process," Shcherbakov said.

Combining the acceleration of photons using metasurfaces and the ability to boost their energy using harmonics offers numerous practical applications, and opens up new research directions. "Lasers at the visible and the near-infrared range are abundant," Shcherbakov said, "but there are certain ranges where you would love to have affordable lasers, but the technology just isn't there."

One example is lasers in the extreme ultraviolet range, which can't be easily produced with existing technology but which would have important uses in physics, materials science, chemistry and biology. The researchers' findings could make this possible.

"This is where combining photons and accelerating them will become useful," Shcherbakov said. "And most importantly, these lasers will be producing very short bursts of energy, which is either very expensive or unavailable. This could enable more discoveries, relating to anything that moves or any process that takes place in these very short amounts of time."

The paper is co-authored by postdoctoral researcher Zhiyuan Fan and Ohio State University researchers.

The work was supported by the Office of Naval Research, the Air Force Office of Scientific Research, and the Cornell Center for Materials Research, with funding from the National Science Foundation. Part of the study was carried out at the Cornell NanoScale Science and Technology Facility, which is also supported by the NSF.

Xallent LLC Thrilled to Announce First Sale of DARIUS and SAKYIWA Nanoprobers

[Ithaca, April 9, 2019] — Xallent LLC, manufacturer of solutions and equipment for testing semiconductors and thin film materials at the nanoscale, announced today the sale of the DARIUS and SAKYIWA Nanoprobers to the Cornell NanoScale Facility (CNF).

"This is a great landmark for our company! After several months of validation and functional demonstrations, CNF has teamed with the Kavli Institute at Cornell (KIC) to purchase our nanoprobers to allow its user base to more rapidly and economically test semiconductors and thin-film materials in ambient air and vacuum. "We believe our products will advance the research and development of knowledge driven devices and materials with significant impact in health care, defense and energy," said Dr. Kwame Amponsah, CEO and Founder, Xallent LLC.

"The ability to electrically characterize materials and devices within very confined areas on a routine basis will open up new possibilities for exploration for our user community. It has been great to see this startup company innovate and build their business within CNF and now we have the advantage of being the first to be able to make this capability available to the R&D community," said Donald Tennant, CNF Director of Operations.

The DARIUS (SEM or ambient-air-based) and SAKYIWA (ambient-air-based) Nanoprobers enable among other things sheet resistance measurements in thin films and semiconductor production applications in ambient or vacuum, for samples with minimum sizes of 200 nm by 4 µm. With its low profile, fast setup and minimized sample preparation requirement,

200 µm

Kwame Amponsah '06, M.Eng. '08, M.S. '12, Ph.D. '13, foreground, and Tom Schryver '93, MBA '02, executive director of the Center for Regional Economic Advancement, participate in a panel discussion during Entrepreneurship at Cornell's Celebration conference April 17 — https://news.cornell.edu/stories/2015/04/university-resources-are-boon-alums-ithaca-business

the nanoprobers offer simple, fast and reliable characterization in many thin film and semiconductor test applications. The nanoprobers are programmable and semi-automatic, providing unprecedented high-speed testing with reliable and repeatable measurement results.

The nanoprobers leverage Xallent's proprietary nanomachine probes that are designed and fabricated using advanced nano-electro-mechanical-systems (NEMS) technologies, enabling continuously improved scaling to meet future needs of nanoscale technology nodes. Oxidation resistant metals used for the probe tips eliminate the need for *in situ* tip cleaning and spring loaded probe tips support probing of 3D structures.

About Xallent LLC

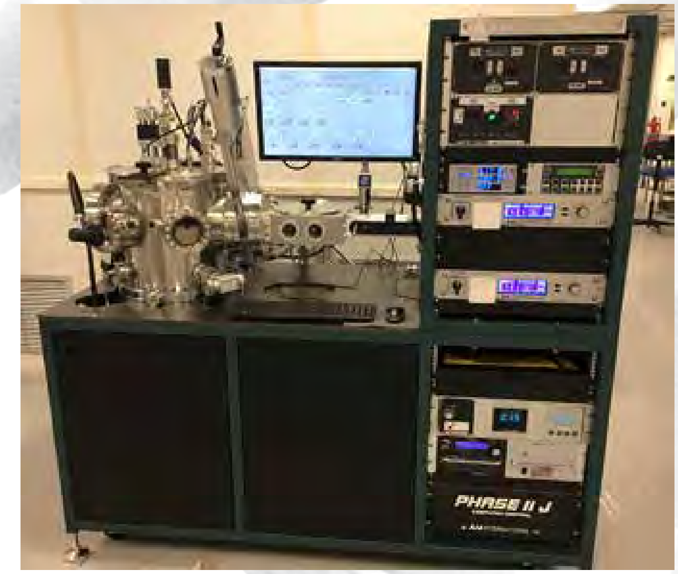
Xallent LLC designs, develops, manufactures, and markets advanced nanoprobing solutions for imaging, electrical measurement, and testing of thin film materials and semiconductor devices. Our unique nanoprobers and nanomachine probes are used in scanning electron and optical microscopes to more rapidly and economically test semiconductor devices and thin film materials during manufacturing. We understand our customer's needs, offering fast, simple and affordable solutions to meet specific applications. Our research was funded by NSF, DARPA, NYSERDA, Empire State Development and FuzeHub. Find out more at www.xallent.com

CNF Director of Operations Position Open

Cornell is seeking candidates for the position of Director of Operations for the Cornell NanoScale Science and Technology Facility (CNF). CNF is a pre-eminent national user facility that supports a broad range of nanoscale science and technology projects by providing state-of-the-art resources coupled with expert staff support. Research at CNF encompasses the physical sciences, engineering, and life sciences with a strong inter-disciplinary emphasis. Serving the science and engineering community since 1977, CNF has over 500 users per year many external to Cornell who use the fabrication, synthesis, computation, characterization, and integration resources of CNF to build structures, devices, and systems from nanometer to micrometer length-scales. With a multi-million dollar operation, CNF is part of the NNCI, the NSF-funded nanofabrication network.

Reporting to the Director of CNF, the Director of Operations is the chief operating officer of CNF whose responsibilities include oversight of facility management and operations, user research programs, facility financials, external and internal relations, industrial relations, and program development, including outreach, education, and sponsored research funding, that are necessary for successful fulfillment of the mission of CNF and the NNCI. Working with CNF's Director and its Executive Board, the Director of Operations plays a key role in strategic planning, development of and implementation of new and innovative programs, as well as the acquisition of facility tools and capabilities to meet current and emerging research needs with a goal to grow the CNF user base.

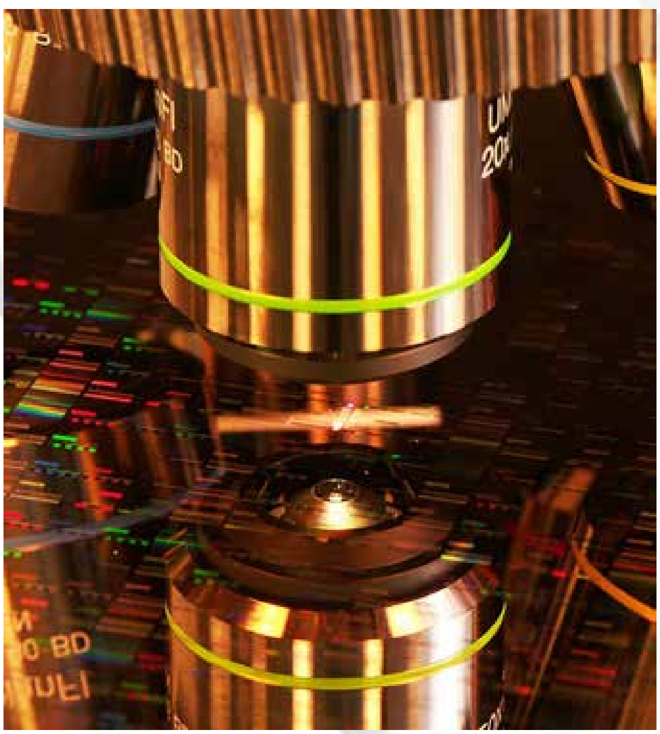
The job description and instructions for applying can be found here: https://cornell.wd1.myworkdayjobs.com/CornellCareerPage/job/Ithaca-Main-Campus/CNF-Director-of-Operations_WDR-00013731-2?shared_id=e93a311e-57b3-4f35-8244-46d4ea33c895



AJA Orion Sputter System

Recently the CNF decommissioned the CVC sputter deposition system and purchased a new AJA Orion sputter system. The new AJA is now installed and is open to users. The new system adds the capability of depositing magnetic materials and also has two switching DC power supplies to enable co-sputtering of materials.

For more information and training on the tool, please contact Thomas Pennell, pennell@cnf.cornell.edu.



Introducing JETStream

GDS2 is the standard CAD format for micro/nano lithography. JETStream is a software tool that can generate GDS2 with a program. It is a Java library that can be used with a java program or a python script. This allows for its users to automate the creation or modification of GDS2 files. Information about using JETStream can be found on the CNF website at: https://confluence.cornell.edu/display/CNF/Software+Tools and find the "Java GDS Library" link. The linked page describes using JETStream at the CNF and has links to documentation.

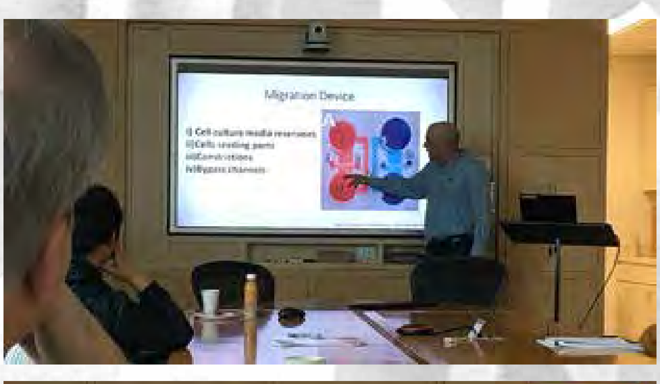
Here is a sample java program that will generate a GDS2 file called Hello.gds. The file will contain a cell called "top" that has polygons on layer 2 that look like the text "Hello World" and are 200 µm tall.

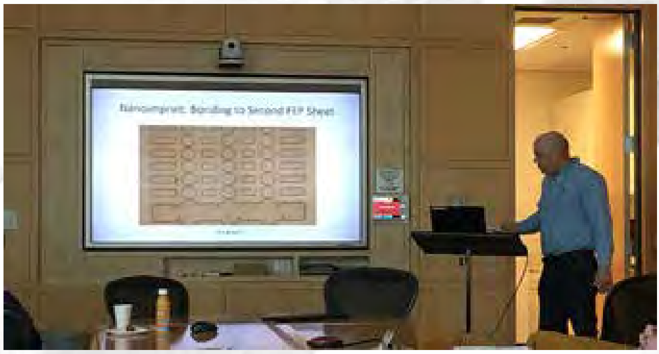
```
import JetStream.Poly;
import JetStream.Lib;
import JetStream.Cell;

public class GettingStarted {

 public static void main(String[] args) {
 Lib lib = new Lib();
   Cell top = new Cell("top",Poly.text("Hello World",2,200));
 lib.add(top);
 System.out.println(" Saved to " + lib.GDSOut("Hello"));
 }
}
```

JETSteam can also be used to modify or reuse parts of GDS2 files created elsewhere. The following line gets a cell named "PM" from the file "PM.gds" and creates a new cell, named "NewPM", with the flattened area on layer 1 of the cell PM.

```
Cell pm = new Cell("NewPM", Lib.GDSIn("PM.gds").getCellNamed("PM").toPoly(1));
```

Contact John Treichler, treichler@cnf.cornell.edu, with questions.





CNF Staff Member, Aaron Windsor, successfully defended his Master of Science thesis in April 2019. His work on "Advancements in Design and Application of Microfluidic Devices to Study Cell Migration in Confined Environments" was through the Meinig School of Biomedical Engineering and in collaboration with Profs. Jan Lammerding and Mingming Wu.

Congratulations, Aaron!

Students from Ithaca High School's Code Red Team Showcase Their Skills

By Edwin J. Viera
Ithaca Times
February 15, 2019

The Code Red Robotics team at Ithaca High School (IHS) held an open house to showcase some of their work from past years. Along with having a small arena set up so people could see three of the previous robots they've built, there were other tech-centric activities scattered throughout the cafeteria, as well as in the rest of the building's E-wing.

Some members of the IHS team showed the attendees how the robots worked as well as the different methods of coding used in building them. While many of the robots seemed to be designed and built with the skill of a seasoned engineer, the process only took a matter of six weeks.

Emily Klayben (pictured below), the build team manager, spoke about the rigorous process that goes into getting one of the robots ready for the For Inspiration and Recognition of Science and Technology (FIRST) Robotics Competition. The team is currently in the middle of their build season, with about three weeks left to build the robot. This year's theme is "First Deep Space."

"[For] Our robot this year, we have a climbing, lift and apposition team. Each team works independently of each other and they start to design their systems and then we have meetings where we make sure each one is going together. But around week five, we start

to pull together our robot. We use every single minute of the six weeks working on this because it takes so long to design and get together. Students do everything. We have them designing, running machines, and putting everything together."

Down the corridor from the cafeteria, many of the team members were busy crafting parts for this year's robot. Sarah Xin, an IHS student member of the team, spoke about some of the things that go on in their workspace. Xin said the space is the genesis of many robots as well as the many parts that go into them. Some of the parts are built from metal, while other parts are created using 3D printers.

Other crafts going on throughout the day came courtesy of the Sciencenter making paper helicopters with kids, a sand pendulum, and shaving cream art. Two students from Cornell, Liz Sherman and Christopher Zmodi, gave people a chance to test the strength of paper tubes to see how many textbooks could be held up. The record for the day was 16 textbooks, help up by two sheets of paper or eight paper tubes.

Another highlight of the day was the DeWitt Middle School Technological Students Association (TSA) helping folks build small towers of popsicle sticks and other materials to the test their durability under the effects of an earthquake. Using a machine that simulates earthquakes, TSA member Elijah Burger put the towers through the ringer.

Finally, there was a demonstration of how to analyze objects at a nanoscopic scale. Senior biology associate Beth Rhoades, who is a part of the Cornell NanoScale Science and Technology Facility, showed people just how to analyze certain organisms and everyday plants at a 50x scale. Along with this, she also portrayed how plasma can be used in nanoscale science and how to create a human circuit with a plasma ball.

The day ended with Code Red Team member Eli Froehlich demonstrating how to drive the robots. One robot, continually upgraded using the parts of past robots, uses a tank style of driving. It has two handheld controls: one for going forward and backward and the other for turning assistance. Another robot was designed to use a simple arcade-style control, meaning it can be moved using something as simple as an Xbox controller.

Code Red, aka Team 639, will soon be battling it out with other teams from across the country in the FIRST Robotics Competition. With the taste of glory already from years past, they are looking for more of the same from this year's competition.

The 13th CNF FIRST LEGO League Jr. Expo was a blast! The teams who attended showed off great imagination and thinking in the work on the Mission Moon challenge. http://www.cnf.cornell.edu/cnf_flljr.html

2019 CNF & PARADIM REU PROGRAMS

Once again, the Cornell NanoScale Science & Technology Facility (CNF) is teaming up with the Platform for the Accelerated Realization, Analysis, and Discovery of Interface Materials (PARADIM) to host Research Experience for Undergraduates (REU) programs from June through August.

In addition, CNF has the honor of hosting this year's network-wide National Nanotechnology Coordinated Infrastructure (NNCI) REU Convocation, Saturday-Tuesday, August 10-13.

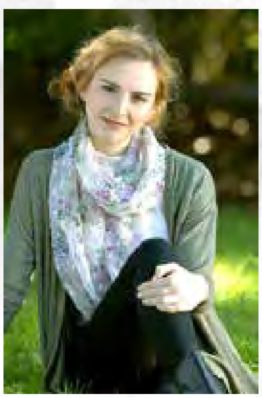
http://www.cnf.cornell.edu/cnf5_reuprogram.html

Ms. Anna Alvarez
2019 CNF REU Program
CNF REU PI: Itai Cohen

Mr. Jacob Baker
2019 CNF REU Program
CNF REU PI: G. Lambert

Mr. Jonathan Ortiz
2019 PARADIM REU
PARADIM REU Mentor: Darrell Schlom

Mr. James Tran
2019 CNF REU Program
CNF REU PI: J. Engstrom



Ms. Caroline Fedele
2019 PARADIM REU
PARADIM REU Mentor: Nate Schreiber

Mr. Darien Nguyen
2019 CNF REU Program
CNF REU PI: Alireza Abbaspourrad

Ms. Katie Munechika
2019 CNF REU Program
CNF REU PI: David Erickson

Mr. Jarek Viera
2019 PARADIM REU
PARADIM REU Mentor: Saien Xie

Mr. Oluchi Onwuvuche
2019 PARADIM REU
PARADIM REU Mentor: Matt Baron

Ms. Priscila Santiesteban
2019 PARADIM REU
PARADIM REU Mentor: Nicole Benedek

Mr. Samuel Straney
2019 PARADIM REU
PARADIM REU Mentor: Saien Xie

5kV 8 mm

John Chong of Kionix Named Chair of MEMS & Sensors Industry Group Governing Council

MILPITAS, Calif. — February 6, 2019 — SEMI, the global industry association serving the electronics manufacturing supply chain, today announced the appointment of John Chong, vice president of product and business development at MEMS manufacturer Kionix, as Governing Council chair of the SEMI-MEMS & Sensors Industry Group (SEMI-MSIG), a SEMI Strategic Association Partner. The Council provides guidance and oversight for SEMI-MSIG's strategic direction and initiatives.

As chairman, Dr. Chong, a member of the SEMI-MSIG Governing Council since 2015, will work to advance the interests of the MEMS and sensors community globally and drive its expansion. Spurred by surging growth in smartphones, smart speakers, autonomous cars, and fitness and healthcare wearables, the global market for MEMS and sensors is expected to double in the next five years, reaching $100 billion by 2023, according to Yole Développement, a market research firm.

"John's technical expertise and industry insights have been great assets to SEMI-MSIG," said Michael Ciesinski, vice president of Technology Communities at SEMI. "We are pleased that he will now focus his leadership on programs designed to deepen industry collaboration, drive innovation, and seize the tremendous market opportunity that lies ahead. Further, as we make this leadership transition, SEMI gratefully acknowledges the many contributions of our past chair, Dave Kirsch, vice president and general manager of EV Group."

Among other achievements, Kirsch led the successful integration of MSIG with SEMI in 2016.

Dr. Chong brings to the chair rich industry experience. He leads Kionix's growing portfolio of sensors and oversees its Software and Solutions Development Center. Before joining Kionix in 2006, Dr. Chong led the development of optical MEMS at Calient Networks. He holds multiple patents and has spoken extensively at industry conferences about the role of sensors in the Internet of Things (IoT). Dr. Chong earned his B.S. and Ph.D. in electrical engineering at Cornell University, where he worked on novel techniques for the design and manufacturing of Microfludic MEMS at the CNF.

"I am excited by the central role MEMS and sensors will play in the age of IoT, artificial intelligence (AI), and autonomous agents," Dr. Chong said. "With collaboration and coordination within the industry critical to its prosperity, SEMI-MSIG is key in providing the vision, resources and platform necessary to enable innovation and get business done."

BioE Student is Yale Ciencia Academy Fellow

Published: Friday February 15, 2019

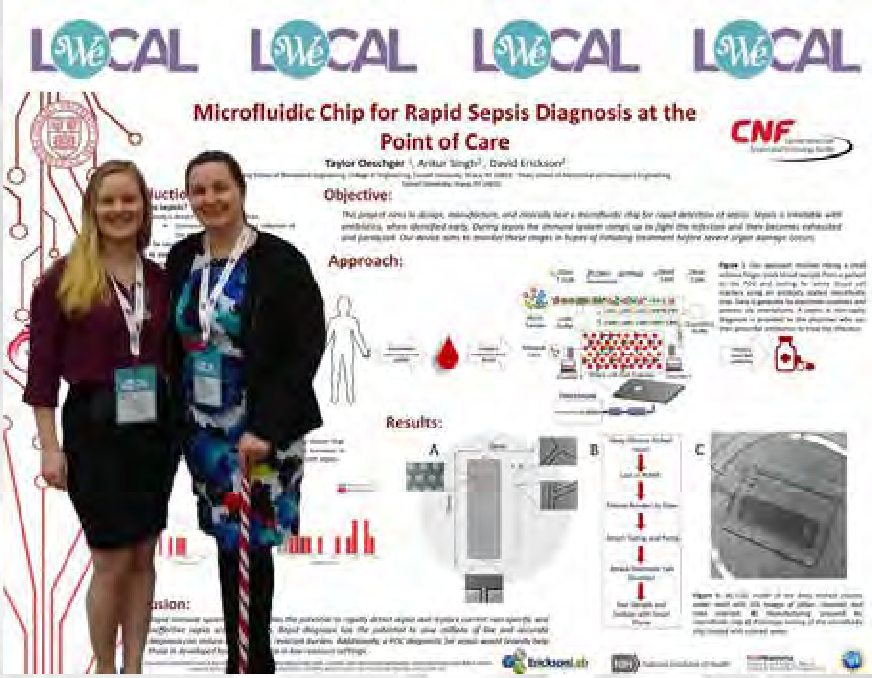
Adriana Mulero-Russe has been selected for competitive year-long career development program and sees limitless possibilities in her future as a Yale Ciencia Academy Fellow. Adriana was a 2014 CNF REU intern working with Prof. Abraham Stroock and then a 2015 CNF iREU intern working at NIMS Japan. She is currently a first-year Ph.D. student in the interdisciplinary Bioengineering program based in the Petit Institute for Bioengineering and Bioscience at the Georgia Institute of Technology.

Mulero-Russe is one of only 40 scholars in the year-long program. The students kicked off their year as fellows of the Yale Ciencia Academy for Career Development this week (Feb. 14-18) by attending the American Association for the Advancement of Science (AAAS) Annual Meeting in Washington, D.C. It was exactly the kind of networking opportunity Mulero-Russe was hoping for when she applied for the highly competitive program.

"I still feel new to everything, and I'm eager to learn how to network with other people in similar areas of research," she said. "I expect to put these skills into play in the four years I have ahead of me as a Ph.D. student."

The Yale Ciencia Academy was developed in 2016 by Ciencia Puerto Rico, a non-profit organization comprised of scientists, students, citizens, and professionals committed to the advancement of science in Puerto Rico and with promoting science communication, education, and careers. The career development program targets grad students studying biomedical and behavioral sciences in Puerto Rico and the U.S., giving them an opportunity to participate in workshops, conversations with scientists, mentoring, networking, and science outreach.

200 µm



Taylor Oeschger, Second Year Biomedical Engineering Student Working in MAE Wins First Prize

Taylor Oeschger, a 2nd year Cornell Biomedical Engineering student working in the Sibley School of Mechanical and Aerospace Engineering, and five other engineering graduate students traveled to the Society of Women in Engineering Local conference in Baltimore, Maryland February 8-9, 2019.

Taylor competed in the graduate level poster and presentation competition and received 1st prize for her research on a point of care diagnostic for sepsis.

Her objective for the project aims to design, manufacture, and clinically test a microfluidic chip for rapid detection of sepsis. Sepsis is treatable with antibiotics, when identified early. During sepsis the immune system ramps up to fight the infection and then becomes exhausted and paralyzed. The device aims to monitor these stages in hopes of initiating treatment before severe organ damage occurs. She concludes that rapid immune system monitoring has the potential to rapidly detect sepsis and replace current non-specific and ineffective sepsis scoring systems. Rapid diagnosis has the potential to save millions of live and accurate diagnosis can reduce the antibiotic resistant burden. Additionally, a POC diagnostic for sepsis would broadly help those in developed hospitals but also in low resource settings.

This work was completed as a co-mentorship between the labs of David Erickson and Ankur Singh.

WE Local is a Society of Women Engineers (SWE) program that brings together participants in all stages of their collegiate and professional journey. The program hosts conferences across the globe so engineers can connect through professional development workshops, inspirational speakers, networking opportunities and outreach activities.

Reminder to Submit to CNF User Wiki

Dear CNF Community:
Please share your process and recipe updates on the CNF User Wiki.

wiki.cnfusers.cornell.edu

Several CNF staff were acknowledged in the Science Advances article, “Adaptive metalenses with simultaneous electrical control of focal length, astigmatism, and shift”, authored by Alan She, Shuyan Zhang, Samuel Shian, David R. Clarke, and Federico Capasso. (Science Advances 23 Feb 2018: Vol. 4, no. 2, eaap9957, DOI: 10.1126/sciadv.aap9957)

Congratulations to John Treichler, Aaron Windsor, Garry Bordonaro, Karlis Musa, and David Botsch!

A recent CNF-research-related article in Integrative Biology was featured on the journal’s front cover — “Substrate stiffness heterogeneities disrupt endothelial barrier integrity in a micropillar model of heterogeneous vascular stiffening”; VanderBurgh, J.A., Hotchkiss, H., Potharazu, A., Taufalele, P.V. and Reinhart-King, C.A., 2018. Integrative Biology, 10(12), pp.734-746.

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NanoMeter
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Your comments are welcome!

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 Empire State Development's Division of Science, Technology and Innovation (NYSTAR), Cornell University, Industry, and our Users.

To be added to our CNF NanoMeter 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 web site at: http://www.cnf.cornell.edu