NanoMeter

The newsletter of the Cornell NanoScale Facility

Winter 2019 • Volume 28 • Issue 2

REGISTER NOW FOR OUR SHORT COURSE!
see page 3 for details!

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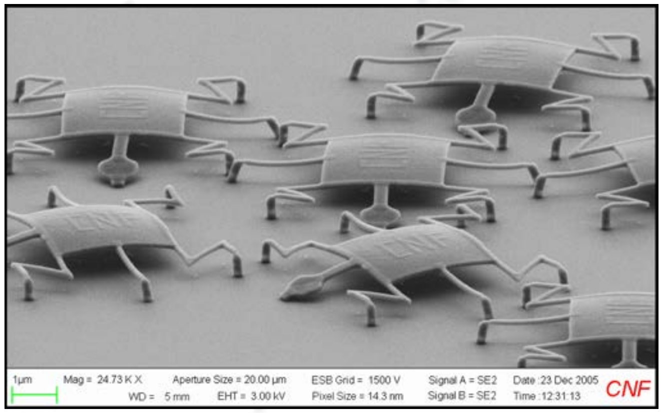
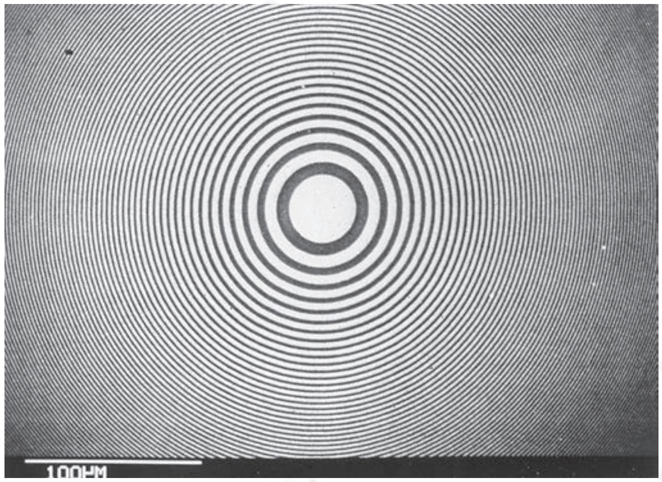




Our cover "CNF BUGS" were fabricated back in 2005 by past CNF staffer, Michael Guillorn, now of IBM Thomas J. Watson Research Center, Yorktown Heights. Melanie-Claire discovered she'd never used them in a NanoMeter — so this is their debut, 14 years later! The background for this issue harkens back to our NNF years. Just one of the many device images in our archives created by an unknown CNF researcher. The photographs in this newsletter were primarily provided by the author(s), but also by University Photography, Gary L. Hodges, 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!

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

CNF Cornell NanoScale Science and Technology Facility · National Nanotechnology Coordinated Infrastructure · Cornell University · New York State of Opportunity. Empire State Development · NSF

The next CNF Short Course, Technology & Characterization at the Nanoscale (CNF TCN), will take place January 14-17, 2020

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 of Cornell University, 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, but you must contact Rebecca Vliet first though to make sure this special funding is still available for your institution.

REGISTER ONLINE AT HTTP://CNF.CORNELL.EDU/EDUCATION/

CNF Directors' Column

We are excited to introduce the latest edition of the NanoMeter.

This year was an impressive one marked by the arrival of Ron Olson (see page 5), plus new equipment and capabilities in our lithography, plasma etching, deposition, wet chemistry, and test and advance packaging areas in the fab. The continual improvement of process capabilities will ensure CNF implements its strategic mission, which includes Heterointegration, 2-D Materials, Biotechnology, Quantum Materials and Devices, and Artificial Intelligence in the Cleanroom.

Examples of recently installed equipment include the Keithley 4200A-SCS Analyzer, an AJA ORION-8 sputter deposition system, Xallent nanoprobe, CEE spin coat systems, Finetech-flip chip bonder and the Nanoscribe Photonic Professional GT 2 3D Laser Lithography System. Installation of a C&D Semiconductor custom designed liftoff tool, and a Plasma-Therm Atomic Layer Etch system is planned in Q1 2020. As always, we welcome your comments and suggestions for improving CNF.

To advance lithography capabilities, CNF will submit an NSF MRI proposal for a Heidelberg MLR 150 Maskless Aligner. The facility is proud to be one of Cornell's two nominations to the NSF MRI program.

The CNF staff and Fellows continue to do a great job developing new process capabilities for new materials and improved process control. Improvements in lithography include: upgrade of the ASML operator workstation, implementation of software and techniques for solving lithography problems on the JEOL JBX-9500FS and the JBX-6300FS electron beam lithography systems and the addition of a CompileSDF application icon to the JEOL JBX-6300FS. The etching team continues to develop, document and characterize processes for etching TaN, TiN, Nb, Mo, $MoSi_2$, GaN, Si, dielectrics and SiC. The wet area is expanding its 200 mm wafer processing capabilities for ammonium hydroxide/hydrogen peroxide/RC1 cleaning. In the thin film deposition area, the Arradiance ALD system was upgraded with the addition of an ozone generator to increase deposition capabilities.

As a member of the National Nanotechnology Coordinated Infrastructure (NNCI), Cornell is one of 16 sites collaborating as a national user consortium committed to providing researchers from industry and academia with access to facilities equipped with in-house expertise, as well as state-of-the-art fabrication and characterization tools. With the NNCI program approaching its five-year anniversary, all sites will participate in the renewal process targeting an additional five years of funding subject to review. The CNF team will be submitting its proposal highlighting the program vision and goals, previous results and future plans. Support from the National Science Foundation and membership in NNCI is vital in keeping CNF at the forefront of nanofabrication. The ability to offer its user community access to an advanced toolset and the expertise of an accomplished, knowledgeable staff contributes to CNF's position as a state-of-the art research facility.

The CNF has served as an effective resource for the commercialization of nanotechnology. One hundred sixty-nine (169) different companies have benefited from using the facility over the past decade. Thirty-four (34) startups began at Cornell through CNF and at least 45 additional small startup companies and 90 established companies have used CNF for major research and development/prototyping. Over the last four years CNF has averaged 2.5 new startup company launches including; Xallent, Esper Biosciences, FloraPulse, Ultramend, Jan BioTech, Heat Inverse, JR2J, White Light Power, Odyssey Semiconductor, and GeeGah. In 2016, Xallent, in conjunction with CNF, was the recipient of a Fuzehub Manufacturing Award. During the last ten years over $1.5 billion dollars of revenue/year was generated from the startup companies originating at Cornell through CNF.

CNF has a demonstrated history of support for undergraduate research initiatives. Among our most notable endeavors; a 28-year history of hosting Research Experiences for Undergraduates Programs as well as sponsoring the International Research Experiences for Undergraduates (iREU) Program since 2008. This year was no different! We worked with eleven interns. Plus, CNF was honored to host the network-wide NNCI REU Convocation in August. (See page 23 for details.)

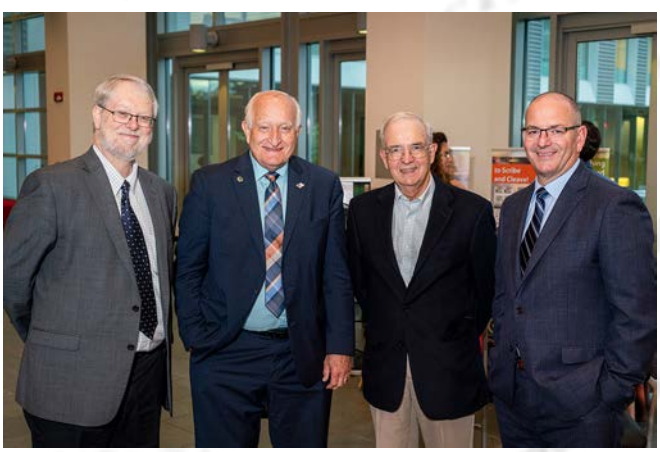
Be sure to register for one of our short courses: Technology & Characterization at the Nanoscale scheduled to start on Tuesday, January 14, 2020, and Tuesday, June 2, 2020. Details are provided on page 3.

CNF staff would like to thank the corporate sponsors, speakers, poster session participants, and attendees who made the 2019 Annual Meeting a great success. A special congratulations is extended to the student award winners listed on page 7. The 2020 Annual Meeting is scheduled for Thursday, September 10^{th}. Consider pledging your sponsorship now! Contact Melanie-Claire for details (mallison@cnf.cornell.edu).

The entire CNF family extends to all of you our best wishes for a warm holiday season and a happy, peaceful New Year!

Thank you,
Chris Ober, director@cnf.cornell.edu
Ron Olson, olson@cnf.cornell.edu

Ron presented at the 2019 CNF Annual Meeting. (UPhoto)



Left to right; Christopher Ober, current CNF Director;
Edward Wolf, the original full time CNF Director, 1978-1988;
Alton Clark, CNF Associate Director, 1994-2000;
Ronald Olson, current CNF Director of Operations.
(Gary L. Hodges, Photography)

Cornell NanoScale Facility Hires New Director of Operations

By David Nutt
Cornell Chronicle
October 22, 2019

Ron Olson has joined the Cornell NanoScale Facility (CNF) as director of operations.

Ron Olson has worked for more than 32 years in industrial fabrication operations, and process and device development. For the last 14 years, he held a variety of research and management roles at General Electric Global Research, most recently managing its SiC Technology Transfer Team at State University of New York Polytechnic Institute's Power Electronics Manufacturing Consortium. Prior to working at GE, Olson co-founded a startup company, Xanoptix, Inc., that specialized in creating next-generation optical connections. It was through Xanoptix that Olson first came to CNF, in 1999.

"I actually was a CNF user," Olson said. "Our startup was making devices in the nanofab facility to help with our new product launch. That's how I got to know the place. I was always really impressed with the staff, the tools and the capabilities."

Olson succeeds Don Tennant '73, who had served as director of operations since 2006. "It's great to follow in Don's footsteps," Olson said. "He laid a great foundation, and I would like to build upon that foundation and keep continuously improving. We want to keep Cornell at the forefront of nanotechnology."

Since it opened in 1977, CNF has hosted scientists and engineers from academia and industry, enabling them to conduct micro- and nanoscale research with the most state-of-the-art technology and expertise.

"Our mission is to keep advancing science by working with Cornell, our users, the government, and New York state," Olson said. "We want to continue to have a strong relationship with the NSF-supported National Nanotechnology Coordinated Infrastructure as well, and that includes outreach. We hope to encourage kids to be the next engineers and scientists who win the Nobel Prize."

In his new role, which he assumed in August, Olson oversees facility management and operations, and user research programs; he also handles academic and industrial relations.

Olson said he looks forward to helping the facility expand into new strategic directions, specifically heterointergration, 2D materials, biotechnology, quantum materials and devices, and artificial intelligence in the cleanroom.

"Ron brings his operational excellence and his good humor to the team at CNF," said Christopher Ober, the Lester B. Knight Director of CNF. "We are delighted to have Ron join us and look forward to benefiting from his expertise as we continue to add new nanofabrication capabilities."

2019 CNF Annual Meeting Summary

The 2019 CNF Annual Meeting was held on Thursday, September 12, with a record number of corporate sponsors, to whom we are very grateful! They are listed below. We also had a higher-than-usual number of participants – over 180 people registered! We are really pleased that after 42 years, we can still pack in a crowd to hear about our nano-world.

We began the meeting by introducing our new Director of Operations, Ron Olson (see page 5), and then heard from our plenary speaker, Britton Plourde, Professor of Physics, Syracuse University, who presented his work on "Building Quantum Processors with Nanoscale Superconducting Circuits."

A hearty THANK YOU to our eleven CNF User presenters: Baris Bircan, Cornell University (PI: Itai Cohen); Kyle Dorsey, Cornell University (PI: Paul McEuen); Marissa Granados Baez, University of Rochester (PI: Jaime Cardenas); Austin Hickman, Cornell University (PI: Debdeep Jena); Golsa Mirbagheri, Clarkson University (PI: David Crouse); Kazuki Nomoto, Cornell University (PI: Huili Grace Xing); Mehmet Ozdogan, Mechanical Engineering (PI: Amit Lal); Jisung Park, Cornell University (PI: Darrell Schlom); Alexander Ruyack, Cornell University (PI: Amit Lal); Summer Saraf, JR2J LLC (PI: Richard Brown); Fan Ye, Cornell University (PI: Michelle Wang). Find the proceedings with their abstracts online at https://cnf.cornell.edu/events/past/annual_meetings/2019.

Finally, the 2020 CNF Annual Meeting is scheduled for Thursday, September 10th. Save the date and consider pledging your sponsorship now! Contact Ms. Melanie-Claire Mallison for details (mallison@cnf.cornell.edu).

CORPORATE SPONSORS

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CORPORATE SPONSORS PLUS

(Funded the Student Awards)

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2019 CNF ANNUAL MEETING STUDENT AWARDS

CNF BEST POSTER AWARDS

Baris Bircan, "Self-Folding Micro-Origami with Atomic Layer Deposition Bimorph Actuators"

Kyle J. Dorsey, "Atomic Layer Deposition for Membranes, Metamaterials, and Mechanisms"

Edward Szoka, "Neural Probes for Microcoil Magnetic Stimulation with CMOS Technology Integration"

Yinglu Wang, "Synthesis of semi-dilute SiO_2-Polystyrene (PS) hairy nanoparticles (PGNs)"

CNF BEST PAPER AWARD

Summer Saraf, "Area-Selective Doping of GaN for the Realization of Vertical Conduction, High Voltage Power Switching Devices"

CORNING BEST PAPER AWARD

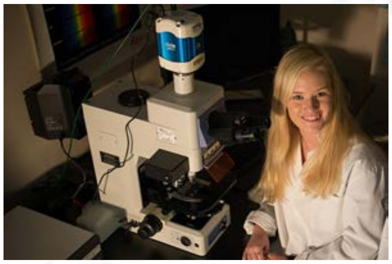
Fan Ye, "Parallel Unzipping of DNA Molecules using Nanophotonic Tweezers"

CNF WHETTEN MEMORIAL AWARD

Taylor Oeschger, "Microfluidic Chip for Sepsis Diagnosis at the Point of Care" (see page 8)

(All by Gary L. Hodges, Photography)

2019 CNF Nellie Yeh-Poh Lin Whetten Memorial Award Winner: Taylor Oeschger



Taylor Oeschger is a third year Ph.D. student in Biomedical Engineering at Cornell and the recipient of the 2019 CNF Nellie Yeh-Poh Lin Whetten Memorial Award. The Whetten Award recognizes an outstanding female graduate student at CNF who shows spirit and commitment to professional excellence, as well as professional and personal courtesy.

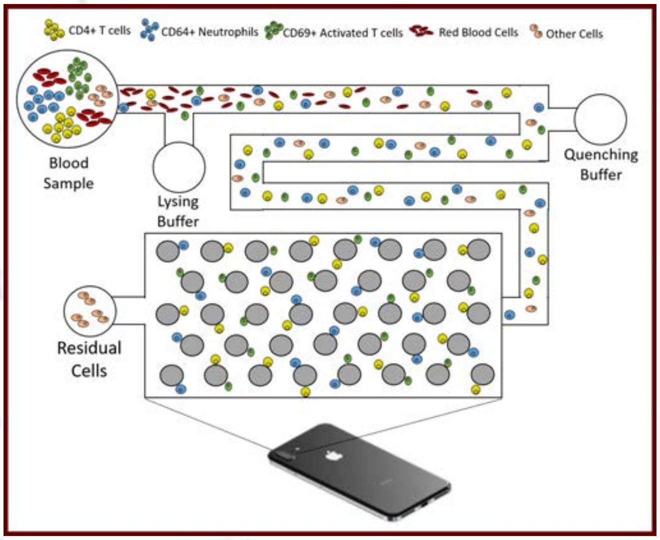
Taylor holds dual bachelor's degrees in Chemical Engineering and Biological Engineering from Montana State University in snowy Bozeman, Montana. While there, she researched environmental biofilms and their resistance to ultraviolet radiation in Antarctica. This gave her a love of biology and a respect for bacteria, but she sought work related to human health, thus her current pursuit of research in low-cost medical diagnostics here at Cornell.

Taylor's Ph.D. research focuses on low-cost diagnostics that can be used in limited-resource settings such as rural clinics in developing countries. Her work in the CNF focuses on designing a diagnostic device for sepsis, the body's drastic response to any kind of infection.

In septic patients, infections enter the bloodstream and can cause systemic organ failure. Current diagnostic methods are too slow and non-specific to effectively save lives. Taylor aims to develop a microfluidic chip for Immunochemical Rapid Identification of Sepsis (IRIS) to capture white blood cells that indicate sepsis. Abnormal changes in these white blood cell concentrations can hopefully identify sepsis earlier than other methods, allowing treatment to be administered quickly.

This device is manufactured with a silicone mold that is deep reactive ion etched in the CNF cleanroom with the final devices cast in PDMS in the CNF second floor labs. The device is capable of rupturing red blood cells in a matter of seconds while still maintaining intact white blood cells. The cells of interest will then be counted using an iPhone or Raspberry Pi enabled portable microscope. In the end, the disposable chips should cost less than $10 and has the potential to deliver clinically-relevant results within a few hours.

Taylor's second project focuses on combating the increasing problem of antibiotic resistance. She is developing a micro-volume colorimetric assay for phenotypically testing the susceptibility of *Neisseria gonorrhoeae*, the causative agent in gonorrhea, to clinically-relevant antibiotics. The CDC currently lists gonorrhea as one of the biggest antibiotic threats since it has become resistant to all but one recommended dual antibiotic therapy.



If successful, this assay will cost less than $10 and take less than six hours to run, potentially opening the door to personalized antibiotic susceptibility testing for gonorrhea patients. This can help delay further development of resistance to last-line antibiotic therapies and delay the time to untreatable gonorrhea infections in the USA and across the globe.

In addition to her research, Taylor is the Outreach Coordinator for Cornell's Graduate Society of Women in Engineering (GradSWE). With her co-coordinator, Rose Buchmann, she has arranged a variety of fellowship reviews, youth outreach, and crochet for charity events. She has also arranged collaborations between GradSWE and Habitat for Humanity Women Build, where she acts as a site supervisor building homes for low-income families in Tompkins County. In addition, Taylor gets her weekly fuzz therapy at the Tompkins County SPCA animal shelter where she volunteers by socializing cats, kittens, and bunnies.

After graduation, Taylor hopes to run a research and development lab for a biotech company focusing on immunology and infectious diseases.

Taylor has been incredibly inspired by the CNF staff, especially Beth Rhoades and Tom Pennell. Not only have they made her experience at the CNF much easier, but they have also provided her with valuable mentorship. They inspired her to mentor her first undergrad, Katie Munechika, through the 2019 CNF Research Experiences for Undergraduates Program.

Taylor would also like to thank her advisor, David Erickson, for his continued support, funding, mentorship, and inspiration.

Taylor Oeschger received the 2019 CNF Nellie Yeh-Poh Lin Whetten Memorial Award at the CNF Annual Meeting on September 12th. The award and plaque were presented to her by Christopher Ober, CNF Director, and Ronald Olson, CNF Director of Operations. Assisting in the festivities was Prof. Cindy Harnett, Electrical & Computer Engineering, University of Louisville — our 2001 Whetten Memorial Award winner and an invited speaker at the meeting. (Gary L. Hodges, Photography)

Photograph provided by Tim Whetten

Nellie Yeh-Poh Lin Whetten; CNF Memorial Award

This award is given in fond memory of Nellie Whetten (above) — a CNF staff member from 1984 to 1987 who died on March 24, 1989. In honor of Nellie's spirit, 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 have the brilliance, stubbornness, and cheerfulness to succeed."***

https://cnf.cornell.edu/highlights/whetten — a list of all the CNF Whetten Memorial Award Winners

Nicole Chu Conducts Sensor Research at Cornell NanoScale Science and Technology Facility

Graduate student Nicole Chu creates framework for personal air quality sensors

By Blaine Friedlander
May 21, 2019
Cornell Chronicle

Nicole Chu in the CNF cleanroom.

(Lindsay France/Cornell University)

Indoors or out, Nicole Chu, M.Eng. '19, loathes breathing in carbon monoxide, sulfur dioxide and other volatile organic compounds. They're bad for everyone's health.

Since last August, Chu has been fabricating the foundation of a wearable, personalized air quality monitoring device, by using nanotechnology, photolithography and other tools at the Cornell NanoScale Science and Technology Facility (CNF).

"The end goal is to create small, personalized sensors that communicate to a smartphone and deliver data," said Chu, who explained that air quality monitoring systems now on the market lack sensitivity and tend to be expensive. "Many people are unaware of just how polluted the air is around them," she said.

Indoor air can be two to five times more polluted than outdoor air, Chu said, based on data provided by the U.S. Environmental Protection Agency. On average, Americans spend around 90% of their time inside, which leads to prolonged exposure to harmful chemicals such as nitrogen dioxide, ammonia and other volatile organic compounds.

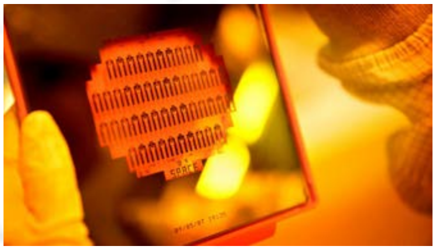
"In this project, we're hoping to maximize the sensors' ability, bring down costs and use the technology for other applications and other flexible devices," she said.

Chu — like other students in Cornell's Materials Science and Engineering Master of Engineering (M.Eng.) program — conducted this hands-on project matched with a nearby small company. Chu was matched with FlexSurfaces in Binghamton, via the Cornell Center for Materials Research's Industrial Partnerships program and funded by Empire State Development.

CORNELL IMPACTS NEW YORK STATE

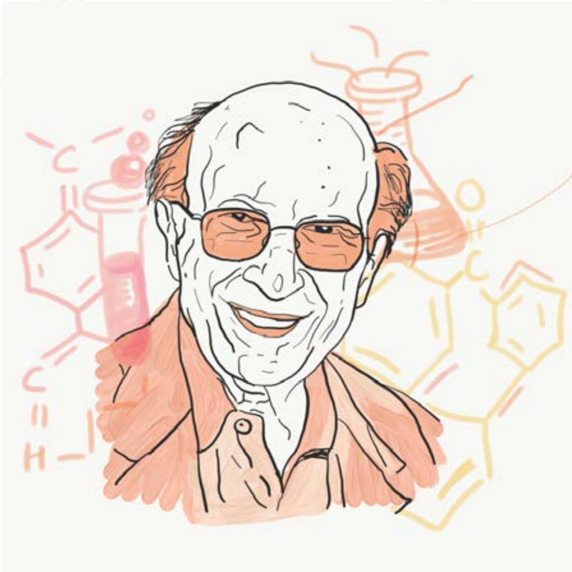
"The projects integrate materials science, engineering and design and provide students with an immersion and fast-track, in-depth experience figuring out tools or trying out solutions — all while learning material properties, synthesis and processing," said Alex Deyhim, adjunct professor of materials science and engineering and associate director of the M.Eng. program. At the heart of the flexible design Chu created for FlexSurfaces is a substrate material made from a heat-resistant polymer on which sensors —nanofabricated, interlocking microelectrodes, which she developed — can be imprinted via photolithography. "The most challenging part of my project was becoming familiar with the process and clean room tools," said Chu. "I had no prior experience with these and it took a little practice to get some of the skills in the cleanroom right."

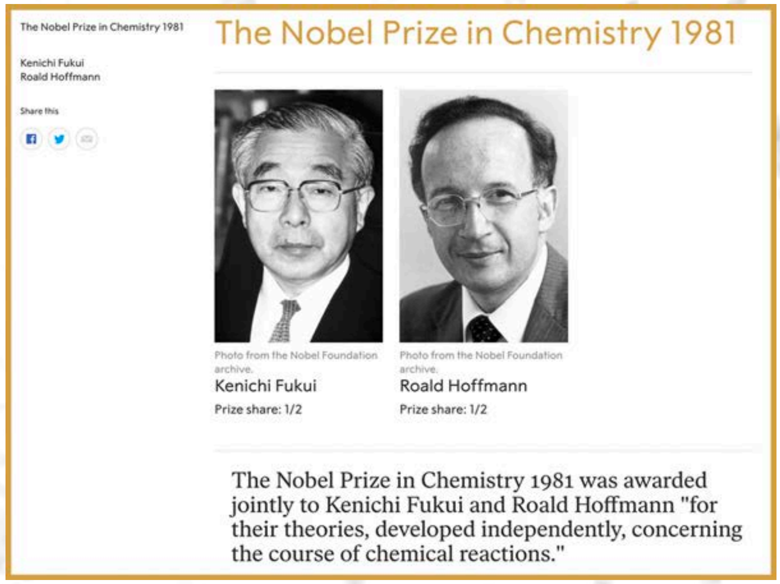
Several sensors have been produced by Chu using photolithography techniques at the CNF. "Aside from the training by the CNF staff, I was for the most part on my own in there," she said. "It took a little time and I trashed a few samples, but I soon became comfortable using all the tools and machines I needed."



In two semesters, Chu created a solid process for producing the heart of the devices on flexible substrates. So far, early tests show that Chu's microfabricated electrodes worked well, detecting volatile organic compounds.

"We ran into a few technical issues when attempting to transfer our devices from glass onto flexible substrates," she said, "but we were able to figure out each problem as it arose and I was able to fabricate hundreds of devices for the company to test further."




The Nobel Prize in Chemistry 1981

Kenichi Fukui
Roald Hoffmann

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The Nobel Prize in Chemistry 1981

Photo from the Nobel Foundation archive.
Kenichi Fukui
Prize share: 1/2

Photo from the Nobel Foundation archive.
Roald Hoffmann
Prize share: 1/2

The Nobel Prize in Chemistry 1981 was awarded jointly to Kenichi Fukui and Roald Hoffmann "for their theories, developed independently, concerning the course of chemical reactions."

A Look at Past Cornell-Affiliated Nobel Prize Laureates: How their Legacy will Inspire Generations of Scientists to Come

By Tamara Kamis and Louis Chuang
Thursday, October 10, 2019
Cornell Daily Sun

In light of the announcement of the 2019 Nobel Laureates, we are highlighting three of the 50 Cornell faculty and alumni, past and present, who have been awarded Nobel Prizes in Physics, Chemistry and Physiology and Medicine.

Prof. Roald Hoffmann, chemistry, is the Frank H. T. Rhodes Professor of Humane Letters, Emeritus, and has been part of the Cornell faculty since 1965. Hoffmann has researched a variety of sub-fields within chemistry, including organic chemistry, inorganic chemistry and solid state chemistry.

Hoffmann shared the Nobel Prize with Kenichi Fukuiwon in 1981 for "their theories, developed independently, concerning the course of chemical reactions." However, Hoffman has mixed feelings about the Nobel Prize, describing the jealousy of peers and the pressure of being watched in the future.

"If everyone around you asks you what are going to do next, you begin to think about that and that inhibits creativity," Hoffman said. However, winning the Nobel Prize didn't change his focus on research and teaching, including teaching undergraduates.

"I remained a scientist and I remained teaching Introduction to Chemistry, though I haven't done it for ten years now because I'm retired," Hoffman said.

Hoffmann has also been heavily involved in the humanities throughout his life, writing plays, books and poetry. Hoffmann has always believed strongly in the importance of communicating science to the public, saying that scientists should "take every opportunity to speak to the general public."

When asked what advice he had for students interested in a future in research, Hoffmann suggested getting research experience in college. "The research experience allows you to move from very large classes […] to the research group and the research group meetings. which are usually smaller and which are more of a scientific family," Hoffman said.

Zhiting Tian, Assistant Professor (MAE), Selected as a 2019 PMSE Young Investigator.

March 11, 2019

The American Chemical Society Division of Polymeric Materials: Science and Engineering invited Tian to present her work during a symposium at the Fall 2019 ACS National Meeting in August.

Dr. Zhiting Tian joined Mechanical and Aerospace Engineering in July 2018. Her research interests include micro/nanoscale heat transfer, thermal energy conversion / storage, thermal management, multiscale thermal transport in organic, inorganic, and hybrid materials.

Stressing Metallic Material Controls Superconductivity

By David Nutt
Cornell Chronicle
October 11, 2019

No strain, no gain — that's the credo for Cornell researchers who have helped find a way to control superconductivity in a metallic material by stressing and deforming it.

The researchers, led by Katja Nowack, assistant professor of physics in the College of Arts and Sciences, collaborated with a team led by Philip Moll from the Institute of Material Science and Engineering at L'Ecole Polytechnique Fédérale de Lausanne in Switzerland. Their paper, "Spatial Control of Heavy-Fermion Superconductivity in $CeIrIn_5$," published Oct. 11 in Science*.

The project began as a puzzle. Moll's team had been measuring superconductivity in microstructure devices made from cerium iridium indium-5 ($CeIrIn_5$), a heavy fermion metal. The team was perplexed to find that the device's critical temperature, also known as the transition temperature, changed when the devices were measured in different configurations. Typically, the critical temperature should be the same throughout the structure.

Moll's frequent collaborator, Brad Ramshaw, Cornell assistant professor of physics and a co-author of the paper, told Nowack about the results, and Nowack decided to investigate the issue. Her lab had constructed a scanning probe microscope ideally suited for imaging the structures Moll was studying. The probes are superconducting quantum interference devices, or SQUIDs.

When Nowack and her team imaged the small structures, they realized that deformations in the material were enabling the superconductivity to form in a spatially patterned way.

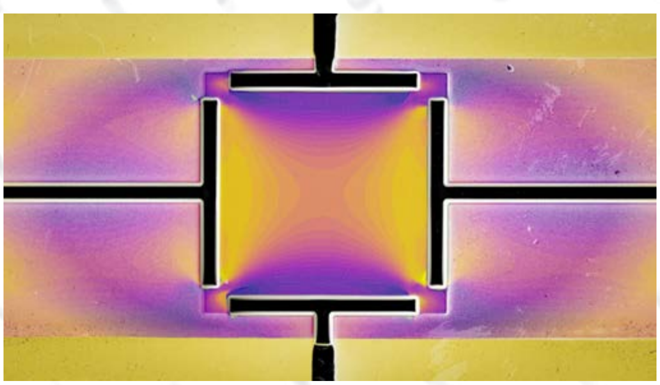


Figure 1: SEM showing the local superconducting transition temperature caused by strain in a microstructure device.

"The pattern we observed looked like something was pulling on the four corners of the square-shaped sample," Nowack said.

To fabricate the devices, Moll's team had glued $CeIrIn_5$ crystal structures to a layer of sapphire and patterned them with a focus ion beam. Like most metals, $CeIrIn_5$ contracts when cooled, but sapphire, an insulator, hardly shrinks at all. When the two materials were cooled together, the $CeIrIn_5$ was deformed by the mechanical tension between the two layers. "The critical temperature in $CeIrIn_5$ responds to strain," Nowack said. "So pulling on the crystal in one direction will make that temperature go a little higher, and then pulling on the crystal in another direction will make it go lower."

These strains can shift the superconducting transition temperature by nearly a factor of four, from approximately 200 to 800 millikelvin. "The structures have trenches and features cut into them with high spatial control," Nowack said. "All those details in the geometry heavily influence how the deformation looks at the end. This is really exciting because by modifying the geometry, we can spatially control the superconductivity in these little structures accordingly." Using this method allows the researchers to modulate superconductivity without relying on chemical augmentation, known as doping, which can compromise how clean the crystal is and its electronic properties.

"Now that we understand how to use microstructuring to tune the electronic properties of $CeIrIn_5$, we can extend our approach to other materials, or we can design more sophisticated structures and fine-tune our control over the superconducting transition in heavy fermion compounds," said doctoral student Matt Ferguson, who performed the imaging and served as co-lead author along with Maja Bachmann from the Max Planck Institute in Germany and the University of St. Andrews, Scotland. "In addition, we want to see if we can do something similar to other types of electronic order, such as magnetism," Nowack added.

** Co-authors include doctoral students David Low, Sayak Ghosh, and Florian Theuss, and researchers at the Max Planck Institute for Chemical Physics of Solids; University of St. Andrews; Los Alamos National Laboratory, New Mexico; and Technical University Dresden, Germany. The Cornell research was primarily supported by the U.S. Department of Energy, and the Cornell Center for Materials Research, with funding from the National Science Foundation's Materials Research Science and Engineering Center. This work was performed in part at the Cornell NanoScale Facility (CNF).*

SEMI Teams with Cornell University to Accelerate Technology Development Using Machine Learning and AI

SEMI PRESS RELEASE
June 27, 2019, 10:00 ET

MILPITAS, Calif., June 27, 2019 /PRNewswire/ -- SEMI today announced a research and development (R&D) project to speed technology progress and problem-solving in microelectronics manufacturing and across the supply chain by driving new efficiencies using machine learning (ML) and artificial intelligence (AI). Under an agreement with SEMI, Cornell University will optimize and accelerate two critical process steps — lithography and plasma etch. Supported through SEMI's R&D program with the U.S. Army Research Laboratory (ARL), the project aims to help accelerate the adoption of data-driven AI methodologies to streamline microelectronics operations.

The project will lay the foundation for SEMI to establish data transfer and management standards crucial to the trusted exchange of trade secrets, IP and other sensitive information. New standards and protocols are vital as the industry moves into the era of big data.

Semiconductor manufacturing is extremely complex due to the intricate interdependencies among various processes, environments, tools, and materials. This complexity deepens with the rise of new technologies and makes existing analytical approaches such as statistical process control (SPC) and design of experiments (DOE) more challenging. In addition, analyzing cleanroom data is now harder because of varying formats and lack of physical models for categorizing the data. Consequently, identifying root causes of manufacturing problems is much more difficult, slowing the development of new technologies.

"Streamlining manufacturing processes across the microelectronics supply chain to address the rising complexity of technology development is key for the industry to keep pace with market demand and drive growth," said Ajit Manocha, SEMI president and CEO. "The microelectronics industry has been slow to adopt ML and AI due, in part, to IP and data security concerns that impede data-sharing. SEMI's agreement with Cornell, supported by ARL, is an important step in using ML and AI techniques to tackle this and other issues and bring new technologies to market faster."

Tools and materials from several SEMI members will be used for the project at Cornell NanoScale Science & Technology Facility (CNF).

The budget for the year-long project is provided by the ARL grant, SEMI, and through in-kind contributions from companies in the form of materials and testing services. The principal investigators from Cornell University are Dr. Christopher K. Ober, professor of Materials Engineering and Director of the CNF, and Dr. Amit Lal, professor in the School of Electrical and Computer Engineering. Peter Doerschuk, Ed Suh, and Don Tennant will also support the project with expertise spanning computer systems, high-performance software and facilities management.

Susan Daniel Receives the Senior Faculty Champion Award

May 13, 2019

This award honors faculty members who have served as dedicated advocates who foster diversity, inclusion, and equity in higher education through exemplary mentorship, leadership, and/or outreach activities within the Cornell community. Those who receive this award have shown an unwavering commitment to promoting the growth and personal and professional development of graduate and professional students who represent the diversity of the Cornell community. It is given by the Office of Inclusion and Student Engagement at the Graduate School and selected by the Graduate and Professional Diversity Council.

Helping to Relieve Crop Survival Stress

Engineers and plant biologists are seeding a groundbreaking era in digital agriculture, with new technologies such as a microtensiometer and AquaDust.

by Jackie Swift

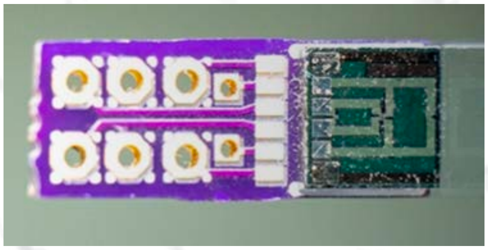
"Plants have a pulse," says Abraham Duncan Stroock, Chemical and Biomolecular Engineering. "It's the tug-of-war that goes on between the plant's leaves and the water in the soil. A leaf loses hundreds of water molecules for each molecule of cardon dioxide (CO_2) it captures during photosynthesis, so it has to rehydrate. The liquid in the leaf is at a negative pressure, and it pulls water up the plant, out of the roots, and out of the soil. Plants have evolved this beautiful design for moving liquids by very large tension, which is something that engineers never do. We always push liquids, but plants pull."

Stroock has spent much of his career studying microfluidics, wet chemical processes on small scales. About a decade ago, he became intrigued by plant microvasculature, the webs of capillaries that move liquid around inside tissue. Plants have two systems: the xylem, which brings water up to the leaves, and the phloem, which carries photosynthetic products down from the leaves to the rest of the plant's tissues. Important questions remain about how these systems work.

The Microtensiometer, a Device that Mimics a Plant's Capillary System

Focusing on the xylem, the Stroock group uses the Cornell NanoScale Science and Technology Facility to fabricate a device that mimicks plant microvasculature. "We take the approach that if we can build something, we can understand something about it," Stroock says. "In this case, we built a very simple mimic of some the basic physiological characteristics of plant microvasculature, and we were able to move liquid around in the way plants are believed to do."

Soon after that early breakthrough, the Stroock group began working closely with Alan N. Lakso, Horticulture (now emeritus), who is an expert on grape and apple physiology and cultivation. "We started to pursue a parallel path with this device," Stroock says. "Partly we wanted to use it in the lab, which we still do, to study this state of liquids under tension. But we also wanted to develop a version we could place directly inside a plant, to fuse with the plant's tissue, where it would monitor the plant's pulse and communicate to us about the plant's ability to manage its water needs."



Microtensiometer

The researchers were successful in creating a tiny microtensiometer which senses the plant's pulse, or drought stress. "It's a translator," Stroock explains. "It feels stress the way a plant does and then turns that into a voltage that we can read easily." Over the last few years, Stroock and his collaborators have been testing the device by embedding it in apple trees, almond trees, grape vines, and other crops. "It feeds us data that we send to the web," he says. "We're getting beautiful, unprecedented dynamics out of the test plants. It works well enough as a scientific tool that we think it can now become a technology to serve irrigation management."

FloraPulse, Bringing the Microtensiometer to Market

In 2014 Stroock, Lakso, and Michael Santiago, Ph.D.'16 Chemical and Biomolecular Engineering, attended a pre-seed workshop at the Kevin M. McGovern Family Center for Venture Development in the Life Sciences to explore the potential for commercialization of the microtensiometer. The possibilities looked good, so the team founded a company called FloraPulse, with Santiago as the chief executive officer. Now based in Davis, California, FloraPulse has licensed the microtensiometer patents from Cornell and is working with almond and grape growers in California—along with Stroock, Lakso, and Lialiang Cheng, Horticulture, working on apple trees—to explore the full potential of the technology.

"The market needs to be matured," Stroock says. "There's a question about what we should sell. Is it a hardware or a service? My lab, Alan Lakso, and other colleagues from the School of

Integrative Plant Science (SIPS) and the Collage of Agriculture and Life Sciences (CALS) are doing further research.

Stroock explains, "We're asking, what can we learn from a plant and its soil and local microenvironment by doing year-long measurements in the field? How do we understand the whole population of trees when we only have detailed sampling of a few of them? How do we bring together this detailed sensing with available remote sensing data to provide something that is interpolated across all plants in the orchard? The answers to these types of questions will help us discover the limits of the added value we can give to a grower."

AquaDust, a Nanoparticle that Can Convey a Plant's Water Stress

The FloraPulse device is just one of many research projects Stroock is working on. Continuing his investigations around plants, he joined with Michael A. Gore, Plant Breeding and Genetics, to develop a different technology that can communicate a plant's response to water stress. In this case, the Stroock group created a nanoparticle, a type of hydrogel they call AquaDust, that can be embedded in the leaf of a plant. The nanoparticle changes the fluorescence spectrum of the leaf depending on how much water stress the leaf is undergoing. When viewed with a multispectral camera, the leaf will appear to glow in differing degrees of red, green, or blue.

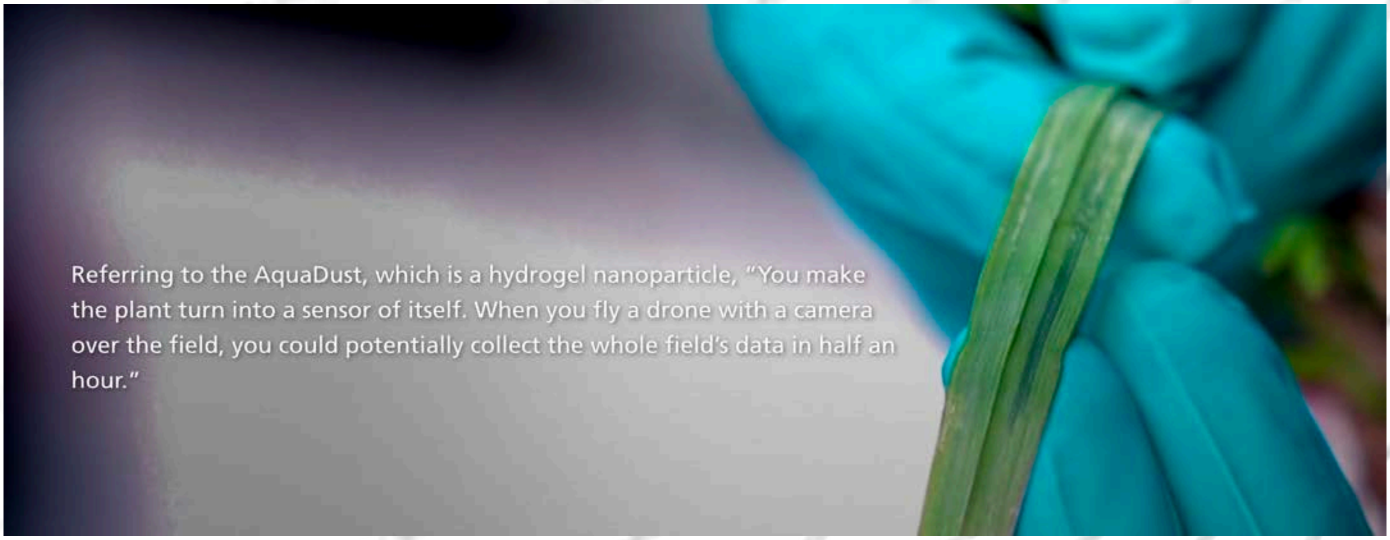
"To create the AquaDust particle, Mike gave me a sense of the constraints he's working under as a plant breeder," Stroock says. "He has to take thousands of measurements of hundreds of plants in a field on a daily basis to find the genes associated with water stress. We came up with this distinct strategy we think is generalizable, whereby you make the plant turn into a sensor of itself. When you fly a drone with a camera over the field, you could potentially collect the whole field's data in half an hour."

The researchers manually inoculate each leaf with AquaDust by squeezing it through the leaf's stomates, minute pores that allow the movement of gases in and out of intercellular spaces. "The goal is ultimately to just spray it over the field and have the leaves take it up," says Stroock. "Our next step will be to include a collaboration with a company that has the industrial expertise for formulating a spray like that."

Digital Agriculture, Breaking New Ground in Collaboration

Stroock has taken his love of collaboration to a new level as the associate director and one of the founding members of the Cornell Initiative for Digital Agriculture. The initiative is a collaboration of researchers from SIPS, CALS, Computing and Information Science, the Colleges of Engineering, Business, and Veterinary Medicine.

"This initiative is an enormous opportunity with lots of grassroots enthusiasm that's been matched by top-down support from the deans and provosts," says Stroock. "It's the beginning of a new phase of bioengineering in agriculture where I think Cornell can be a world leader. It's a very exciting time to start conversations with plant biologists who never thought they'd ever be talking to an engineer like me."



Referring to the AquaDust, which is a hydrogel nanoparticle, "You make the plant turn into a sensor of itself. When you fly a drone with a camera over the field, you could potentially collect the whole field's data in half an hour."

Dave Burbank

Scientists Unwind Mystery Behind DNA Replication

By Linda B. Glaser
Cornell Chronicle
October 17, 2019

The molecules of life are twisted. But how those familiar strands in DNA's double helix manage to replicate without being tangled up has been hard to decipher. A new perspective from Cornell physicists is helping unravel the mystery.

Researchers approached the problem from a topological perspective, asking what impact the helix shape itself has on deoxyribonucleic acid (DNA) replication. Using eukaryotes — which comprise the vast majority of living things — as their model system, they found that the intrinsic mechanical properties of the chromatin (a complex of DNA and proteins) determine how the chromatin fibers will entwine.

This topology is crucial to the successful separation of newly replicated DNA: If the fibers twist too tightly too early, then the molecules are unable to properly segregate during cell division.

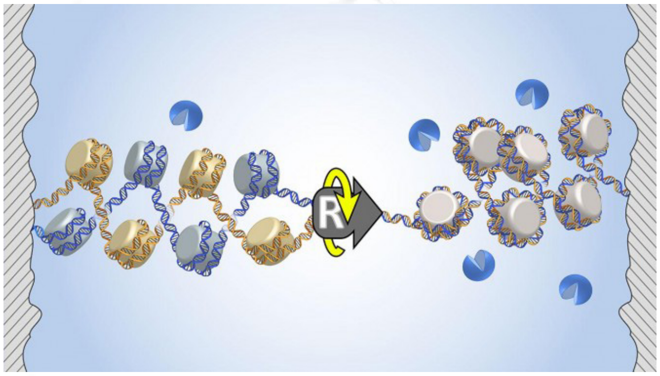
"This research highlights the importance of physical principles in fundamental biological processes," said lead author Michelle Wang, professor of physics in the College of Arts and Sciences and a Howard Hughes Medical Institute Investigator.

The paper, "Synergistic Coordination of Chromatin Torsional Mechanics and Topoisomerase Activity," published October 17 in Cell.

During DNA replication — as a replisome splits two DNA strands and moves forward — the DNA must also twist around the helical axis. This puts DNA under a great deal of torsional stress, which then results in an extra twist in the DNA.

The question: Where does the extra twist go? If the extra twist goes only to the front of the replisome, then the two daughter DNA molecules would not get tangled up, so they can separate. However, if the extra twist goes to the back of the replisome, then the two daughter DNA molecules would get tangled up and could not separate. This would create a major issue for chromosome segregation during cell division, which could cause DNA damage and result in cell death or cancer.

The researchers found that twisting a single chromatin fiber is much easier than twisting a double fiber. This means that the extra twist will preferentially go to the front, thus minimizing the intertwining of the two daughter DNA molecules.



An illustration of chromatin fiber and the enzyme topoisomerase II during DNA replication. Wang Lab.

"Although chromatin is normally considered an obstacle to replication," Wang said, "our results show that chromatin also simplifies replication topology and thus facilitates replication dynamics. We feel that this is rather remarkable."

In a separate experiment, the researchers found that an enzyme that untangles DNA (topoisomerase II) strongly prefers the single chromatin fiber in the front. The chromatin mechanics and topoisomerase activity seem to coordinate in a synergistic fashion to reduce daughter strand intertwining.

In order to understand how chromatin behaves mechanically, the researchers had to create new ways of handling it. Creating a substrate of braided chromatin fibers had not been previously attempted, because of the complexity of the task. Wang and her team used the angular optical trap tool that her group previously developed, as well as other methods to both create and work with both single and braided chromatin fiber substrates, enabling them to examine their torsional mechanical properties.

Paper co-authors include postdoctoral associates Tung Le, Xiang Gao and Jessica Killian from the Laboratory of Atomic and Solid State Physics; research specialist James Inman; graduate students Seong ha Park, Jaeyoon Lee and Ryan Badman; and Joyce Lee and James Berger of Johns Hopkins University School of Medicine. This work was performed in part at the Cornell NanoScale Facility (CNF), a member of the National Nanotechnology Coordinated Infrastructure (NNCI), which is supported by the National Science Foundation (Grant NNCI-1542081).

Aaron Windsor Receives M.S. in Biomedical Engineering

Cornell University
Meinig School of Biomedical Engineering

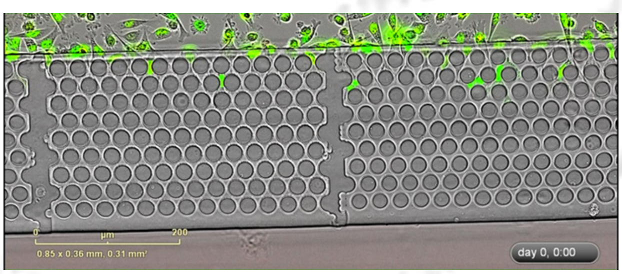
The Meinig School of Biomedical Engineering was thrilled this past spring to add its first staff graduate to the commencement program; Aaron Windsor, an employee at Cornell NanoScale Facility (CNF), and a member of the Meinig School's Lammerding Research Group, received his M.S. in biomedical engineering in May.

Windsor being hooded by Lammerding at the May 2019 BME Commencement. (Heather Ainsworth Photography)

While Windsor's walk across the stage to receive his diploma took minutes, his journey to that moment began nearly 15 years earlier when he started as a tech at the Cornell Nutrient Lab in July 2004. After moving to a Research Support Specialist (RSS) position at Laboratory of Elementary Particles Physics (LEPP) in 2006, Windsor found a home at the CNF in 2009. Through his work at CNF, Windsor discovered his role involved more than facility maintenance and he came to appreciate the interdisciplinary and rapidly-evolving nature of the nanotechnology field.

After a year at CNF, Windsor decided he could best serve this diverse research community by going back to college. He began by auditing nanofabrication courses through Cornell's part-time study (formerly extramural study) program, but when he found he was not absorbing any of the material that way, he decided to start taking the courses for credit. This decision, said Windsor, not only helped him learn what came easy at his later age, but also gave him the credentials required for his next step; entering a graduate program.

"After assisting others with their research and external remote projects, I wanted to work on something that was my own."



Windsor's research at the Meinig School focused on designing microfluidic devices that mimic the confined environment inside living tissues, enabling the study of cancer metastasis in vitro. Shown here are fluorescently-labeled cancer cells migrating through such a microfluidic device (Image: Lammerding Lab).

Windsor approached the Biomedical Engineering (BME) field about entering graduate school through Cornell's Employee Degree Program. "I remember professor Chris Schaffer asking me if I wanted to do a lengthy research project or make some 'cool stuff' and I knew [BME] was the right place for me," said Windsor. It turned out Meinig School Professor Jan Lammerding was looking for a student with CNF experience, and the rest is history.

"I couldn't have asked for a better group of people to work with for over the past three years," said Windsor.

The feeling was mutual. "It was wonderful having Aaron in our lab," said Lammerding of Windsor's role and impact. "His outstanding experience with nanofabrication lead to the implementation of several new ideas and fabrication of microfluidic devices that are now being used in the lab on a daily basis."

While the experience was worthwhile, Windsor acknowledges there were also challenges. "I graduated with my B.S. in biology in 1995 before the internet existed, so there was a huge technical gap I had to overcome. As a non-traditional student, I was on my own most of the time, which sometimes made class work and projects difficult. Plus, I was single when I started taking classes nine years ago and now I'm married with two children. I had to do most of my work after my family went to bed, so I haven't really slept much in the past six years."

But it was worth the work, says Windsor. "I am extremely thankful for Cornell not only to be an employee, but also, now, an alumnus. I now feel I am truly a part of the university."

Symposium Honors Nanofabrication Pioneer Harold Craighead

By Syl Kacapyr
Ezra Magazine
Cornell Chronicle
June 5, 2019

(Laura Mortelliti/Cornell University)

Harold Craighead sits next to his wife, Teresa, as former students share stories during a symposium honoring his career, held on June 1st in Physical Sciences.

Nanoscale scientists and industry professionals gathered in Cornell's Physical Sciences Building June 1st for a symposium to honor the career of nanofabrication pioneer Harold Craighead, Ph.D. '80, the Charles W. Lake Professor of Engineering, who will become an emeritus professor July 1st.

Craighead, who became a professor in the School of Applied and Engineering Physics in 1989, focused his research on micro- and nanofabrication and on finding biological applications for the unique microscopic nanostructures he was creating.

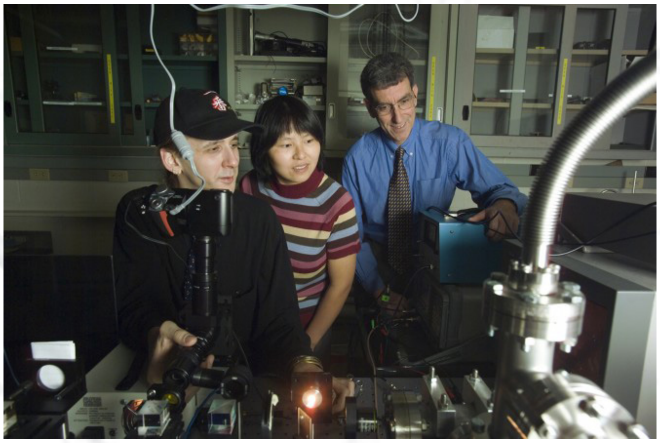
In 1997, he entered The Guinness Book of World Records after he and his graduate student Dustin Carr, working at the Cornell NanoScale Science & Technology Facility, used electron-beam lithography to carve the world's smallest guitar out of crystalline silicon. At 10 micrometers long, the instrument was as small as a human blood cell and demonstrated a new technique for fabricating at the nanoscale (see page 19). Using similar techniques, Craighead began his most notable work in engineering a nanofluidic device that can separate, count and analyze individual DNA molecules.

Lois Pollack, director of the School of Applied and Engineering Physics, said Craighead's work has been important to the field of biology, especially "what he's done for single-molecule analysis, like DNA sequencing. His ideas, like working on a zero-mode waveguide, really started a brand new way of sequencing DNA and that's had a huge impact."

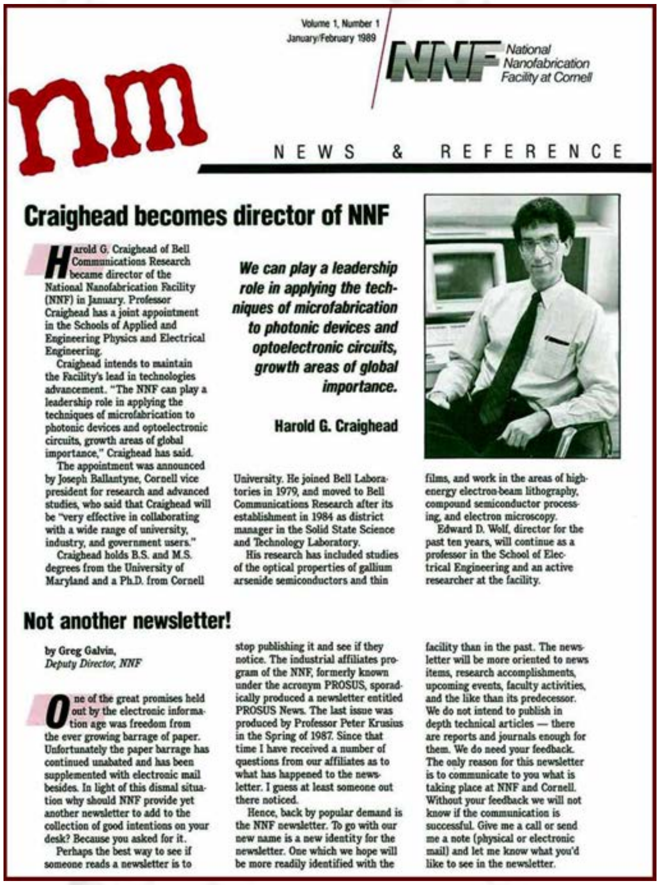
Craighead used the zero-mode waveguide technology – essentially a nanosized hole in metal film that enables scientists to examine individual DNA molecules – to co-found the company Nanofluidics, which eventually became Pacific Biosciences of California and is valued at more than $1 billion.

His lab also engineered devices that can detect single-cell bacteria and viruses, the accuracy of which was demonstrated when Craighead detected the mass of a single E-coli bacterium weighing just 6.3 attograms, an achievement that earned him a second spot in the record book, this time for lightest object weighed.

Craighead served as director of his school from 1998 to 2000, director of what is now the Cornell NanoScale Science and Technology Facility from 1989-95 (see page 19), and interim dean of the College of Engineering from 2001-02. Among other accolades, he is a member of the National Academy of Engineering and the National Academy of Inventors.



Harold Craighead, with graduate students Bojan Ilic and Yanou Yang, in his lab in 2004. (UPhoto)



Volume 1, Number 1
January/February 1989

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NNF National Nanofabrication Facility at Cornell

NEWS & REFERENCE

Craighead becomes director of NNF

Harold G. Craighead of Bell Communications Research became director of the National Nanofabrication Facility (NNF) in January. Professor Craighead has a joint appointment in the Schools of Applied and Engineering Physics and Electrical Engineering.

Craighead intends to maintain the Facility's lead in technologies advancement. "The NNF can play a leadership role in applying the techniques of microfabrication to photonic devices and optoelectronic circuits, growth areas of global importance," Craighead has said.

The appointment was announced by Joseph Ballantyne, Cornell vice president for research and advanced studies, who said that Craighead will be "very effective in collaborating with a wide range of university, industry, and government users."

Craighead holds B.S. and M.S. degrees from the University of Maryland and a Ph.D. from Cornell University. He joined Bell Laboratories in 1979, and moved to Bell Communications Research after its establishment in 1984 as district manager in the Solid State Science and Technology Laboratory.

His research has included studies of the optical properties of gallium arsenide semiconductors and thin films, and work in the areas of high-energy electron-beam lithography, compound semiconductor processing, and electron microscopy.

Edward D. Wolf, director for the past ten years, will continue as a professor in the School of Electrical Engineering and an active researcher at the facility.

We can play a leadership role in applying the techniques of microfabrication to photonic devices and optoelectronic circuits, growth areas of global importance.

Harold G. Craighead

Not another newsletter!

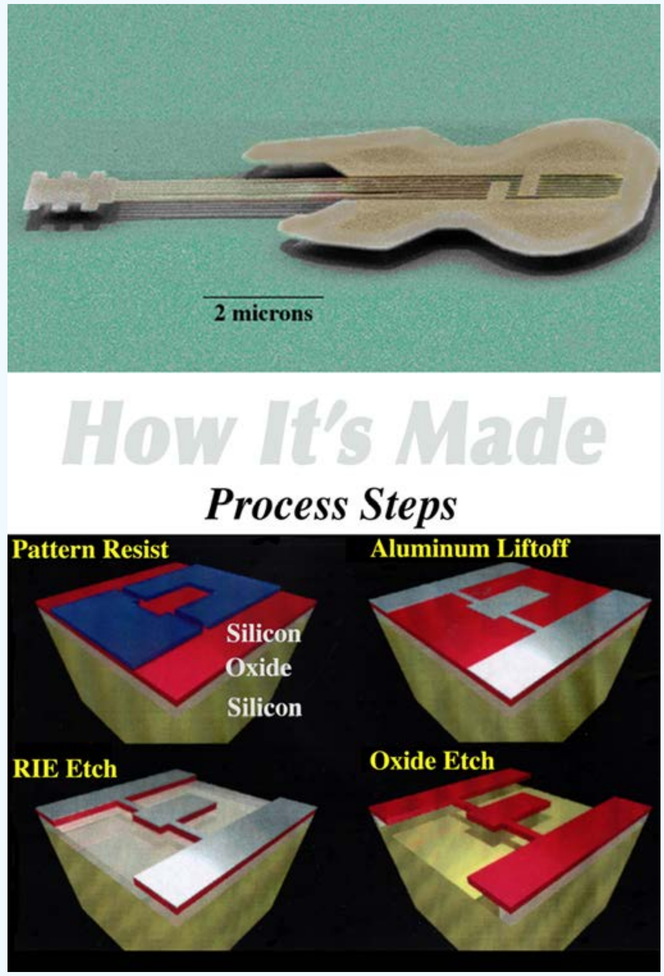
by Greg Galvin,
Deputy Director, NNF

One of the great promises held out by the electronic information age was freedom from the ever growing barrage of paper. Unfortunately the paper barrage has continued unabated and has been supplemented with electronic mail besides. In light of this dismal situation why should NNF provide yet another newsletter to add to the collection of good intentions on your desk? Because you asked for it.

Perhaps the best way to see if someone reads a newsletter is to stop publishing it and see if they notice. The industrial affiliates program of the NNF, formerly known under the acronym PROSUS, sporadically produced a newsletter entitled PROSUS News. The last issue was produced by Professor Peter Krusius in the Spring of 1987. Since that time I have received a number of questions from our affiliates as to what has happened to the newsletter. I guess at least someone out there noticed.

Hence, back by popular demand is the NNF newsletter. To go with our new name is a new identity for the newsletter. One which we hope will be more readily identified with the facility than in the past. The newsletter will be more oriented to news items, research accomplishments, upcoming events, faculty activities, and the like than its predecessor. We do not intend to publish in depth technical articles — there are reports and journals enough for them. We do need your feedback. The only reason for this newsletter is to communicate to you what is taking place at NNF and Cornell. Without your feedback we will not know if the communication is successful. Give me a call or send me a note (physical or electronic mail) and let me know what you'd like to see in the newsletter.

The NanoMeter, Volume 1, Issue 1. CNF Archives.



The award winning nanoguitar. CNF Archives.

Through it all, Craighead said it is the relationships he formed that he'll remember most.

"The most rewarding part of my time at Cornell was the ability to interact with intelligent, bright, active young and older people," Craighead said to symposium attendees, most of whom were former students. "So as I look back at my career, it'll be interactions with all of you that really made it worthwhile."

Christine Tan, Ph.D. '11, was one of several former students invited to present at the symposium. She is the vice president of business development for the Fuzhou Internet of Things Open Lab in China, and said several lessons she learned from Craighead have been helpful throughout her career, including the lifelong curiosity he instilled in her.

"I learned even the simplest thing can be filled with signs and concepts and theories," said Tan. "It's very easy to make assumptions, especially about things we don't know. The onus and responsibility is on us as scientists to really learn, keep an open mind, and really go and find out for ourselves."

Jose Moran-Mirabal, Ph.D. '07, associate professor of chemistry and chemical biology at McMaster University in Hamilton, Ontario, studied the interaction between liquid membranes and nanostructured materials as a member of Craighead's research group.

"What I really appreciated from Harold is that he gave you all the freedom to do the stuff you found most interesting," said Moran-Mirabal.

Current postdoctoral researcher Harvey Tian, Ph.D. '17, agreed.

"It's been a lot of freedom, but a lot of guidance at the same time. Harold sort of guides you in a way that still makes you feel like you can discover your own way as you go," said Tian, who continues to build microfluidic devices to investigate cancer cells as the last remaining member of Craighead's research group.

Craighead thanked the organizers and those in attendance, including his wife, Teresa, and his son, Daniel. While he won't be teaching in his retirement, he plans to stay active and continue some of his work.

"I don't look at this as the end of something," Craighead said, "but sort of the change of how I operate at Cornell and elsewhere."

Jonathan Butcher

Christopher J. Hernandez

Three Meinig School Faculty Inducted into AIMBE's Prestigious College of Fellows

March 25, 2019

The American Institute for Medical and Biological Engineering (AIMBE) announced the induction of Cornell faculty Jonathan Butcher, Christopher Hernandez, and Chris Schaffer to its College of Fellows. Election to the AIMBE College of Fellows is among the highest professional distinctions accorded to a medical and biological engineer. The College of Fellows is comprised of the top two percent of medical and biological engineers. College membership honors those who have made outstanding contributions to "engineering and medicine research, practice, or education" and to "the pioneering of new and developing fields of technology, making major advancements in traditional fields of medical and biological engineering, or developing/implementing innovative approaches to bioengineering education."

Drs. Butcher, Hernandez, and Schaffer, were nominated, reviewed, and elected by peers and members of the College of Fellows for the following:

Jonathan Butcher, Ph.D. (Professor and Associate Director, Director of Undergraduate Studies) for "pioneering the emerging field of heart valve mechanobiology by combining cardiovascular tissue mechanics with paradigms from developmental biology."

Christopher J. Hernandez, Ph.D. (Associate Professor) for "outstanding contributions to the understanding of bone mechanical properties and bone quality."

Chris Schaffer, Ph.D. (Associate Professor) for "outstanding contributions to understanding the cellular interactions that drive neurological disease using nonlinear optical techniques."

A formal induction ceremony was held during the AIMBE Annual Meeting at the National Academy of Sciences in Washington, DC on March 25, 2019. Drs. Butcher, Hernandez, and Schaffer join 156 colleagues who make up the AIMBE College of Fellows Class of 2019. AIMBE Fellows are among the most distinguished medical and biological engineers including two Nobel Prize laureates and seventeen Presidential Medal of Science and/or Technology and Innovation recipients.

Jared Maxson

Brad Ramshaw

Three on Cornell Faculty Awarded DOE Early Career Grants

August 1, 2019

Three Cornell faculty members were awarded grants by the U.S. Department of Energy (DOE) as part of its Office of Science Early Career Research Program.

All three — Greeshma Gadikota, assistant professor of civil and environmental engineering and the Croll Sesquicentennial Fellow; Jared Maxson, Ph.D. '15, assistant professor of physics; and Brad Ramshaw, assistant professor of physics — will receive at least $750,000 over five years to support their scientific endeavors.

Gadikota will use the funds to pursue her research in developing clean methods for storing and delivering energy, while simultaneously converting the carbon dioxide created in energy production to a useful, environmentally harmless solid.

Jared Maxson's research aims to create electron beams that can observe interactions of light and matter on some of nature's fastest time scales – quadrillionths of a second. Ultrafast light-matter interactions interest researchers because they can generate and control entirely new properties in materials, potentially including superconductivity. "We want to make an electron beam probe that can watch light rearrange atoms in real time, to enable researchers to understand how and why new phenomena emerge on very short time scales," Maxson said. Maxson, whose lab studies high-brightness electron beams and works at the Cornell NanoScale Facility (CNF), joined the College of Arts and Sciences faculty in 2017.

Brad Ramshaw's research proposes a new method, based on extremely high-frequency ultrasound, to solve the decades-old problem of measuring the viscosity of electrons moving through ultra-pure metals. Ramshaw's project makes use of the CNF and hopes to answer fundamental questions about how electrons in metals interact with each other, and to guide the use of new ultra-pure metals into future nanoscale electronic devices. Ramshaw, whose lab designs and builds experiments to probe the fundamental transport and thermodynamic properties of quantum materials, has been on the Arts and Sciences faculty since 2017.

Liepe, Sethna, Xing

Three Faculty Elected Fellows of American Physical Society

By David Nutt
Cornell Chronicle
September 24, 2019

Three professors — representing the departments of physics, materials science and engineering, and electrical and computer engineering — have been elected fellows of the American Physical Society (APS).

The fellowship program recognizes physicists who have made exceptional contributions in physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education.

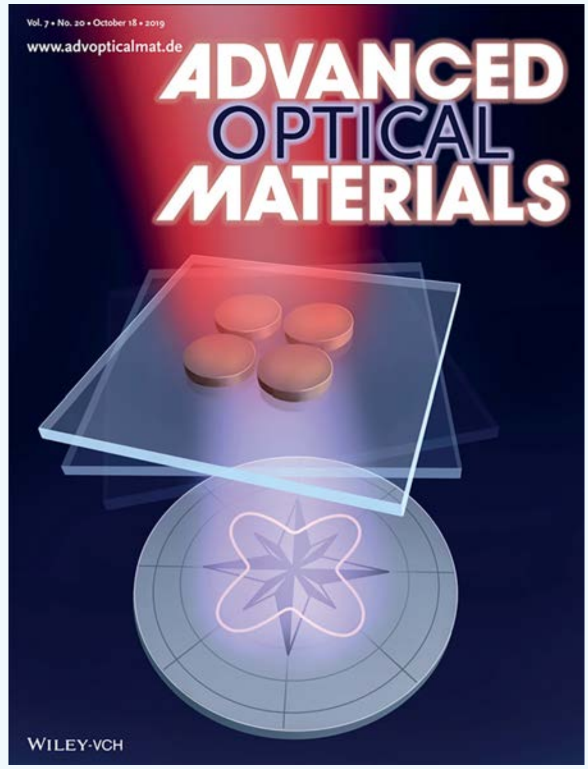
Matthias Liepe, professor of physics in the College of Arts and Sciences, was elected for multiple contributions to the fundamental science and engineering of radiofrequency superconducting materials, accelerating cavities, cryomodules, and instrumentation and controls. He was also honored for excellence in graduate and undergraduate physics education. Liepe studies the science, technology and applications of bulk and thin-film superconductors in high electromagnetic fields at ultra-high frequencies.

James Sethna, professor of physics in the College of Arts and Sciences, was cited for seminal and wide-ranging contributions to information geometry, "sloppy models," crackling noise, fracture and emergent self-similarity. His work explores how multiparameter, or "sloppy," models behave collectively; his team is using statistical mechanics to understand plasticity and fracture in disordered materials.

Huili Grace Xing, the William L. Quackenbush Professor of Electrical and Computer Engineering, and Materials Science and Engineering in the College of Engineering, was elected for pioneering contributions in polar wide-bandgap semiconductors, 2D crystal semiconductors and layered crystals. Her research focuses on semiconductor electronic and optical materials and devices, primarily III-V nitride semiconductors, 2D crystals, gallium oxide, more recently piezoelectric, multiferroics and magnetic materials.

APS fellowship is limited to no more than 0.5% of all APS members in a given year. There were 168 members elected APS fellows this year. A total of 108 Cornell researchers have been elected since the fellowship was established in 1921.

(All three are principal investigators at the Cornell NanoScale Science & Technology Facility.)



Hi Melanie-Claire,

The **Gennady Shvets Research Group** just had a paper on the cover of Advanced Optical Materials (see above) — work performed in part at the Cornell NanoScale Facility!

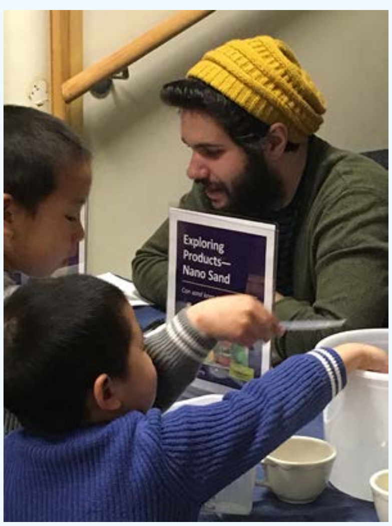
Max

"Tailored Nonlinear Anisotropy in Mie-Resonant Dielectric Oligomers"; Maria K. Kroychuk, Damir F. Yagudin, Alexander S. Shorokhov, Daria A. Smirnova, Irina I. Volkovskaya, Maxim R. Shcherbakov, Gennady Shvets, Yuri S. Kivshar, Andrey A. Fedyanin. https://doi.org/10.1002/adom.201900447. First published: 28 July 2019

Professor Zehnder named a Fellow of the Society for Experimental Mechanics

In recognition of distinguished contributions to the field of experimental mechanics, and service to that field through the Society, **Professor Alan Zehnder** was recognized as a Fellow of the Society for Experimental Mechanics at their June 2019 meeting.

NanoDays 2019



The CNF took part in the Cornell Conference and Event Services STEM Expo for the National Science Olympiad Tournament on May 31st. About 400 high school students out of 1800 registered participants stopped by the CNF tables and talked to Beth Rhoades (CNF), Dan Ralph (AEP), Arianna Gagnon (CCMR), Ryan Bouck (CCMR), Bill Katt (CNF Outreach Ambassador), and Brian Schaefer (CNF Outreach Ambassador).

A FEW SCENES from a YEAR of CNF OUTREACH!

Taylor Oeschger (below), Grad SWE Outreach Coordinator, who worked with 129 Girl Scouts between 2nd-7th grades, said; "The girls had a lot of fun and were super excited to show off their UV detector bracelets made with CNF beads. I also handed out all the LED pens and the environment issue of the Nanooze! Thank you so much for your support!"

(UPhoto)

THE 2019 CNF FIVE
left to right, above:

Ms. Katie Munechika
CNF REU PI: David Erickson

Ms. Anna Alvarez
CNF REU PI: Itai Cohen

Mr. Jacob Baker
CNF REU PI: Guillaume Lambert

Mr. Darien Nguyen
CNF REU PI: Alireza Abbaspourrad

Mr. James Tran
CNF REU PI: James R. Engstrom

(CNF REU intern photos above and below were taken by Don Tennant.)

The 2019 REU Program

https://cnf.cornell.edu/education/reu

During the summer of 2019, CNF hosted five Research Experiences for Undergraduates (REU) interns. In addition, six interns from Cornell University's Platform for the Accelerated Realization, Analysis, and Discovery of Interface Materials (PARADIM) REU Program were included in our activities. CNF also coordinated the NNCI International REU Program for six interns in Japan (NNCI iREU @ NIMs). Finally, the CNF was honored to host the 2019 National Nanotechnology Coordinated Infrastructure (NNCI) REU Convocation, where 61 NNCI interns plus three Johns Hopkins University PARADIM REUs joined us for presentations, posters, and swing dancing! Each of the CNF, iREU, and PARADIM interns completed a 10-week research project and submitted a final report, found online at https://cnf.cornell.edu/education/reu/2019. After those online reports is the convocation info and a photo album from the summer!

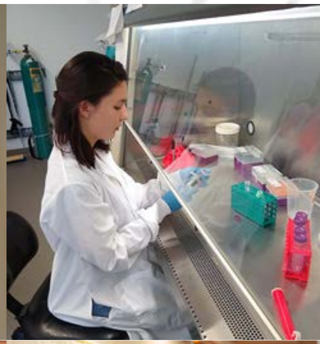
Hi Melanie-Claire, the paper resulting from the special nanoparticles **Wagma Caravan** helped fabricate for us as a CNF REU student was just published in a high impact journal. All the particles in the paper were made during her 2016 summer tenure, we just did follow-up analysis on them for a couple years and then published. Thanks for hosting her and inviting us to join the program that year!
https://pubs.acs.org/doi/abs/10.1021/acsami.9b10041

Ryan Badman, PhD Student, M. D. Wang Group

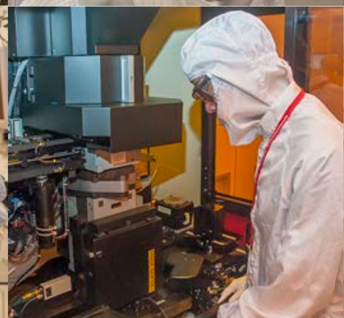
Eligible undergraduates are encouraged to apply to the 2020 REU Programs!
http://reu.nnin.org/









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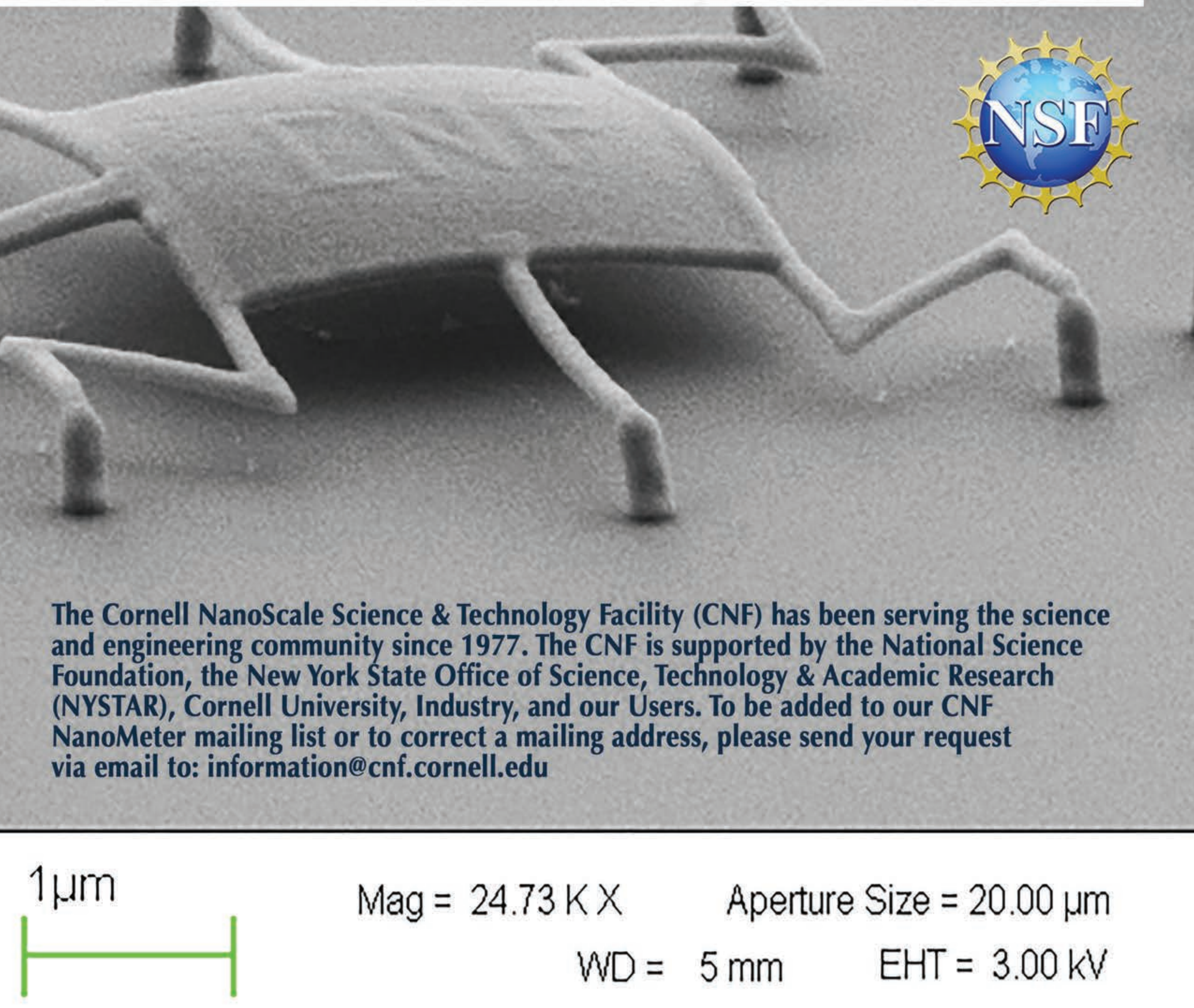

The Cornell NanoScale Science & Technology Facility (CNF) has been serving the science and engineering community since 1977. The CNF is supported by the National Science Foundation, the New York State Office of Science, Technology & Academic Research (NYSTAR), Cornell University, Industry, and our Users. 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