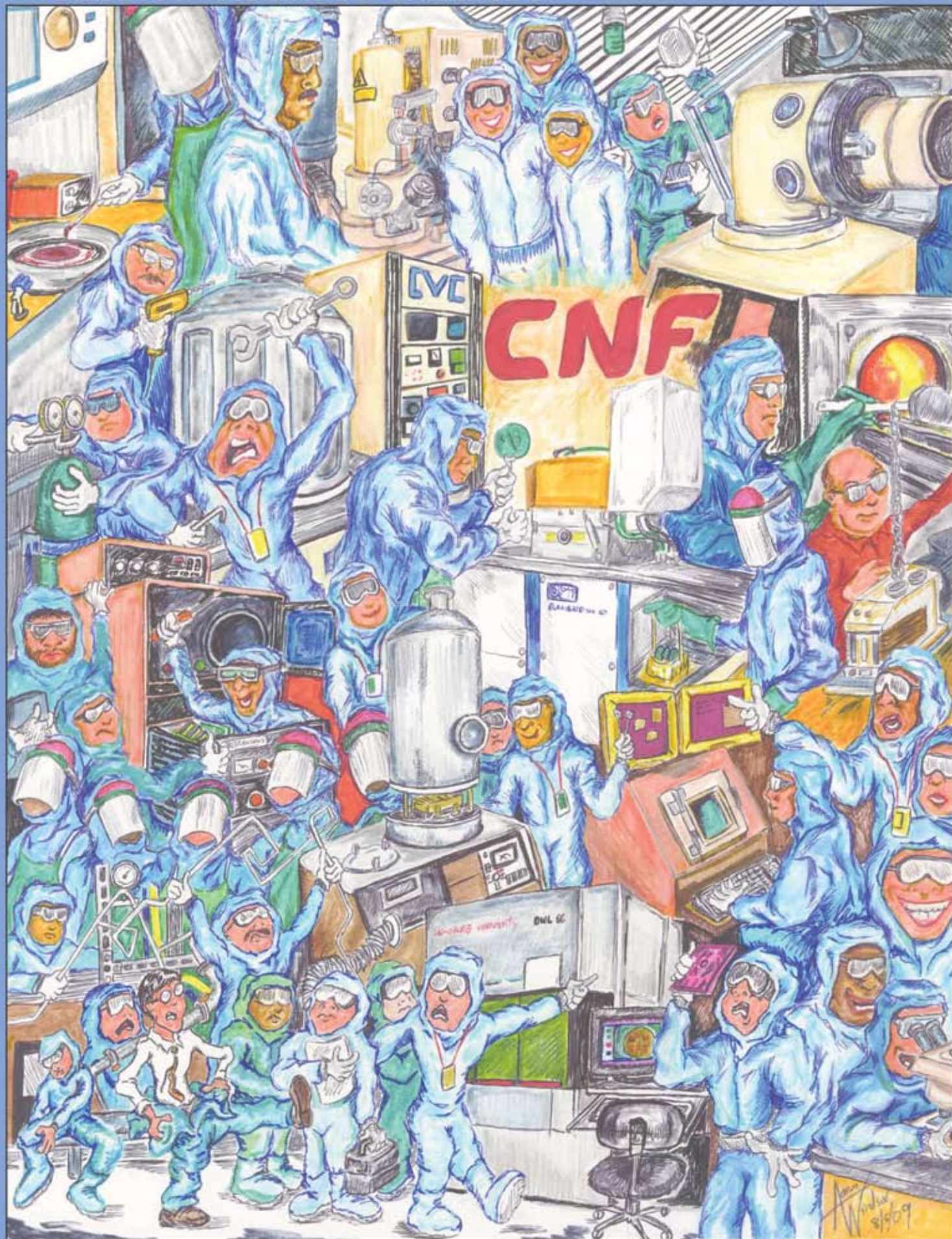


NanoMeter

Fall 2009 • Volume 18 • Number 2

The newsletter of the Cornell NanoScale Science & Technology Facility



Director's Column

It is with great pleasure that I present the 2009 Fall issue of NanoMeter. In it you will read about the latest developments at the Cornell NanoScale Facility (CNF), including new staff members, equipment acquisitions, research highlights, and various technical and social events. It has been a very exciting six months since the last NanoMeter and there is plenty of good news to report!

August 2009 marks my last month as CNF Director, as I am moving back to Europe with my wife and son to be closer to our families. I would like to take this opportunity to reminisce about the past three years, to say goodbye, and most importantly, to thank the many people who helped me with this assignment over the past three years.

Let me start with the most important thing first. To the CNF staff, the heart and soul of this magnificent operation: I cannot adequately express how grateful I am to you. It has been an extraordinary pleasure and a privilege to work with you. I have learned a lot, was continuously inspired to strive for bigger and better things, and had a lot of fun in the process. This nanometer issue is dedicated to you.

My special thanks to my co-captain, Don Tennant, whose vision, experience and friendship made my job so much easier. Thanks are also due to the NNIN Director and my predecessor at CNF, Sandip Tiwari, for showing me the ropes (ditto for former interim director John Silcox) and for his always insightful advice. The Cornell administration has been very supportive; in particular Kent Fuchs, Chris Ober, Joe Burns, Steve Kresovich, and especially Bob Buhrman. I received a lot of help with outreach and publicity from Lesley Yorke, Tommy Bruce and Blaine Friedlander. The wisdom of the executive committee was of great help, while the user committee provided important feedback.

Through the efforts of the people listed above, CNF is in an exceptionally strong position today. Our award from the National Science Foundation was recently renewed, at an expanded level, for another five years. Support from NYSTAR and industry continues to be strong. Our user community has grown to record numbers, and the quantity and quality of research being produced at CNF are nothing short of amazing. It is rare that you read an issue of a high impact journal without seeing work that was enabled by CNF.

Several new staff members have joined CNF and are dedicating their talents to the service of the user community. Our equipment base has been expanded with key acquisitions of DUV and nanoimprint capabilities, with the addition of tools for atomic layer deposition, for carbon-based materials, and for thin film electronics, as well as with an expansion of our etching and characterization capabilities. A major expansion of our e-beam capabilities that will guarantee our continued leadership in this field for the next decade is in the works and will be announced soon. We anticipate additional major equipment acquisitions to be made possible through stimulus funding.

Our efforts to promote the use of nanotechnology have led us to engage the medical community with an office at the Weill Cornell Medical College in New York City. This effort has already yielded several exciting projects and we look forward to many more. The emerging field of carbon-electronics now has a home at CNF, with new tools and techniques that serve this rapidly expanding community. Our educational effort has been expanded, with many workshops offered over the past few years on topics ranging from the application of nanotechnology to cancer research, to the commercialization of nanotechnology. Our efforts on this front have achieved broad recognition: an NPR Science Friday show and an Associated Press article.

Last but not least, I would like to thank you, the user community of CNF. Your enthusiasm, creativity and loyalty to CNF have been a constant source of inspiration. I wish you all the best with your research endeavors.

Warm regards,
George Malliaras, *Lester B. Knight* Director



Aaron Windsor, Cover Artist



Our very own Aaron Windsor won the first ever Cornell Research Division Art Contest. His creation — the CNF technical staff hard at work in the clean room — graces this issue’s front cover.

Aaron works mostly in pen and ink (and whatever art supplies he can find at work or at Staples). He is currently working on a children’s book and a graphic novel. His website is: <http://www.aaron-windsor.com>.

Farewell to George...



It has been a privilege and a great pleasure to work with George Malliaras, our CNF Director, these past three years. We will miss his talent and contagiously positive outlook. He has provided new vision that brought initiatives in Nanomedicine and Carbon based electronics to CNF, among many other accomplishments. His generous nature is evidenced by his request to dedicate this issue of the Nanometer to the staff of CNF who we both believe are at the heart of CNF’s success.

We tip our glasses to you George, and wish you the very best in your new position across the pond!

Don Tennant
CNF Director of Operations

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Cornell NanoScale Science & Technology Facility
is a member of the

National Nanotechnology Infrastructure Network
www.nnin.org

and is supported by:

**The National Science Foundation,
the New York State Office of Science,
Technology and Academic Research,
Cornell University, Industry, & our Users.**

Photographs in this issue were taken by Charles Harrington Photography, and CNF staff members Don Tennant and Sam Wright — unless otherwise noted. Melanie-Claire Mallison created the layout.

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NIST-Cornell Team Builds World's First Nanofluidic Device with Complex 3-D Surfaces Chamber: Separates Nanoparticles like a 'Coin Sorter'

March 31, 2009
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Gaithersburg, MD

Researchers at the Commerce Department's National Institute of Standards and Technology (NIST) and Cornell University have capitalized on a process for manufacturing integrated circuits at the nanometer (billionth of a meter) level and used it to develop a method for engineering the first-ever nanoscale fluidic (nanofluidic) device with complex three-dimensional surfaces. As described in a paper published online today in the journal *Nanotechnology**, the Lilliputian chamber is a prototype for future tools with custom-designed surfaces to manipulate and measure different types of nanoparticles in solution.

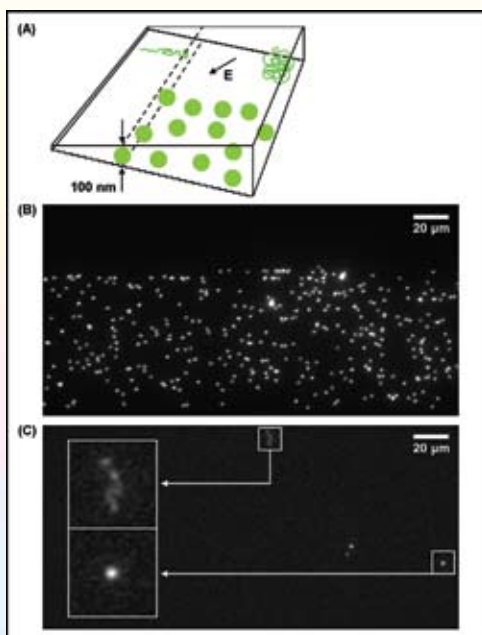
Among the potential applications for this technology: the processing of nanomaterials for manufacturing; the separation and measuring of complex nanoparticle mixtures for drug delivery, gene therapy and nanoparticle toxicology; and the isolation and confinement of individual DNA strands for scientific study as they are forced to unwind and elongate (DNA typically coils into a ball-like shape in solution) within the shallowest passages of the device.

Nanofluidic devices are usually fabricated by etching tiny channels into a glass or silicon wafer with the same lithographic procedures used to manufacture circuit patterns on computer chips. These flat rectangular channels are then topped with a glass cover that is bonded in place. Because of the limitations inherent to conventional nanofabrication processes, almost all nanofluidic devices to date have had simple geometries with only a few depths. This limits their ability to separate mixtures of nanoparticles with different sizes or study the nanoscale behavior of biomolecules (such as DNA) in detail.

To solve the problem, NIST's Samuel Stavis and Michael Gaitan teamed with Cornell's Elizabeth Strychalski to develop a lithographic process to fabricate nanofluidic devices with complex 3-D surfaces. As a demonstration of their method, the researchers constructed a nanofluidic chamber with a "staircase" geometry etched into the floor. The "steps" in this staircase—each level giving the device a progressively increasing depth from 10 nm at the top to 620 nm at the bottom—are what give the device its ability to manipulate nanoparticles by size in the same way a coin sorter separates nickels, dimes and quarters.

The NIST-Cornell nanofabrication process utilizes grayscale photolithography to build 3-D nanofluidic devices. Photolithography has been used for decades by the semiconductor industry to harness the power of light to engrave microcircuit patterns onto a chip. Circuit patterns are defined by templates, or photomasks, that permit different amounts of light to activate a photosensitive chemical, or photoresist, sitting atop the chip material, or substrate.

Conventional photolithography uses photomasks as "black-or-white stencils" to remove either all or none of the photoresist according to a set pattern. The "white" parts of the pattern—those that let light through—are then etched to a single depth into the substrate.



(A) Schematic of the NIST-Cornell nanofluidic device with complex 3-D surfaces. Each "step" of the "staircase" seen on the side marks a different depth within the chamber. The letter "E" shows the direction of the electric field used to move the nanoparticles through the device. The green balls are spheres with diameters of 100 nm whose size restricts them from moving into the shallower regions of the chamber. The coil in the deep end of the chamber (upper right corner) is a single DNA strand that elongates (upper left corner) in the shallow end.

(B) Photomicrograph showing fluorescently tagged spherical nanoparticles stopped at the 100-nm level of the chamber, the depth that corresponds to their diameter.

(C) Photomicrograph of a single DNA strand that is coiled in the deep end of chamber (box at far right) and elongated in the shallow end (box at far left). Larger boxes are closeups showing the fluorescently tagged strands. Credit: NIST

Grayscale photolithography, on the other hand, uses “shades of gray” to activate and sculpt the photoresist in three dimensions. In other words, light is transmitted through the photomask in varying degrees according to the “shades” defined in the pattern. The amount of light permitted through determines the amount of exposure of the photoresist, and, in turn, the amount of photosensitive chemical removed after development.

The NIST-Cornell nanofabrication process takes advantage of this characteristic, allowing the researchers to transfer a 3-D pattern for nanochannels of numerous depths into a glass substrate with nanometer precision using a single etch. The result is the “staircase” that gives the 3-D nanofluidic device its versatility.

Size exclusion of nanoparticles and confinement of individual DNA strands in the 3-D nanofluidic device is accomplished using electrophoresis, the method of moving charged particles through a solution by forcing them forward with an applied electric field. In these novel experiments, the NIST-Cornell researchers tested their device with two different solutions: one containing 100-nm-diameter polystyrene spheres and the other containing 20- μm -length DNA molecules from a virus that infects the common bacterium *Escherichia coli*. In each experiment, the solution was injected into the deep end of the chamber and then electrophoretically driven across the device from deeper to shallower levels. Both the spheres and DNA strands were tagged with fluorescent dye so that their movements could be tracked with a microscope.

In the trials using rigid nanoparticles, the region of the 3-D nanofluidic device where the channels were less than 100 nm in depth stayed free of the particles. In the viral DNA trials, the genetic material appeared as coiled in the deeper channels and elongated in the shallower ones. These results show that the 3-D nanofluidic device successfully excluded rigid nanoparticles based on size and deformed (uncoiled) the flexible DNA strands into distinct shapes at different steps of the staircase.

Currently, the researchers are working to separate and measure mixtures of different-sized nanoparticles and investigate the behavior of DNA captured in a 3-D nanofluidic environment.

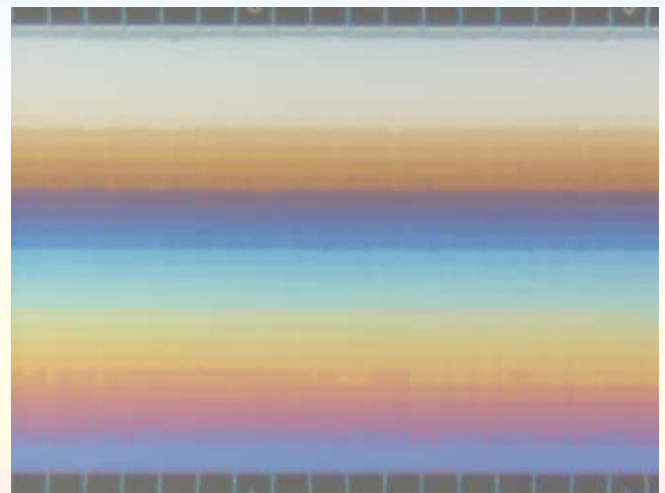
In a previous project, the NIST-Cornell researchers used heated air to create nanochannels with curving funnel-shaped entrances in a process they dubbed “nanoglassblowing.” Like its new 3-D cousin, the

nanoglassblown nanofluidic device facilitates the study of individual DNA strands. More information on nanoglassblowing may be found in the June 10, 2008, issue of NIST Tech Beat at http://www.nist.gov/public_affairs/techbeat/tb2008_0610.htm#glass.

The work described in the *Nanotechnology* paper was supported in part by the National Research Council Research Associateship Program and Cornell’s Nanobiotechnology Center, part of the National Science Foundation’s Science and Technology Center Program. The 3-D nanofluidic devices were fabricated at the Cornell NanoScale Science & Technology Facility and the Cornell Center for Materials Research, and characterized at the NIST Center for Nanoscale Science and Technology. All experiments were performed at the NIST laboratories in Maryland.

As a non-regulatory agency, NIST promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards and technology in ways that enhance economic security and improve our quality of life.

** S.M. Stavis, E.A. Strychalski and M.Gaitan. Nanofluidic structures with complex three-dimensional surfaces. Nanotechnology Vol. 20, Issue 16 (online March 31, 2009; in print April 22, 2009).*



Overhead view of the NIST-Cornell 3-D nanofluidic device showing the different depth levels within the chamber as horizontal bands. The deepest, at the bottom, measures about 620 nanometers (slightly smaller than an average bacterium), while the shallowest, at the top, is about 60 nanometers (1,000 times smaller than the width of a human hair). The colors of the bands result from different mixing of white light components (interference) at each depth. Credit: NIST

The Harry Potter Effect: Cornell Researchers Experiment with Making Objects 'Invisible'

May 12, 2009
Cornell Chronicle
By Bill Steele
ws21@cornell.edu

Somewhat the way Harry Potter can cover himself with a cloak and become invisible, Cornell researchers have developed a device that can make it seem that a bump in a carpet — or, indeed, any flat surface — isn't there. So far the illusion works only at the nanoscale, but the researchers suggest that the basic principle might eventually be scaled up for military and communications applications, or perhaps used in reverse to concentrate solar energy. Devices that bend microwaves around small objects have previously been demonstrated, but this is the first cloaking device to work at optical frequencies, the researchers said.

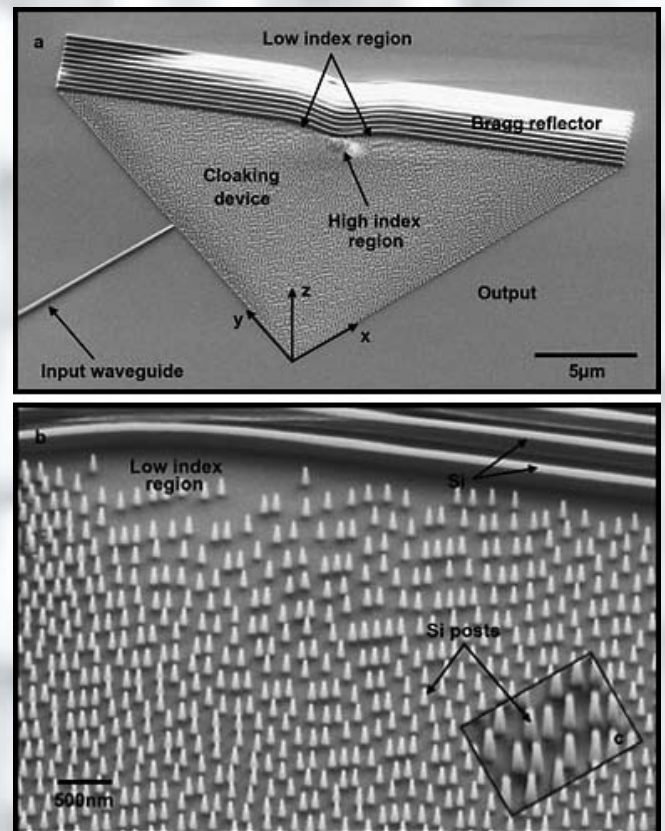
The experimental device was built by Michal Lipson, associate professor of electrical and computer engineering, and colleagues in her Nanophotonics Research Group, based on a design by British physicists Ulf Leonhardt at the University of St. Andrews and Sir John Pendry at Imperial College, London. It bends light bouncing off a reflective surface in a way that corrects for the distortion caused by a bump in the surface. Imagine controlling the light in front of a funhouse mirror so that reflections look perfectly normal, and the mirror looks flat. A similar device that works at one particular wavelength of infrared light has been reported by University of California-Berkeley researchers, but the Cornell device is expected to work over a range of wavelengths from infrared into visible red light.

On a silicon wafer, Lipson's group made a tiny reflector ~ 30 μm long with a 5- μm -wide bump in the middle, then placed an array of vertical silicon posts, each 50 nm in diameter, in front of it. Because the posts are much smaller than the wavelength of the light, the light behaves as if it were passing through a solid whose density varies with the density of the posts. As light passes between regions of high and low density it is refracted, or bent, in the same way light is refracted as it passes from air to glass. By designing smooth transitions of the density of posts, the researchers could control the path of the light to compensate for the distortion caused by the bump.

As a result, an observer looking at light reflected from the mirror sees a flat mirror, with no sign of the bump. The device is expected to work over a range of wavelengths from infrared into visible red light, the researchers said.

Of course it's still a long way to cloaking tanks on a battlefield. For starters, the thing being hidden has to hide behind a mirror, and the presence of a mirror would be a giveaway. A practical cloaking device also would have to adjust in real time to changing configurations of the object behind it. A variation of the method might be used to bend light around an object, the researchers suggested, and a light-bending device could be made much larger by using technology that stamps or molds nanoscale patterns onto a surface. Such refraction control might also be used in reverse, they added, to concentrate light in a small area to efficiently collect solar energy.

"At the core is the fact that we're manipulating light, telling it where to go and how to behave," said Carl Poitras, a research associate on the Cornell team.



Scanning electron microscope images of the cloaking device. Top: Light passes through silicon posts as it bounces off a deformed reflector. Varying density of the silicon posts bends light to compensate for the distortion in the reflector. Bottom: a close-up of the array of silicon posts, each about 50 billionths of a meter in diameter. The device was manufactured at the Cornell NanoScale Facility, which is supported by the National Science Foundation.



**This issue of
the NanoMeter
is dedicated
to the
CNE Staff**

(What follows is the current staff in the order of their hiring...)



Lynn Rathbun
Sometime 1979
NNIN Program Manager
CNF Laboratory Manager

Lynn was one of the first staff members, joining CNF (then the National Research and Resource Facility for Submicron Structures) in 1979, after receiving his Ph.D. from the University of Illinois. Since then, he has become the keystone for everything that happens here, including tool acquisition, NSF proposals, REU programs here and abroad, vegetable batteries (photo above), and Ling Ling Days. No one can quite imagine the CNF without Dr. Rathbun!



Michael Skvarla
Summer 1979
User Program Manager

I enjoy, immensely, the talent and the scientific achievements on display at the CNF. Every day, the researchers present challenges and opportunities that cannot be found elsewhere. It's a pleasure coming to work.



Karlis Musa
August 1989
IT Management

The two most rewarding aspects of working at the CNF are the variety of people you meet, and the variety of challenges that occur. The combination of the two keep things interesting and exciting.



Garry J. Bordonaro
March 1993
Photolithographic Process Engineer

CNF offers me the opportunity to work with leading-edge researchers on leading-edge projects using a leading-edge tool set. I am able to continue learning about my area of expertise while also learning about other disciplines. It is a very stimulating environment!



Jerry Drumheller
March 1994
Thin Film Tool Engineer

There is never a dull moment here. There are always machines to maintain, fix, or improve. There are always people looking for help, and training on machines, and processing. I enjoy working with all the really bright, enthusiastic, and driven people here. Finding a little time to play some Irish and French Canadian fiddle tunes is nice too....



Phil Infante
April 1994
Process Engineer

What makes working at the CNF always interesting is the varied backgrounds and disciplines of the facility users as well as the unique applications and challenges of their research needs here. Helping users finish their time at the CNF on a successful and positive note is always rewarding.



Denise Budinger
June 1994
CNF Financial Manager

I really enjoy the diversity of my job. I am responsible for the CNF user billing (outside users) and Accounts Receivable as well as the Accounts Payable, including financial reporting. There is never a dull moment and I also enjoy helping others when needed. I have met a lot of wonderful people during my career at the CNF both outside of Cornell University and within Cornell University. At George Malliaras' farewell luncheon, he hit it right on the nose when he said "the CNF is like a family to me" — that statement is how I feel as well!



Melanie-Claire Mallison
September 1996
CNF Corporate & Public Relations
NNIN REU Program Assistant

My favorite part of my job at the CNF is meeting people from all over the world, setting them up for a tour or participation in one of our fabulous events, and then feeding them well. The people I most enjoy meeting (and taking care of) are our summer undergraduate interns. Their energy and enthusiasm for learning nano-research is wonderful.



Vince Genova
October 1999
Etch Engineer

My CNF responsibilities include plasma etch process development and characterization, and development of atomic layer deposition (ALD) processes. I am responsible for the cooperative development agreements with Oxford Instruments in the areas of etching and ALD. I serve also as a NNIN technical liaison in the areas of plasma etching, ALD, MEMS, advanced silicon electronic devices, and III-V based devices.



Daniel Woodie
February 2000
Lab Use Manager

The thing I enjoy most about my job here is getting to see the rich variety of research being done, without having to do all the hard work myself. I enjoy helping out in the CMP, film deposition, and photolithography areas. Some users say they are intimidated by me since I enforce the lab rules, but I really am a nice guy!



Sam Wright
July 2000
Research Equipment Technician

What I find exciting about my job—seeing a new user come into the lab and talk about a new idea that maybe has never been tried before. And then watch their progress as they work in the lab, whether it be a long term project or a short term project. Although often I may not know or fully understand the details of the project, it's rewarding to know that I may have helped them in some way along their trials to make their research project work.



Alan Bleier
January 2001
Microelectronics Engineer
Sr. Research Associate

I love working with smart users and learning from them. I do electron beam lithography, CAD training and support for sustainable energy projects at CNF.



Daron Westly
June 2001
Process Engineer for Electron Beam Lithography and Electron Microscopy

What really attracted me to CNF was the all the free food... and technology. CNF is the perfect place to work for someone who needs a daily fix of highly caffeinated science. Mix that with a 60 million dollars of toys and the fun never stops.



John Treichler
August 2001
Research Support Specialist III

I often work with visiting users whose projects require ebeam lithography or photo-lithography. I enjoy working with lab users and staff and appreciate that the variety of their projects keeps teaching me new things. I am usually at the CNF every other week.



Meredith Metzler
March 2002
Research Support Specialist

I enjoy working at the CNF because I get to interact with many researchers whose work spans the entire spectrum from fundamental sciences to companies working on prototype next generation technologies.



Kelly Baker
August 2002
Equipment Technician

Kelly is responsible for keeping the CNF stocked with chemicals, beakers and such, and of course, bunny suits! Demands keep Kelly hopping, but he appreciates that once his day is done, he gets to go home to a fabulous family and they all go jump over mountains on their bikes! Or something equally awe-inspiring to the rest of the CNF staff... (The inset photo is of Kelly flying through his home course!)



Rob Ilic
August 2002
Research Associate
User Program Manager

My position presents an opportunity to participate and offer advice in a variety of exciting multidisciplinary projects with significant impact on the global scientific community. The position enables interaction with a diverse set of researchers along with continuously pushing the limits in order to maintain the mental capacity to provide expert advice on topical problems in modern scientific research of disparate endeavors.



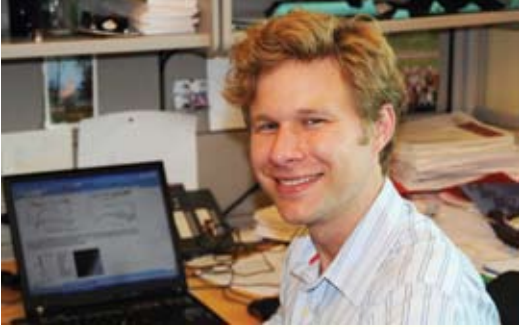
Paul Pelletier
April 2003
Equipment Technician

I am involved in many aspect of the CNF on a daily basis and I never seem to do the same thing two days in a row which is the main reason why I like my job. I am responsible for installation and maintenance of the toxic gas distribution systems. I coordinate our equipment installations and I operate and maintain the Eaton Ion Implanter, AG RTP-8108, and Oxford ALD. I also work with the Duffield Hall building coordinator in maintain the toxic gas monitoring system and other facility systems.



Kathy Springer
April 2003
Administrative and User Program Assistant

The best part of my job is working with our facility users. I meet and work with new people every week from around the world!! I get to welcome our new users and help them settle in and become part of the CNF family. Everyday is different!!!



Derek Stewart
November 2004
Computational Research Associate
NNIN Computation Liaison

I manage the NNIN nanoscale simulation effort at the CNF. I enjoy serving as the resident theorist (with a few guest appearances in the clean room) and working with researchers from around the world on new and challenging problems. With research projects, workshops to organize, new simulation tools, and a computer cluster to run, it's definitely never a dull job!



Edward Camacho
August 2006
Research Support Specialist II
Photolithography Engineer

There are many things that make my job wonderful. You can't get tired or bored of your work day because they are never the same. One day I could be in a technology conference and the next I could be meeting with a researcher to talk over what is wrong with their process in order to find a solution. The lab and its assets—including the CNF staff, the tools and very diverse set of researchers—make this place a micro-reactor of world changing ideas, and guess what — I am taking notes.



David W. Botsch
October 2006
Programmer/Analyst

When it comes to computers, I am a jack of all trades. This job keeps me interested by challenging me to find solutions to new problems and to make disparate systems work well together. Add to that the fun-loving and open atmosphere of the CNF office, and I would be hard pressed to find a better place to work.



Beth Rhoades
January 2008
Life Sciences Liaison

Many projects at the CNF are inter-disciplinary, and it's my job to facilitate the biology-related ones. The best thing about this gig is the tremendous variety in people and projects. One week it's all about fabricating painless needles, and the next, it's looking for an engineer to collaborate on a device that screens the blood for circulating tumor cells.



Debasmita Patra
December 2008
Postdoctoral Associate
NNIN-SEI Associate

CNF is like a family and I feel fortunate for being a part of that family. I enjoy my work especially when I give the Social and Ethical Issues (SEI) Orientation to the new CNF users every Monday. I learn to value different perspectives in this process. Besides that, I conduct research, coordinate among other researchers, and maintain the NNIN-SEI website.



Rebecca Vliet
January 2009
Administrative Assistant IV

The CNF has so much to offer. There are very knowledgeable staff and users working together to create an ever changing and growing environment. This is a daily learning experience for all!



Aaron Windsor
February 2009
Thin Film Process Engineer

I like working here because they have free coffee..... Lots of free coffee. And I will never have to wear a PVC safety suit again. (Plus, he gets to win art awards ed. notes...)

'Lab On A Chip' to Give Growers Real-Time Glimpse into Water Stress in Plants

July 6, 2009
By Chris Bentley '10
cunews@cornell.edu

Fifteen years ago, when Alan Lakso first sought to enlist Cornell's nanofabrication laboratory to develop a tiny sensor that would measure water stress in grapevines, the horticultural sciences professor ended up back at the drawing board.

It wasn't until Abraham Stroock, associate professor of chemical engineering, had a breakthrough of his own that Lakso's vision began to take shape. Stroock's lab recently developed a synthetic tree that mimics the flow of water inside plants using a slab of hydrogel with nanometer-scale pores. At last Lakso had access to the technology to move forward.

The device is an embedded microsensors capable of measuring real-time water stress in living plants. In theory, the sensor will help vintners strike the precise balance between drought and overwatering — both of which diminish the quality of wine grapes.

"To manage for optimum stress," said Lakso, a researcher at the New York State Agricultural Experiment Station in Geneva, "we need to monitor ... exactly what's going on in the vine."

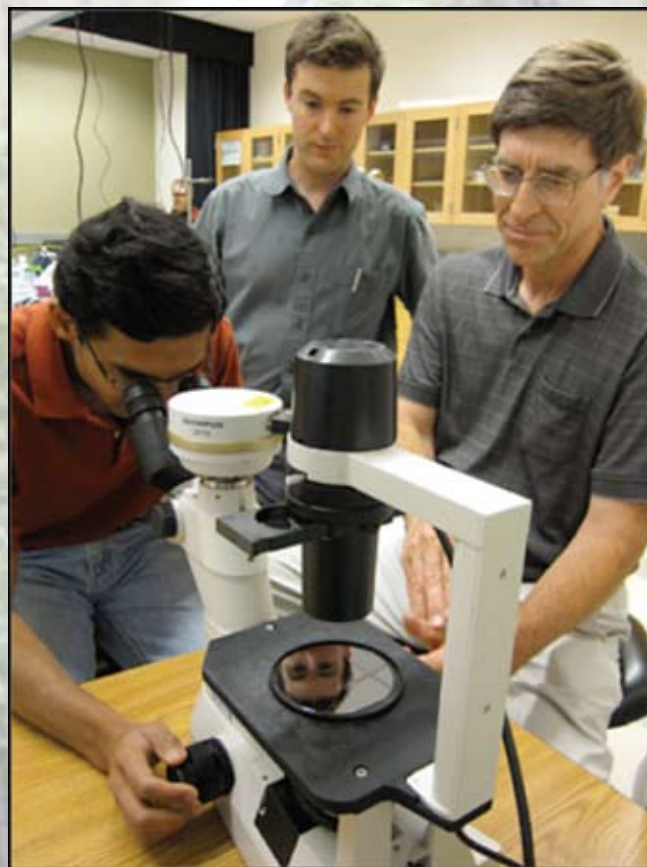
With Vinay Pagay, a graduate student with degrees in computer engineering and viticulture, the team is working at the Cornell Nanofabrication Facility in Ithaca to develop 4-inch diameter silicon wafer prototypes, each containing approximately 100 microsensors. They have also begun collaborating with Infotonics, a firm in Canandaigua, N.Y., that specializes in microelectromechanical systems (MEMS), to plan commercialization of the sensors. The partnership applies cutting-edge engineering to practical agricultural concerns.

The team hopes to design a sensor that will transmit field readings wirelessly to a central server; the data will then be summarized online for the grower. The concept has already received attention from E. & J. Gallo Winery in California as well as researchers and industry leaders from Australia, Spain and Italy. "It's not just for the big growers," Lakso said. "We hope the micro-manufacturing will provide low-cost sensors for small growers as well."

Looking ahead, the team is pursuing alternative sensors that could enhance research in fields from food science to forestry. They have begun development of a "multi-use sensor" that redirects water flow inside the plant through a shunt. In this case, the sensor could measure the flow of water and mineral nutrients through the plant, in addition to water stress. Pagay described it as "a lab on a chip."

Beyond winemaking, the technology has implications for manufacturing, food processing and electronics. Team member Taryn Bauerle, assistant professor of horticulture, described how such sensors could be implanted throughout trees in a forest ecosystem to measure water use and nutrient flow on a large scale with unprecedented accuracy. "All of these [researchers'] brains are coming together," she said. "There's no limit to where we can take this type of technology."

Chris Bentley '10 is a student intern with CALS Communications.



From left, Vinay Pagay, Abraham Stroock and Alan Lakso examine a silicon wafer that will be used to build microsensors to monitor water stress in grapevines. Photograph by Ted Boscia/College of Agriculture and Life Sciences.

NanoDay 2009

Saturday, March 28

by Hester Vermaak

The Sciencenter celebrated NanoDay on Saturday, March 28, with free admission, and more than twenty special hands-on activities and family-friendly presentations about nanoscience and nanotechnology. Co-sponsored by the Sciencenter and Cornell University, NanoDay in Ithaca was part of a nationwide festival of educational programs about nanoscale science and engineering. The Sciencenter in Ithaca developed ten of the NanoDays activities that were used across the country at more than 200 science museums and research centers.

The local community experienced these activities — and over a dozen more — firsthand by visiting the Sciencenter on NanoDay 2009. During the 2nd annual NanoDays™ celebration, Sciencenter visitors got a taste of cotton candy and learned about spinning nanofibers, extracting DNA (putting it in a small tube to take home), and making a nanoparticle stained glass artwork and adding it to a giant hanging sculpture.



Kids got dressed up as nanoscientists in head-to-toe “bunny suits” provided by the Cornell NanoScale Science & Technology Facility, and then the youth investigated surprising materials like sand that doesn’t get wet — even under water! — and a liquid that acts like a magnet. Other

activities included making a pretend nanobot craft to take home, using your nose as a nanoparticle detector, and measuring yourself in nanometers.

At 2 p.m., Sharon Gerbode of Cornell University gave a presentation introducing the field of nanoscience, and describing her research on squishy crystals. (Sharon was the 2008 recipient of the CNF Whetten Memorial Award.)

Sciencenter visitors also got a sneak preview of a new PBS television episode on nanosilver filmed right here in Ithaca by DragonflyTV. The episode, filmed at the Sciencenter and Cornell University, features local children and research.

Free admission to the Sciencenter on March 28 was made possible by the Cornell Center for Nanoscale Systems Institute for Physics Teachers.

NanoDays™, which took place nationally from March 28 through April 5, 2009, is the largest public outreach effort in nanoscale informal science education and involves science museums and research centers from Maine to Hawaii. Regionally, science museums in Rochester, Schenectady, Syracuse, Buffalo and Troy also hosted NanoDays™ activities. The Sciencenter is one of seven hubs nationally in the Nanoscale Informal Science Education Network (NISE NET). Through activities like NanoDays™, NISE Net is building partnerships between science museums and research centers to increase the capacity of both kinds of institutions to engage the public in learning about nanoscale science and engineering.



CNF Users volunteered for NanoDay! They helped the kids get suited up and then get their photo taken in front of a backdrop poster with a photograph of the CNF cleanroom. Much fun was had by all!

OTFE Symposium

THE CNF TCN

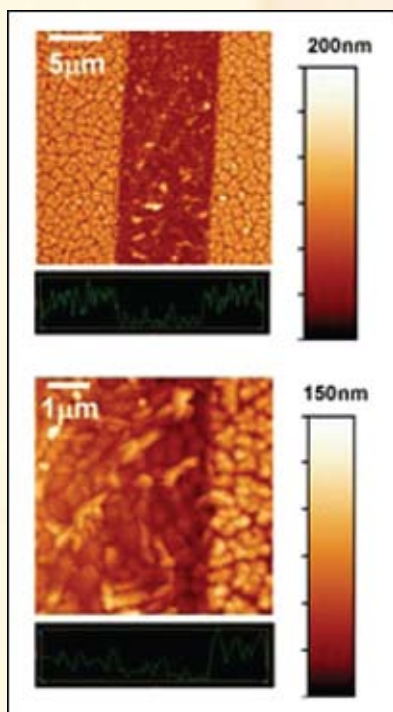
On Tuesday, August 18, 2009, the Society for Information Display - Mid-Atlantic Chapter and the Cornell NanoScale Science & Technology Facility hosted a very successful *Symposium on Organic and Thin Film Electronics* at Cornell University, in Ithaca, New York.

The aim of the symposium was to bring together experts on organic and thin film electronics to discuss recent advances in the field. The symposium was composed of invited presentations from:

- John Kymissis (Columbia University SEAS)
- Ilyas Khayrullin (eMagin)
- Shelby Nelson (Kodak)
- Alon Gorodetsky (Columbia University)
- Karl Hirschman (RIT)
- Vladimir Bulovic (MIT)
- John Marohn (Cornell University)
- Mingqian He (Corning)
- George Malliaras (Cornell NanoScale Facility)

Over 140 people participated in the day-long events, coming from as far away as the United Kingdom and South Korea.

The next CNF Short Course: Technology & Characterization at the Nanoscale (CNF TCN) will be held January 12-15, 2010. Information and registration will be available online in November 2009. <http://www.cnf.cornell.edu/>



Background image and figures at right: Pentacene with PEDOT:PSS Contacts.

From CNF research performed by Malliaras, DeFranco, and Zakhidov

THE 2009 CNF REU PROGRAM



Left: The 2009 NNIN REU interns at the network convocation, held in August at the University of Michigan. Photograph by James Griffin, REU coordinator at Howard University.



The Mighty Mighty 2009 CNF REU Interns!

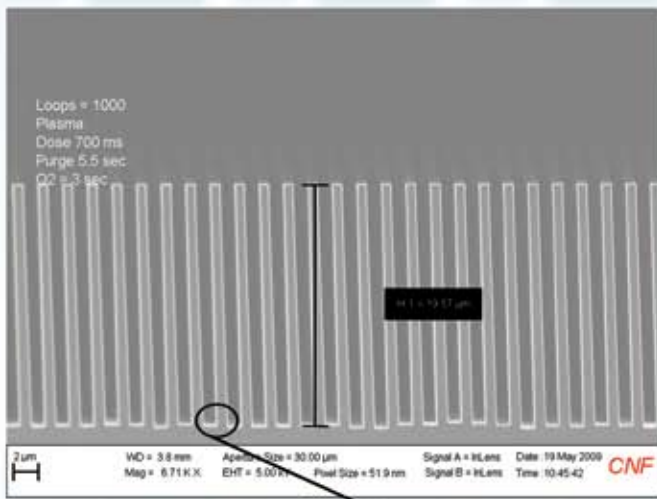
Front: Julie, Amanda, Isaac, Tiffany. Back: Ian, Ellen, Scott

Every year, the National Nanotechnology Infrastructure Network Research Experience for Undergraduates (NNIN REU) Program gets more popular and the CNF ends up with hundreds of applications to consider and I think — how can we choose the right interns with so many wanting to be here?

I can say, after thirteen years working with the program, that this year, we got just about the most perfect seven interns any facility could hope / dream for. Amanda, Ellen, Ian, Isaac, Julie, Scott, and Tiffany poured their hearts and minds into their summer with us and it was a joy to behold. I miss them something terrible! Melanie-Claire, NNIN & CNF REU Program Coordinator

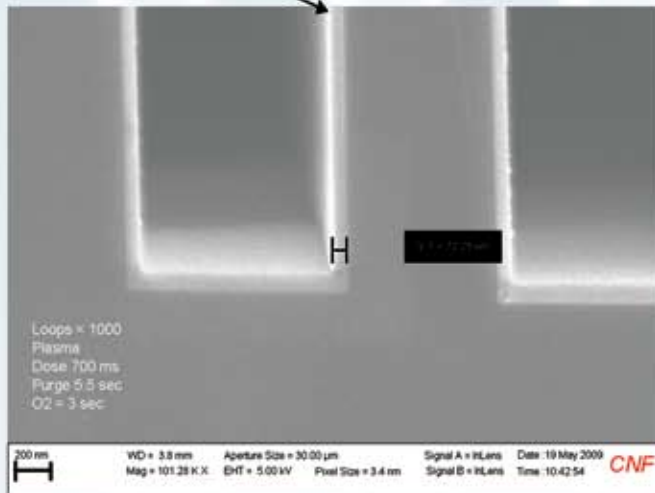
Conformal Coating of High Aspect Ratio Structures

A unique characteristic of ALD is its ability to create completely conformal films over high aspect ratio structures. The images show a 80 nm hafnia film coated into one micron line/spaces and etched twenty microns into silicon – an aspect ratio of 20:1. This coating would be very difficult to obtain with any other technique.



Conformal Coating and Electroplating

Since ALD deposition takes place one atomic layer at a time, it is a slow process by its nature. For this reason, it is not a process used to coat thick films. However, it can be used to deposit a seed layer for electroplating thicker films. While a pure metallic seed layer is common, preliminary results show that low resistivity TaN films may be used for electroplating. Combining this with the ability to coat high aspect ratios gives the possibility of filling high aspect ratio features with the combination of ALD/electroplating.



To learn more about CNF's Atomic Layer Deposition - Oxford FlexAL, or to receive training on the tool, contact Vincent Genova, genova@cnf.cornell.edu

ALD Alumina and Oerlikon Etching

ALD alumina has shown to be a good etch mask for the new Oerlikon silicon etcher. The selectivity to silicon has been shown to be 2000:1.

In the image, left, 15 nm of ALD alumina was used to etch 25 microns into silicon. The alumina can be etched in a chlorine plasma or wet etched in basic developer. The alumina can be put down at temperatures as low as 105°C so it can be used in situations where an oxide or photoresist option might not be available.



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CNF NanoMeter • Volume 18 • Number 2

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

The NanoMeter is published by the Cornell NanoScale Science & Technology Facility.

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