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NanoMeter

The Newsletter of Cornell Nanofabrication Facility – www.cnf.cornell.edu

Volume 13 Summer 2002 Number 1

Director's Column

Many of you have heard of the National Nanotechnology Initiative, the collective effort organized through federal agencies and organized by NSF to harness the potential of small dimensions in the variety of fields. CNF and its predecessors have been participating and supporting the related research activities for nearly 25 years now, and it is heartening to see the effort of many coming to fruition in a variety of fields during the last few years. The moments of discovery, and the moments of adoption of inventions, are some of the most pleasing occasions for the scientist and the engineer. At the same time, there seems to be a distinct shift in the culture of how we get the society to recognize the meaning of our accomplishments. I hope that we will strike a balance between the guesses involved in claims of the implications of the work and the careful enunciation of the assumptions and conclusions that we usually pay attention to in a technical paper. This is a slippery slope whose consequences are evident in the recent history of dot-com, internet and the optical bubble. Nanotechnology has to be careful to not to fall in the same trap as we continue to be successful.

The variety of research and the places the users of CNF come from has continued to grown apace reflecting the significance of the technology available through CNF and the efforts engendered by the federal initiative. We have continued to expand our ability to support through staff, capabilities, space, and we continue to adopt new methods for reaching out to our user community. The latest of this is the web-casting of our Monday discussions. If you can not get to CNF to participate in the technical discussions usually started through a subject brought by a new or old user of the facility, you can still drop in through http://www.cnf.cornell.edu/live.html on Mondays at noon.

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Sensing Trouble

Antje Baeumner is developing field-portable biosensors to detect pathogens such as anthrax in a fraction of the time it takes now.

Last fall, as a stream of letters containing mysterious powdery substances were discovered, the nation—and much of the world, no doubt—paid close attention, awaiting each new verdict as to whether or not this one was some insidious biological substance. Lives hung in the balance as samples were sent off to the lab—sometimes in another state—and the wait for results seemed interminable. The same question was on everyone's mind: wasn't there some better way to get to the bottom of the matter?

The disquieting truth is, of course, that there isn't. Even with the knowledge of Iraq's bioweapons program (discovered by U.N. inspectors in the early 90s) and the 1995 terrorist attack on a Tokyo subway car, in which 12 people were killed by the release of methyl cyanide, concern about biological and chemical warfare has been slow to gain purchase in the U.S.

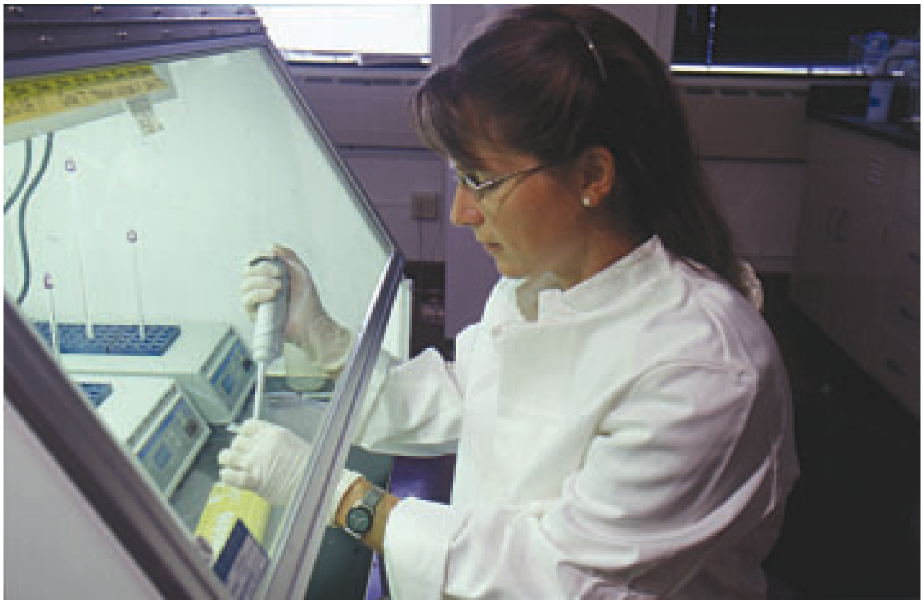
"It has only been very recently," says Cornell biosensor researcher Antje Baeumner, assistant professor in the Department of Biological and Environmental Engineering, "maybe in the last couple of years, that people have started to really say, 'maybe we need something to detect these sorts of organisms rapidly.'"

Because there are so many possibly pathogenic substances that might be used to do harm, no small part of combating biological warfare is knowing which organism you're up against. To create a device versatile enough to both identify a large number of these pathogens and to do so swiftly is a particularly intricate challenge.

It is precisely this challenge, though, that Baeumner confronts daily in her Riley-Robb Hall lab, where she designs portable biological sensors that might be used to detect a wide array of pathogenic organisms. Baeumner first came to Cornell from her native Germany in 1997 as a post-doctoral associate in Cornell's Department of Food Science and Technology in Geneva, N.Y. In the summer of 1999, she accepted a position as assistant professor in what was then the Department of Agricultural and Biological Engineering (now Biological and Environmental Engineering), and immediately set out to continue the biosensor research she'd been expanding upon since graduate school.

In fact, among her many reasons for originally coming to Cornell, says Baeumner, was the appeal of having access to Cornell's world-renowned nanofabrication facility. Nanotechnology, she explains, allows for the miniaturization of biosensors and is playing a crucial role in the creation of devices flexible and quick enough to be useful. Smaller devices use smaller volume samples and have different reaction kinetics governing a detection assay that can make possible the analysis of samples in a fraction of the time required by today's detection systems.

In This Issue...



Additionally, because they are so small, many microbiosensors can be run in parallel, which allows for high throughput screening—throughput is industry speak for the amount of data transferred from one place to another. This further allows for the testing of multiple possible pathogens, or analytes, by one biosensor. Ultimately, though, it is the portability that is so attractive—the replacement of an entire lab by an onsite device the size of a PDA.

"The idea behind biosensors," says Baeumner, "is that you can take them wherever you want to analyze something. It is portable, field usable. If you're using it for clinical diagnostics, a patient might use it at home. Or if a doctor's office is using it, they wouldn't have to send the sample out to a lab."

In conjunction with a number of colleagues worldwide, Baeumner is developing a myriad of biological sensors that might be set up to detect any number of pathogenic organisms. Anthrax, or Bacilus anthracis—the deadly spore-bearing organism we've become so familiar with as of late—is among such pathogens. Though she certainly hopes that her work might aid in the fight against anthrax, it is important to note that its implications stretch well beyond this ominous and immediate threat. (Of equal importance to note, stresses Baeumner, is that she works only with surrogate organisms or harmless RNA sequences—not the pathogenic organisms themselves.)

She is interested in finding quick, easy, and cheap ways of detecting all kinds of biological pathogens—a category of organisms much too large for anyone's liking. A small sampling of some of these stealth killers includes E. coli, Salmonella, HIV, Cryptosporidium parvum (the water-borne protozoan parasite that infected Milwaukee's water supply in 1993), and the Dengue virus, which is, according to the Centers for Disease Control, "the most important mosquito-borne viral disease affecting humans."

Baeumner says that a biosensor for Cryptosporidium parvum, or C. parvum, already exists as a prototype. C. parvum is present in 80 percent of the surface waters of the U.S. and possesses a very distinct advantage in finding its way into our bodies: it is not killed by chlorination, our primary water treatment method. "Often," says Baeumner, "the likelihood is that if there is C. parvum in the water you treat, it still ends up in the water you drink."

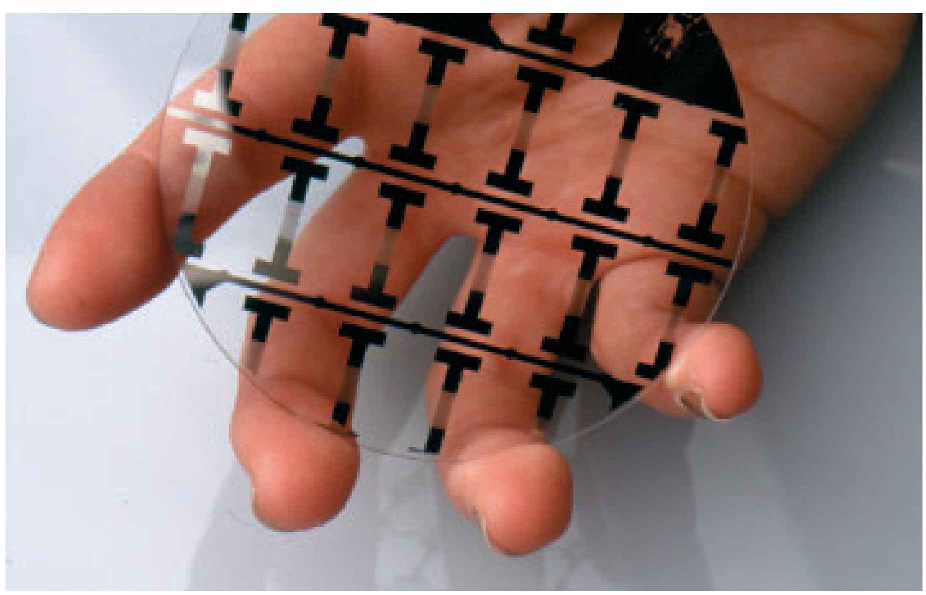
A startlingly small number of oocysts of C. parvum is necessary to infect a human—some believe just one is sufficient—and while the effect on healthy adults is insignificant, the results can be fatal for individuals whose immune systems are generally not as strong—infants, for instance, and the elderly—because no treatment for the illness exists. This is what happened in Milwaukee, when an estimated 1.6 million people were exposed. Some 400,000 of those were made ill, and over 100 lost their lives.

"Only the largest treatment plants analyze C. parvum because it's expensive to do so," says Baeumner. "This is why we chose it as our first model analyte. We wanted to develop a biosensor, and we picked C. parvum because it's such an important and interesting analyte to try to detect." Current testing methods for C. parvum, like those used for anthrax, require sending samples away to labs and can take seven days. "When you're getting results back seven days later," says Baeumner, "it's kind of late." The biosensor that Baeumner has developed would not only give nearly instant results; it would do so at a charge of just a few dollars per test. The sorts of lab tests currently employed, estimates Baeumner, run in the ballpark of $350 for a single sample.

She likens the mechanism of her C. parvum biosensor to a pregnancy test. It actually looks like a pregnancy test strip, and, similarly, its results come out as either clear or red—clear for no organism, red for contamination. That is to say, you needn't be a biochemist to operate it. "Inside it's complicated," says Baeumner. "But the use of it is as simple as it gets. You just put in two solutions and that's it. That's really what you want a biosensor to be like."

A similar project designed to identify the Dengue virus is in the works. The Dengue virus causes Dengue Fever, which occurs primarily in the tropics and can be deadly. The vector for the virus is Aedes aegypti, a day-biting mosquito with a taste for humans. In recent times, the virus, native to Asia, has been on the move, showing up in Texas three times in the last few decades and in Hawaii in the fall of 2001. As with C. parvum, detection is difficult because of its expense, a particularly true fact in the places hardest hit by Dengue: third world countries.

"If this were available," says Baeumner, holding up the prototype for the Dengue test in her office, "it would be very simple. To make it,



including everything you need to run it, will maybe cost a few dollars. That is something very attractive for third world countries. You could do the test and analyze it right there and you could know."

Sylvia Kwakye

One of Bauemner's graduate students, Sylvia Kwakye, who comes from Ghana, West Africa, says working on biosensors was appealing to her because of the opportunity of helping to develop technology she might then take home, including the detection of environmental and food pathogens. "As a result of my research experience," she says, "I hope to work when I'm done as a research engineer designing miniaturized analytical systems that can be used anywhere in the world."

The types of devices that Baeumner and her students develop are reliant on a number of different technologies. We might think of them—crudely, to be sure—as having a front-end, which does the biochemistry, and a back-end, which does the accounting.

Biologically, the device must have some way of recognizing the organism—a fingerprint, so to speak. This is obtained through a nucleic acid amplification technique, which, says Baeumner, "makes out of one RNA molecule a million, like a molecular copy machine." She uses a particular technique called nucleic acid sequence-based amplification (NASBA). The point of this is not to amplify the entire strand of genetic material, but to merely amplify the part of it that is distinct to that organism, the part that cannot be mistaken for even a close relative.

Bacillus anthracis, for instance, has a staggering number of non-pathogenic relatives, one of which is Bacillus subtilis, a ubiquitous substance in the soil that, like B. anthracis, also forms spores. Unlike B. anthracis, though, it is harmless. "Some very high percentage of the genome of the two species is the same," she says. "So it is really difficult to decide if you have this one or that one. You need to detect something that is very specific to the organism, and this is very difficult."

With the biological identifier in place, the test is then run by combining a suspect sample—for the sake of argument, let's say a mysterious powdery substance—with a membrane that has been treated with the DNA of Bacillus anthracis (through the use of NASBA). If it is indeed anthrax in the sample, the DNA on the membrane will bond with the B. anthracis RNA in the sample. The next step is to then send the RNA concentration through a contraption called an interdigitated ultramicroelectrode array, which determines the presence and number of cells in the sample. And, thirty minutes to an hour later—depending on what your poison is—voila: identification.

These processes, of course, are extraordinarily complex, and becoming more complex all the time, as microchips are brought in to expedite the process. "Whatever sequences you want," Baeumner explains of the generic device, "you can just plug them in. Only the part that bears the biological information will change; the second part is always the same."

A side, though related, project Baeumner has been working on lately is a biosensor for Vibrio parahaemolyticus, a bacterium that causes foodborne illness and is often found in seawater. Like other pathogens, a number of days is currently required to identify V. parahaemolyticus—far too much time when you are talking about whether or not to close a fishing area that might be infected.

The device that Baeumner is creating for this project is quite different from her other biosensor approaches. It can be used as a toxicity biosensor, in which a mammalian cell is exposed to the sample. If something in the sample is harmful, the cell will respond. The identity of the harmful agent can be obtained by coupling the toxicity-biosensor element to an immunomagnetic capture module, in which highly specific antibodies bind to the analyte of interest.

Though the project is in the very early stages, Baeumner thinks restaurants and food processing plants might be able to use this sort of technology in the future. "She's got her foot in both worlds," says her colleague on this project, Kathryn Boor, associate professor in the Department of Food Science.

"Dr. Baeumner brings an extraordinary technical sophistication to this task. Others can have biological ideas, but without someone like her to create the biosensor, you're nowhere."

By Jerry Gabriel, Reprinted with Permission

Jerry Gabriel teaches writing in Cornell University's Writing Workshop, in addition to writing about science for a number of publications.

CNF Annual Meeting and Career Fair

Monday & Tuesday, September 23 & 24, 2002

Statler Hotel, Cornell University, Ithaca, NY

The CNF Annual Meeting provides an excellent opportunity for our industrial colleagues to learn of the exciting research carried out by our users at CNF over the past year. By combining the meeting with a Career Fair, we also offer recruiters a forum to discuss career opportunities with the CNF's experienced nanofabrication student/users. (*)

Registration materials are all online at: http://www.cnf.cornell.edu/2002cnfamcf.html

The CNF Annual Meeting & Career Fair is:

- CNF student/user presentations on recent research and discoveries.
- An opportunity for CNF and Cornell University engineering students to learn about career opportunities in engineering or related industries, and a chance for you to illustrate the benefits of employment in your company to a focused group of engineering and science students.
- Informal lunches offering one-on-one time with students and faculty members.
- An evening dinner—a more formal occasion to meet, and enjoy an invited speaker.
- The opportunity for on-campus interviews with experienced nanofabricators.

Outline of Events:

Monday, September 23, 2002

Oral Presentations
8:30 a.m. - 3:30 p.m.

Student Poster Session
4:30 p.m. - 6:00 p.m.

Reception & Dinner
6:00 p.m. - 9:00 p.m.

Tuesday, September 24, 2002

CNF Career Fair
8:30 a.m. - 1:00 p.m.

Please visit http://www.cnf.cornell.edu/2002cnfamcf.html to register

** We choose our dates so that you can combine your travel to Ithaca with the University Career Fair on September 24 and 25. For further details on the university fair, please contact Nancy Law at the University Career Office: nfl1@cornell.edu or 607-255-9046.*

Taking the Helm

W. Kent Fuchs, head of the School of Electrical and Computer Engineering and the Michael J. and Catherine R. Birck Distinguished Professor at Purdue University, has been named the Joseph Silbert Dean of the College of Engineering at Cornell University.

Fuchs, who has been a student of divinity as well as electrical engineering, succeeds interim dean Harold Craighead, the Charles W. Lake Jr. Professor of Engineering and professor of applied and engineering physics. Craighead assumed the interim post in July 2001, succeeding Dean John Hopcroft.

Making the announcement, Cornell Provost Biddy Martin said that she and Cornell President Hunter Rawlings were “delighted that Kent Fuchs has agreed to lead our College of Engineering.” She continued, “Professor Fuchs has considerable administrative experience, and he brings foresight, thoughtfulness and an impressive ability to communicate with a range of audiences to this important position. He will have the support of outstanding faculty, staff and students in the college and will play a crucial role in the development of the university’s cross-college scientific initiatives.”

Said Rawlings, “Cornell’s College of Engineering has been a pillar of strength for this university since its inception. The appointment of Kent Fuchs to lead the college’s world-class faculty will ensure the college’s continuing leadership in research and instruction well into the 21st century.” Fuchs, who is a specialist in dependable computing, testing, and failure diagnosis, will serve a five-year, renewable term beginning July 1, 2002. Commenting on his appointment, he said: “It is a great honor to lead one of the world’s finest colleges of engineering. I look forward to serving the Cornell faculty, students, and alumni with dedication, energy, and enthusiasm.”

Prior to being named head of Purdue’s electrical and computer engineering school in 1996, Fuchs was a professor at the University of Illinois in the Coordinated Science Laboratory and the Department of Electrical and Computer Engineering. He joined the University of Illinois faculty in 1985 as an assistant professor. He was named a full professor in 1993.

The new Cornell engineering dean, who is 47, obtained his bachelor of science engineering degree at Duke University in 1977, his master of science degree at the University of Illinois in 1982, his master of divinity degree at Trinity Evangelical Divinity School in 1984, and his doctorate in electrical engineering at the University of Illinois in 1985.

Fuchs’s current research interests include dependable computing, testing, and failure diagnosis. He leads two research groups at Purdue: computer-aided design tools for testing and failure analysis in integrated circuits; and dependable mobile computing, active networks, and high-performance computing.

His research awards include, from the University of Illinois, the Senior Xerox Faculty Award for Excellence in Research, selection as a University Scholar, appointment as fellow in the Center for Advanced Studies and the Xerox Faculty Award for Excellence in Research. He also has received the Best Paper Award from the Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM) Design Automation Conference; and the Best Paper Award from the IEEE VLSI (very large scale integration) Test Symposium. He is a fellow of both the IEEE and the ACM.

David Brand, Cornell News Service

Director's Column, continued from page 1

During the past few months, one additional area of emphasis for us has been the acquisition of equipment that will be installed directly in Duffield Hall during the summer months before the phased move happens in the fall of 2003. I am happy to report that through the efforts of the staff, particularly Lynn Rathbun, and through our industrial benefactors, we have been quite successful in this effort. This will be reflected in vast improvement in our hot processing and characterization capabilities. In the shorter term, CNF has also obtained laboratory space at the Langmuir Lab at the Ithaca airport where we can provide specialized capabilities to our users, particularly chemistry users, which our main laboratory space limitations did not permit.

Sandip Tiwari

Knight Director, CNF

CNF Extension Laboratory

Chemical self-assembly is a powerful method of providing addition functionality to nano- and micro-patterns and devices fabricated via traditional semiconductor processing approaches. The number of users interested in chemical self-assembly has increased drastically at CNF in the last few years.

CNF’s expertise and equipment capabilities in traditional nanofabrication are world renown. Virtually any nano- and micro-device can be fabricated here on a variety of substrates. However, CNF users now want to be able to carry-out self-assembly on templates and devices fabricated at CNF. Frequently, a simple test is needed to determine whether the device fabricated inside the clean room is actually performing to the level of expectations.

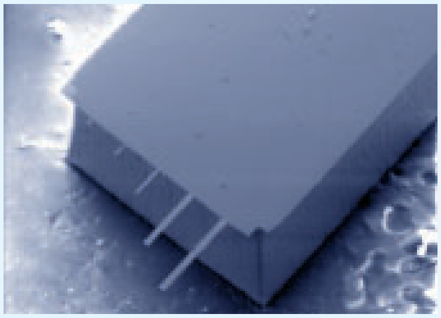
To meet the various needs of the growing number of users interested in performing chemical self-assembly procedures on semiconductor templates and nanodevices, CNF has established the CNF Extension Laboratory.

The new laboratory will offer CNF users a wide range of basic chemical laboratory equipment and supplies, such as an inert atmosphere glove box with attached vacuum oven, two chemical exhaust hoods, tube and box furnaces for synthesis of nanoparticles, fibers, and carbon nanotubes, a state-of-the-art fluorescent microscopy, sonicators and glassware fro sol-gel synthesis, wafer spinners, biological cabinets, equipment for electrochemical and optical characterization and much more.

The CNF Extension Laboratory is located at Langmuir on Brown Rd in Ithaca and is expected to become fully functional by the end of this summer, and will be intergrated into our new clean room facilities in Duffield Hall in 2003. At this stage, the staff is welcoming any input from our users on the equipment and methodology that they would like to have in this new user laboratory.

Interested users can contact Mr. Meredith Metzler or Dr. Mandy Esch with comments, suggestions, and for more information.

User Profile:
Lauren DeFlores



We are pleased to announce that Lauren DeFlores is one of two winners nationally of the 2001 American Microchemical Society Undergraduate Research award. Lauren recently received her bachelor's degree in Chemistry at Cornell University and will be attending the Massachusetts Institute of Technology to pursue a Ph.D. in Chemistry in the Fall of 2002. Since the spring of 2000, she has been working with Prof. John Marohn in the Department of Chemistry and Chemical Biology on the fabrication of ultra-floppy single-crystal silicon cantilevers for use as ultrasensitive mechanical force probes.

Silicon cantilevers are routinely used to image surfaces by atomic force microscopy. There is growing interest in using cantilevers as a more general and chemically informative analytical tool, to detect nanoscale magnetic resonance of electron or nuclear spins, or to detect and image single charges, for example. This requires developing cantilevers that are much thinner, and far more sensitive to small forces, than have been available previously.

Lauren has developed a process for fabricating ~340 nm-thick cantilevers over the last 2 years at the Cornell Nanofabrication Facility in collaboration with chemists Jack Allen and Neil Jenkins. Developing the process involved perfecting a challenging wafer-backside deep etch and a high-tolerance wet etch release, and required carefully controlling surface stress to avoid cracking a thin buried silicon dioxide etch-stop layer. Finally, the delicate cantilevers need to be dried using supercritical CO_2 to avoid being destroyed by meniscus forces that would be present during the usual solvent evaporation.

Lauren DeFlores,
Cornell University

NNUN Video Conferencing

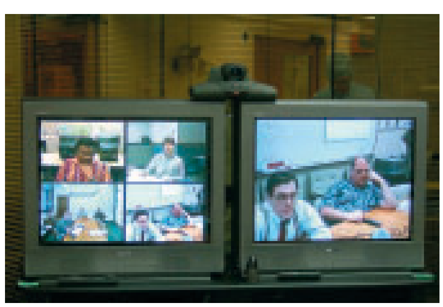
A few weeks ago, a seemingly unremarkable event took place in the CNF Conference Room. It went virtually unnoticed by CNF users and staff. However, this event will undoubtedly have large implications to the type and frequency of interactions between staff and users from all five user facilities that comprise the NNUN.

For the first time in the history of NNUN, four of the five NNUN sites simultaneously connected to each other and conducted a videoconference, discussing various technical and administrative issues involving NNUN as a whole. The top picture shows the moment when Dr. Gary Harris, Director of Howard MSRCE, for the first time connected to CNF represented by Drs. Rathbun and Pechenik.

Although videoconferencing is becoming quite common in today's world, the importance of this moment was clearly felt and expressed by all of the participants. The bottom picture captures the video-conference with the four sites engaged in a lively discussion that is obviously aided in great extent by the very high quality of reception.

Providing high-quality conferencing to five sites simultaneously, required top-notch videoconferencing equipment to be installed at each site, which was a major financial undertaking. A generous grant from the National Science Foundation under the auspices of the NSF's Major Research Instrumentation (MRI) Program has made this acquisition possible for the NNUN.

This new videoconferencing capability enables a wide range of exciting activities and interactions within NNUN and with other research centers. Distance seminars, project planning and coordination across all NNUN sites, rapid technical exchanges between the staff and users, students reporting to their supervisors, outreach activities — these are only some of the new exciting possibilities made possible with this NSF grant. NNUN users are invited to boldly incorporate this new capability in their research plans and activities.



CNF Technical Discussions

The CNF staff has, for many years, met with new CNF researchers to break bread and discuss the technical aspects of their proposed work. We have recently expand this meeting to include short reports by members of the CNF community on current topics of interest.

The session is held on most Mondays during the lunch hour in the CNF conference room. The new projects are discussed first, and the technical session follows immediately. If you can't join us for lunch, please feel free to log on to our live-session web cast at: http://www.cnf.cornell.edu/live.html. The link and schedule is also on the CNF Home Page.

Please join us,

Michael Skvarla
User Program Manager
skvarla@cnf.cornell.edu

Workshop on Electron Beam Lithography for Nanostructure Fabrication

The latest NNUN Workshop on Electron Beam Lithography for Nanostructure Fabrication, held at Cornell and organized by the Network Access Committee, attracted a lot of attention and was a great success! The workshop emphasized the latest advances in e-beam-lithography-related equipment and methodology, concentrating on "hands-on" approaches for nanostructure fabrication.

The informal format of NNUN Workshops is especially conducive for unhindered exchange of ideas, latest results, and processing techniques among researchers. The emphasis on technologies that might not be shared at a formal conference, yet are critical to successful fabrication, make these workshops particularly attractive for nanofabrication experimentalists. The turn out at this workshop was remarkable, with teams from MIT, Cornell, Harvard, Stanford, UCSB, Penn State and leading industrial labs: JPL, IBM, and KLA-Tencor delivering exciting talks covering a fascinating range of equipment and novel nanofabrication techniques. Discussion topics ranged from instrument operation and characteristics, resist evaluation, pattern specification, exposure and fabrication schemes, to novel applications. Both SEM-based and commercial system lithography were covered.

The Network Access Committee would like to thank all the participants and Invited Speakers for making the workshop such a big success. The contributing presentations can be found at http://www.cnf.cornell.edu/nnunebeam.html

This workshop follows prior NNUN workshops on Reactive Ion Etching, Photolithography, and BioMEMS held at UCSB, Penn State, and Stanford, respectively. These workshops are an outreach effort of NNUN to promote exchange of micro-fabrication techniques within the academic community.

New Equipment at CNF

Supercritical Dryer

AutoMegaSamDri-915B

An important feature in MEMS fabrication is the use of sacrificial materials which form spacers between the desired 3-dimensional structures. Examples of sacrificial layers are silicon dioxide, silicon nitride, polysilicon, and aluminum. However, forms of silicon oxide such as phosphosilicate glass (PSG) are the most common.

The choice of a sacrificial layer, which can be a film of up to 5 µm in thickness, is governed by its compatibility with the structural layer, the ease by which it can be removed without causing damage to the structured elements, and by its lack of residue upon removal. Sacrificial processes can involve either wet or dry etching. The most common method is wet etching (Hydrofluoric acid in the case of silicon oxides), but stiction becomes a real issue. Stiction is caused by attractive capillary forces induced by a drying medium (typically water), which tends to pull microstructures (eg. cantilevers) into contact with each other or with the substrate.

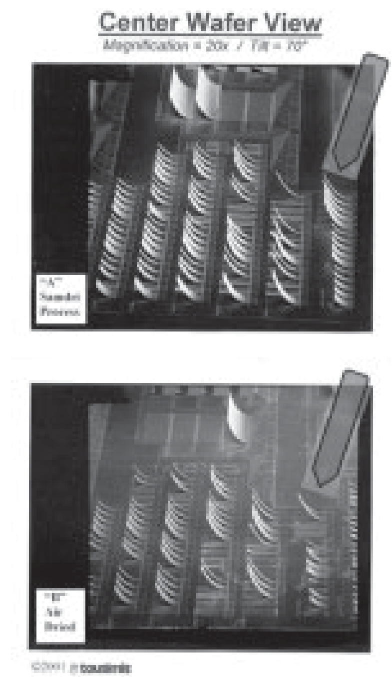
A number of stiction minimization processes have been developed for surface micromachining. Such approaches can involve surface treatments, geometrical/structural alterations, and finally phase change release methods.

The AutoMegaSamDri-915B employs the phase change release method, whereby the surface tension drying force of the drying solvent is bypassed by removing the liquid/gas phase interface. Critical point drying has been used for many years in the processing of biological samples. The technique relies on the use of the "supercritical" region where distinct liquid and vapor phases cease to exist. It is precisely the transition between phases which causes stiction.

The AutoMegaSamDri-915B technique replaces the dissolving fluid (HF in the case of oxides) with an alcohol, whereby the samples are transferred to a pressure vessel in which the alcohol is replaced by the introduction of liquid CO_2. The contents of the vessel are heated and pressurized above the critical point ($P > 1200$ psi, $T > 31°C$) and the interface between the liquid and gas phase is eliminated so that the gas can be gently vented without disturbing the structures. This will greatly increase process yields in the fabrication of micromechanical structures.

The supercritical dryer release capability is a highly valued addition to CNF and is expected to be used extensively by the ever growing MEMS community.

Vince Genova *Sam Wright*



"Micromechanical Actuators"
Comparative Process Micrographs Courtesy Tousimis Research Corp.

Preservation of the 3-d (internal and external) structure of MEMS devices and the ambient supporting liquid (HF) is first replaced with an organic liquid (alcohol) then with liquid carbon dioxide. By raising the temperature and pressure of the LCO_2 above the critical point (supercritical) the ability of CO_2 to form two fluid phases disappears; therefore, the surface tension on the structures vanishes. At the critical point the density of the liquid is exactly the same as that of the gas-thus it goes through the liquid-gas phase boundary-without suffering the distorting effects of surface tension forces. Thus by letting the CO_2 gas escape above the critical point we have a sample that supports its own three-dimensional integrity without the necessity of the liquid medium that initially supported it.

From "Supercritical Point Drying" by Dr. A.J. Tousimis. © 2001 tousimis

The 2002 CNF REU Program

Each summer, as part of the National Nanofabrication Users Network Research Experience for Undergraduates Program (NNUN REU), the CNF hires 12 interns to come and spend ten weeks with us. They work on an active CNF research project, learning various nanofabrication techniques, and suiting up to run the processes themselves.

We do our best to hire students for whom the CNF experience would not normally be easy to come by. While looking for students who have some of the coursework required to work safely in a clean room, we also look for women and minority students from small colleges. But most important, we look for students with the kind of independent spirit needed for research.

And aside from letting them work in our nano-world, we pay them a stipend, and cover all their lab, housing and travel costs. No wonder that this year, we received 210 applications for only a network total of 42 internships. It's an exciting program to be part of and an exciting time to enter the field of nanotechnology.

So it is with pleasure that we introduce CNF's 2002 REU interns:

Ms. Cara Govednik is a junior at University of Texas at Austin, majoring in Chemical Engineering. Cara will be working with Prof. John Marohn on the CNF REU project titled, "Submicron Thick Xylophone Resonators."

Mr. Alexandar Hansen is a junior at Carthage College, IL, majoring in ACS Chemistry. Alex will be working with Prof. Christopher Ober on the CNF REU project titled, "Processing Lithographic Materials in Supercritical CO_2."

Ms. Gizaida Irizarry is a junior at University of Puerto Rico Mayaguez, majoring in MechEngr. Gizy will be working with CNF staff member Mandy Esch on the REU project titled, "Fabrication and Characterization of Microfluidic Structures by Hot Embossing."

Mr. Jacob Jordan is a junior at Vanderbilt University, KY, majoring in Chemical Engineering. Jake will be working with Prof. Carl Batt on the CNF REU project titled, "Microfabrication, Synthesis and Characterization of Bioactive Surfaces."

Mr. Michael Krause is a senior at Wayne State University, MI, majoring in Electrical Engineering. Mike will be working with Prof. Dieter Ast on the CNF REU project titled, "Micropatterning of Optical Waveguides and Bulk Glass."

Mr. Chun-Cheng (Thomas) Lin is a junior at University of Southern California, majoring in Electrical Engineering. Tom will be working with Prof. James Engstrom on the CNF REU project titled, "Semi-Permeable Membranes for Microfluidic Systems."

Mr. Omar Negrete is a junior at University of New Mexico, majoring in Electrical Engineering. Omar will be working with Dr. Alan Bleier on the CNF REU project titled, "Fabrication of Variable-Thickness Structures with E-Beam-Sensitive SU-8 Resist."

Ms. Trang Nguyen is a junior at San Jose State University, majoring in Electrical Engineering. Trang will be working with Prof. George Malliaras on the CNF REU project titled, "Design of Organic Transistors for Biosensors."

Mr. Jonathan Sapan is a junior at Princeton University, NJ, majoring in Electrical Engineering. Jon will be working with Prof. Michael Spencer on the CNF REU project titled, "Fabrication of SiC Tip Structures."

Ms. Nicole Schilling is a sophomore at Corning Community College, NY, majoring in Physics. Nicole will be working with CNF staff member Vincent Genova on the REU project titled, "Low Temperature Wafer Bonding and Bonding of Unconventional Materials."

Mr. Kenneth Vampola is a junior at University of California Santa Barbara, majoring in Electrical Engineering. Ken will be working with Prof. Edwin Kan on the CNF REU project titled, "Physical Manipulation of and by Inorganic Nanostructures."

Ms. Sara Yazdi is a sophomore at University of Massachussetts Amherst, majoring in Chemical Engineering. Sara will be working with CNF staff member Garry Bordonaro on the REU project titled, "Photolithography Characterization and Development."

We're looking forward to an interesting and full summer together!

Melanie-Claire Mallison
CNF REU Program Coordiantor

New Staff & Visitors at CNF

Albert Gerth, left, joined the CNF while on sabbatical from Corning Community College. Al earned his B.S. in Electrical Engineering from Rutgers University and his M.S. from SUNY Binghamton. He has taught courses in electrical engineering and technology, opto-electronics, robotics and automation, and computer repair technology during his 16-year tenure at CCC. Prior to his teaching career, Al was a design engineer at RCA Astro-Electronics in Princeton, NJ where he designed telemetry and power subsystems of communication and defense satellites.

Meredith Metzler, right, completed his B.A. in 1997 in Physics and Mathmatics at Kalamazoo College in Michigan. He researched the electrical transport properties of bulk YBCO high temperature super-conductors. Currently he is working to complete his M.S. in Applied Physics at Cornell University, while serving on the CNF technical staff. Meredith's responsibilities include processes involving reactive ion etching and dry plasma etching, as well as general process assistance.

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The CNF is a member of the National Nanofabrication Users Network, and supported by the National Science Foundation. Serving the Science and Engineering Community since 1978.

CNF Publications

Atomically Flat Areas on Silicon (001) and (111): Fabrication by Evaporation or Growth and Defect Characterization. D. Lee. Cornell University Dissertation, August 2001.

Fabrication of Gated Cathode Structures Using an *in situ* Grown Vertically Aligned Carbon Nanofiber as a Field Emission Element. M.A. Guillorn and M.L. Simpson, ECE, University of Tennessee and Oak Ridge National Lab; G.J. Bordonaro, CNF, Cornell University; V.I. Merkulov, L.R. Baylor, and D.H. Lowndes, Oak Ridge National Lab. J. Vac. Sci. Technol. B 19(2), Mar/Apr 2001.

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