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“Hopefully, we can do this for five years and exchange information,” said Hiroshi Tokumo of Hokkaido University, who worked with Tiwari in organizing the symposium. “You can always see publications, but our feeling was that if scientists and engineers who work in labs could meet face to face there would be a good exchange of information.”

A very practical reason for engaging in close conversation with U.S. researchers was voiced by Tsuyoshi Maruyama, deputy director-general of MEXT: “We have to encourage curiosity-driven opportunities in the U.S.”

He noted that Japan’s nanotechnology research is overseen by MEXT and the Ministry of Economy, Trade and Industry. Although the funding support system is complicated, he said, “The advantage of the organization system is that there are two ministers in charge of science and technology, one in the cabinet office.”

Among Japan’s science and technology policy priorities are the promotion of basic research and research and development in areas that meets social needs, including life sciences, information and communications technology, environmental sciences and nanotechnology and materials. A third priority, he said, is encouraging emerging research areas.

The NSF’s Esin Gulari, the agency’s acting assistant director for engineering, noted how closely Japan’s nanotechnology structure and investments match those in the United States. The NSF is the lead agency for the National Nanotechnology Initiative (NNI), which involves a total of 15 to 16 Washington departments and agencies. Fiscal 2002 funding for the NNI was $604 million, with a similar amount being donated by industry and about a further half of this amount from universities and foundations. “We are adding up to perhaps one-and-a-half times the Japanese investment. But if you compare the two countries, the investments are quite comparable,” Gulari said.

In addition, she said, the NSF’s NNI portfolio is focused on areas very similar to those of the Japanese. Usually the agency invests in three “modes,” she said: small exploratory research projects; major investments in interdisciplinary research teams; and investments in research centers, of which six have been launched to date. “It is exciting to see physicists, biologists, materials scientists and engineers working as a team, and in real time advancing knowledge,” she said.

Among the NSF’s support areas, nanotechnology undergraduate education is a new theme this year, said Gulari. “We are finding that the nanoscale is fascinating for young people learning science and technology. They are learning science in its entirety, not just physics, biology or chemistry, but science,” she said.

During the symposium, U.S. and Japanese researchers presented papers on standards, methodology and research in nanotechnology in the two countries. Among Cornell researchers participating were Héctor Abruña, the E.M. Chamot Professor of Chemistry and Chemical Biology, who spoke on single-molecule transistors; John Silcox, vice provost for physical sciences and engineering science, who spoke on scanning transmission electron microscopy approaches to problems on the nanoscale; and Michal Lipson, assistant professor of electrical and computer engineering, who spoke on the challenge of coupling light from fibers into nano-size optical waveguides.

By David Brand
Cornell News Service
January 30, 2003

Symposium participants enjoyed three days of talks and group discussions. The report to the NSF, symposium proceedings and presentations can be found on the web in PDF at:

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

JapanUSsymposium.html

The 2002-2003 CNF Research Accomplishments

It is time once again for all CNF Principal Investigators and users to submit reports for the Cornell NanoScale Facility Research Accomplishments. As you may recall, one of the requirements of using the CNF for your research is the submission of an annual technical report.

It is extremely important that we receive complete and interesting reports from all users and projects. The CNF Research Accomplishments (R/A) is distributed each year to industrial affiliates, visitors, potential users and sponsors, and therefore is our primary technical CNF publication. This book is also crucial in maintaining our NSF funding, so it must be a comprehensive summary of our user discoveries, technologies, and publications.

We are acutely aware that successful user research programs like yours are necessary for CNF to survive and thrive. In turn, the CNF R/A is a tool to ensure the survival of all CNF projects. Your cooperation in submitting a report as quickly and completely as possible will help assure that CNF remains a leader and an accessible national resource in nanofabrication science.

The TECHNICAL REPORT is a two-part report submitted by each CNF user regarding any and all research accomplishments s/he has achieved in the past year. Part 1 is a written report of the accomplishments, while Part 2 is a pictorial report which summarizes the research through photos, graphs and explanatory bullet items. Each is a stand alone report.

Full instructions can be found at:

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

If you have any questions regarding your report, please contact Michael Skvarla immediately. On behalf of CNF, we would like to thank you for your cooperation.
During the summer of 2003, the National Nanofabrication Users Network will again host a Research Experience for Undergraduates Program (NNUN REU) from June to August. Engineering and science students with a genuine interest in nanotechnology were encouraged to apply, most especially minority and female candidates.

Forty-eight undergraduates have been chosen from 200 applicants to partake in this ten-week program which offers hands-on nanofabrication research through projects designed and supervised by the NNUN Faculty and Technical staff.

A three-day scientific conference, the NNUN REU Convocation, will be held in August at UCSB to allow each intern the opportunity to present a concise scientific summary of their research. In doing so, interns learn from each other as well as from leaders in the field of nanofabrication, who also participate in this event. Finally, each intern submits a written report of their research findings which in turn will become the 2003 NNUN REU Research Accomplishments; a publication distributed to the NSF, corporations, NNUN, and the interns themselves.

The NNUN REU Program is mainly supported by the National Science Foundation, and co-sponsored by the NNUN and its industrial sponsors.

The CNF is looking forward to an event-filled and successful summer with the following twelve NNUN CNF REU interns:

**Ms. Olabunni Agboola**
Molecular & Cellular Biology, University of Illinois at Urbana-Champaign
CNF REU PI: Antje Baemumer
Project Title: Investigation Of Laser-Induced Nanowaveguides

**Ms. Rachel Gabor**
PolyMERUS, Rowan University
CNF REU PI: Michael Miranda
Project Title: Organic Thin Film Transistors For Sensor Applications

**Mr. Sterling Fillmore**
Physics/Chemistry/Math, Brigham Young Univ.
CNF REU PI: Christopher Umbach
Project Title: Two-Dimensional Nanobumps Using Ion Sputtering and Reactive Ion Etching

**Ms. Jill Fitzgerald**
Chemical Engineering/Chemistry, Louisiana State University
CNF REU PI: Michael Spencer
Project Title: Fabrication of Biomolecular Sieves with Novel Geometry

**Mr. Andrew Newton**
Bioengineering, Pre-Med, Kansas State Univ.
CNF REU PI: Amit Lal
Project Title: Ultrasonically Driven Microneedle Arrays

**Ms. D. Marie Nguyen**
ChemEng, Cornell University
CNF REU PI: Christopher Ober
Project Title: Nanolithography using Supercritical CO₂ as an Environmentally Benign Processing Solvent

**Mr. Justin Scott**
Mechanical Engr/Materials Science, UC Berkeley
CNF REU PI: Amit Lal
Project Title: Silicon Ultrasonic Horns For Thin Film Characterization

The full list of the 2003 NNUN REU interns and the 2002 NNUN REU Research Accomplishments can be found on the web at www.nnun.org
Chemistry is one of these areas, and the related equipment at our Langmuir location, and new acquisitions, which will make much of this possible, is being moved in and installed. The first of the enhanced capabilities are the five furnace banks with four tubes each. These will allow a very rational partitioning of the diversified needs of our various users and their needs: from the extremely contamination-sensitive electronics community to the mechanical and optical properties-sensitive electromechanical, optical, and biological community. More similar equipment will be placed during the next few months until the beginning of August when our current instrumentation begins to be moved from our present location.

Included in the new equipment that will appear in Duffield Hall is a new electron-beam lithography system: the JEOL 9300. Together with our VB6, this tool reinforces the unparalleled capability CNF offers in lithography at the nano-scale. The JEOL will be arriving in September, and we plan for the tool to be available for users towards the end of this year after thorough installation and acceptance tests. The VB6 is scheduled to be available in the new location a bit earlier as it will be the first to move on July 15th—dictated by its strategic location in the equipment move corridor between the two sites. We have been requesting that users of electron-beam lithography bear this mind and work hard at doing their work in advance during the current period. We do have arrangements for some work to be done outside Cornell, should rare needs arise.

Sandip Tiwari  
Lester B. Knight Director of CNF

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**New CNF Equipment:**

**Hitachi S-4700-2 SEM with Oxford EDX**

The S-4700 FE Scanning Electron Microscope combines the versatility of PC control with a novel electron optical column to give exceptional performance on large and small specimens. Resolution of 1.5 nm at 15 kV is guaranteed at the EDX and specimen exchange position of 12mm working distance.

The S-4700 also offers excellent low kV performance with guaranteed resolution of 2.1 nm at 1 kV—now at a working distance of 1.5 mm. The Type II features a five-axis eucentric motorized stage which will accommodate specimens up to 150 mm in diameter.

Pre-programmed operating modes allow the user to switch from high-resolution conditions to microanalysis conditions at the click of the mouse with no change of objective aperture. The fully integrated new ExB filter opens the door to low voltage, high resolution, backscattered imaging never before possible on a conventional SEM.

The tool manager for the Hitachi SEM is Daron Westly and he can be reached at westly@cnf.cornell.edu

Hitachi  
http://www.hitachi-hhta.com/  
Oxford  
http://www.oxford-instruments.com/OIGMSH2.htm

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**Oxford PlasmaLab 80+ RIE System**

The CNF has acquired two Oxford PlasmaLab 80+ RIE systems; one for immediate use in the Knight Lab and the second to be installed in Duffield Hall.

The Oxford PlasmaLab 80+ is an 8-inch diameter parallel plate, turbo-pumped RIE system dedicated to processes involving Fluorine based gas chemistries such as CHF₃, CF₄, and SF₆. Processes are available to anisotropically etch silicon dioxide, silicon nitride, and silicon. Other gasses available are argon and oxygen.

The system has a 500 W 13.56 MHz RF power source coupled to a solid state matching network. The active electrode is equipped with a heater/chiller and is capable of operating at various temperatures. The operating pressure regime for processes in the PlasmaLab 80+ is 10⁻¹₀⁻¹₀₀ mT.

The PC interfaced system is equipped with a laser interferometry endpoint detection scheme that can be configured to allow the PC to control and stop the etch. This also allows the etch depth to be used to control when an etch process is stopped.

The Oxford tool manager is Meredith Metzler and he can be reached at metzler@cnf.cornell.edu.

The website for this tool at Oxford Instruments is http://www.oxford-instruments.com/PLMPDP415.htm.
**User Profile:**

**Helena Silva**

Helena Silva is currently a graduate student in the School of Applied and Engineering Physics at Cornell University. She came to Cornell in August 1998 after obtaining her bachelor’s degree in Engineering Physics from the Lisbon Technical University, Portugal. At LTU, her undergraduate project involved amorphous and micro-crystalline silicon thin film transistors (TFTs) for large area electronics, and since then Helena has become interested in solid state and device physics.

Although still working mainly in the fields of silicon and devices, she moved from large area electronics, where large areas are needed at the expense of speed (displays, photocopy machines, scanners, etc) into the ultra-small area electronics, where speed is the priority. Helena is also interested in nano-electronics and the physics of small devices.

After one year at Cornell, Helena joined Professor Tiwari’s research group where she has been working on silicon nano-crystals memories, and the role of defects and interface states in small devices. She started working at the CNF in September 1999.

Currently she is working on a new device structure, a scalable non-volatile memory cell and transistor based on back-side trapping. This is a charge-trapping based memory where the trapping occurs at the interface or bulk defects in oxide-nitride-oxide stacked films placed on the back of a thinned Si channel.

Helena uses a method that has been developed by Lei Xue, Arvind Kumar and Chris Liu, also in Professor Tiwari’s group. This process consists of a low temperature bonding followed by a hydrogen-induced exfoliation which allows the transfer of a thin single-crystal silicon layer onto another wafer that may already have other devices (for 3D integration, e.g.) or stacks of films, as for this memory-transistor device fabrication. This process makes use of chemical mechanical polishing (CMP) and bonding techniques available at CNF. Helena uses the Leica VB6 electron beam lithography tool and has fabricated memory-transistors of 40 nm gate length.

The unique feature of this new device—the fact that the same structure can operate both as a scalable SOI (silicon-on-insulator) transistor and as a scalable reliable non-volatile memory—may lead to useful and creative developments in the integration of logic and memory on a chip.

Figure 1: Schematic cross-section of the device.

Figure 2: SEM image of a cross-section of a memory array.

Figure 3: Transistor and memory operation of a 0.5 µm device with back ONO stack of 7/20/100 nm. (a) Transfer characteristics in erased and written states, $V_D = 1$ V. Threshold slope degrades from 119 mV/dec to 160 mV/dec after charging.

Figure 4: Transfer and output characteristics of a 50 nm x 50 nm device. $S = 157$ mV/dec

(a) $V_D = 0.1, 0.2$ V.

(b) $V_G = 0, 0.1, 0.2, 0.3, 0.4, 0.5$ V.
A Selection of CNF Patents

[1] Project Number: 381-90
[3] Principal Investigator: David Hsu
[4] Institution: Naval Research Laboratory


[1] Project Number: 408-91
[2] MEMS
[3] Principal Investigator: Joseph Ballantyne
[4] Institution: Cornell University

Technology Transfer: Patent application in process for growing microcrystals of GaN (believed to be defect - free) on Silicon Tips processed in CNF.

[1] Project Number: 599-96
[2] NEMS
[3] Principal Investigator: Harold Craighead
[4] Institution: Cornell University


[1] Project Number: 639-97
[2] MEMS Device Development
[3] Principal Investigator: Joel Kubby
[4] Institution: Xerox Wilson Ctr for R&T


[1] Project Number: 657-97
[2] Retinal Implant Project
[3] Principal Investigator: John Wyatt
[4] Institution: MIT

TT: A patent, “Ab Externo Retinal Prosthesis,” has been applied for.

[1] Project Number: 715-98
[2] Technology For Self-Assembled Entities In Logic And Memory Units Below The Optical Lithography Limit
[3] Principal Investigator: Edwin C. Kan
[4] Institution: Cornell University


[1] Project Number: 731-98
[2] Mouse on a Chip: A microfluidic cell culture analog device to mimic animal responses to chemical exposure
[3] Principal Investigator: Michael Shuler
[4] Institution: Cornell University


[1] Project Number: 836-00
[3] Principal Investigator: Michael Simpson
[4] Institution: Univ. of Tennessee, Knoxville


[1] Project Number: 903-00
[3] Principal Investigator: Susan Trolier-McKinstry

[1] Project Number: 917-00
[3] Principal Investigator: Stephen Turner

Technology Transfer: Effective this year, Nanofluidics, Inc. and the Cornell Research Foundation executed a license agreement providing NFI with exclusive worldwide rights to a suite of technologies originating from Cornell and work conducted in the CNF. These include: entropic trap array DNA separation, integration of planar waveguides with capillary microfluidics, entropic recoil separation of long strand DNA, the Zero-Mode waveguide, and monolithic fabrication of nanofluidics structures for DNA manipulation.

[1] Project Number: 926-01
[2] Electrochemically Based Microfluidic Components
[3] Principal Investigator: Susan Hua
[4] Institution: SUNY Buffalo


[1] Project Number: 972-01
[2] A Microreactor for In-Situ Hydrogen Production by Catalytic Methanol Reforming
[3] Principal Investigator: Mayuresh Kothare
[4] Institution: Lehigh University


[1] Project Number: 984-01
[3] Principal Investigator: Joel Kubby
[4] Institution: Xerox Wilson Ctr for R&T

Technology Transfer: Technique for deposition of SiNx on silicon and etching of required patterns have been transferred for use at the microelectronics laboratory of the New Jersey Institute of Technology.

[1] Project Number: 101602
[3] Principal Investigator: Daniel Murnick
[4] Institution: Rutgers University


[1] Project Number: 101602
[3] Principal Investigator: Wayne White

Technology Transfer: Luxtera has demonstrated proof of concept for several novel nanophotonic structures on silicon. Those structures are now being reproduced in a wafer foundry using the foundry’s standard processes. Products utilizing integration of those structures with electronics are expected out in late 2004.
A Selection of CNF Publications and Presentations

“4He Confined to 1 µm Boxes, 0D Crossover, Surface and Edge Effects”; M.O. Kimball and F.M. Gasparini paper, proceedings, 23rd International Conference in Low Temperature Physics, Hiroshima, Japan, 2002.


“Atomically Flat Areas on Si(001) and (111): Fabrication by Evaporation or Growth and Defect Characterization”; D. Lee, Cornell University, 2002.


“Heat Capacity of Mixtures of 3He-4He Confined to Coupled 1 µm Boxes”; M.O. Kimball and E.M. Gasparini, proceedings, 23rd International Conference in Low Temperature Physics, Hiroshima, Japan, 2002.


“Manipulating Nanomagnets with Spin-Polarized Currents”; E.B. Myers, Cornell University, 2002.


The NanoMeter is published four times a year by the Cornell NanoScale Facility, Cornell University, Knight Laboratory, Ithaca, New York, 14853-5403.

Your comments are welcome!

To be added to our mailing list please email: nm@cnf.cornell.edu.
Find the NanoMeter in pdf at: http://www.cnf.cornell.edu/

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