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The Newsletter of Cornell NanoScale Science & Technology Facility

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Director's Column

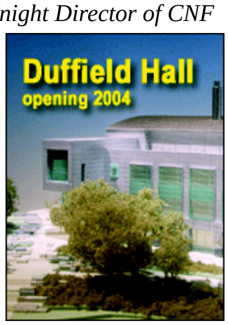
We are now in the midst of the most critical period of the move into Duffield Hall. Until August, our effort in Duffield Hall consisted of bringing in and fitting out new acquisitions (furnace banks, wafer-scale resist and chemistry tools, new etching tools, etc.).

But, now we are in the midst of the ordered move of equipment from its current location in the CNF clean room and in the CNF Extension Laboratory at Langmuir Labs, and of bringing them up in short order in order to minimize research disruption. The latest information related to this move can be found at http://www.cnf.cornell.edu/cnf/duffieldnews.html.

We are also organizing twice a week lunch-hour meetings with our users to make sure that our research service continues at an undiminished level during this period and so that we can take care of any surprises that any such complex move would create.

If there are any issues, please do bring them to our attention. Our users are our primary priority and we wish to make sure that any research impact caused by this move is minimal.

Sandip Tiwari
Lester B. Knight Director of CNF



Large Building, Small Science, Big Dreams

Duffield Hall, taking shape on the Engineering Quad, will be the country's foremost facility for collaborative research in nanoscience.

by Lisa Cameron-Norfleet
First published in Cornell Engineering Magazine
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Once nondescript in the company of such architectural statements as the turrets of Sage Hall and the stately columns of Goldwin Smith, Cornell's Joseph N. Pew Engineering Quad is now the site of a construction project that will not only change the face of the campus but will also change the nature of research and academic collaboration forever. Duffield Hall, the new home for nanotechnology at Cornell, is nearing completion.

Model Rendition Courtesy of Duffield Project

In elegant counterpoint to its size, this large building—150,000 square feet of stone, glass, and steel—will facilitate the small science of nanotechnology: research and engineering at the molecular level. *("Nano" refers to a nanometer which is one-billionth of a meter. To gain a little perspective on that scale: a human hair is approximately 100,000 nanometers wide.)*

Nanotechnology research allows scientists to arrange individual atoms and molecules to create custom materials with specific properties—for improving the world as we know it and for designing a future we have only imagined. Nanotechnology has the potential to affect almost every aspect of daily life. Perhaps the most dramatic advances are those anticipated in health care and medicine.

Scientists are collaborating at the interface of engineering, physical sciences, and biology to create devices, materials, and systems to diagnose, cure, and prevent disease; repair injured tissue and organs; and protect against chemical and biological weapons.

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In This Issue...

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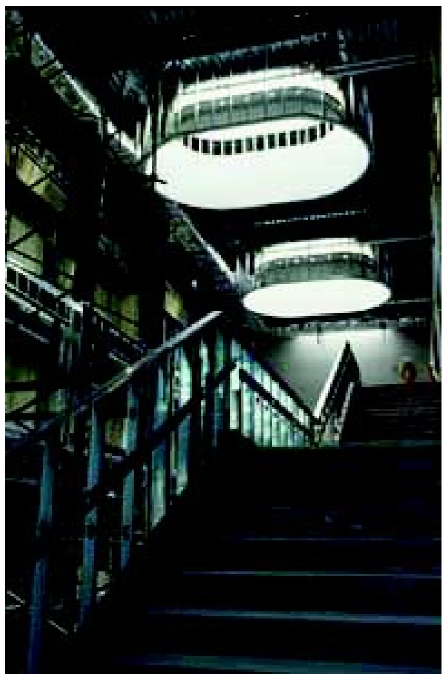
In 1995—five years before the White House announced the National Nanotechnology Initiative—John Hopcroft, then the dean of engineering, sat down with fellow members of the Research Futures Task Force formed by Cornell's President Hunter Rawlings to determine which research areas would become influential in the next thirty years. It became quickly apparent that nanotechnology was in the forefront. And clearly Cornell—at the cutting edge of the field since the 1970s, when the National Science Foundation selected the Ithaca campus as the site of the first national microfabrication facility (forerunner to CNF, the Cornell Nanoscale Science and Technology Facility)—was perfectly positioned for a strategic focus in nanotechnology. An examination of the Engineering Quad, however, made it equally clear that some serious work was needed. "The increasing demands in nanotechnology research required sophisticated laboratory space—ultra clean, vibration-free, shielded from electromagnetic fields—for which our existing buildings were not suited," Hopcroft explains. "To remain a leader in nanotechnology science and engineering, we needed a facility that would let researchers continue to work at the cutting edge."

It sounds simple enough: Engineering needs a new building; let's build one. But the process of getting ground broken for Duffield Hall was arduous, at best. First, Hopcroft did a lot of homework. He called the CEOs of a number of Fortune 500 companies, asked for the loan of their strategic planners, then hosted a brainstorming session that resulted in a conceptual plan for the building. This was taken to other academic institutions such as Berkeley and Stanford for another round of review. Hopcroft distilled the results into a document that he brought before President Rawlings and the Cornell board of trustees for approval. He was given the go-ahead—provided that Engineering could fund the building.

The first gift to the then-unnamed facility came from an alumnus, the late Dwight C. "Bill" Baum '36 EE. Baum, in his eighties at the time, gave $1 million to fund an instructional lab. "Bill really understood the vision of nanotechnology from the start—even before it was a buzzword," says Marsha Pickens, assistant dean for alumni affairs and development. "It was very important to him that the undergrads have access to this wonderful new space."

After that, fellow alum and founder of PeopleSoft Inc. David Duffield '62 EE gave the project the first of multiple gifts—this one totaling $20 million—and the project was on its way. Ultimately, construction was funded entirely ($62.5 million) by about thirty alumni and friends who embraced the vision of Cornell's continued leadership in the nanosciences.



Duffield Hall's atrium under construction

Meanwhile, Hopcroft and Professor Clifford Pollock, Charles and Ilda Lee Professor and director of the School of Electrical and Computer Engineering and academic program leader on the Duffield Hall project, began to think about siting the building, which also proved to be laborious. Many locations were considered: the baseball field, the gorge-side space currently occupied by Ward Lab, off-campus sites in the Cornell Orchards and the Technology Park near the Ithaca airport. Hopcroft and Pollock visited other universities with similar buildings and came to the conclusion that the ultimate success of Duffield came down to one thing: location, location, location. Both tell stories of gorgeous facilities that looked like ghost towns because of their lack of proximity to the hub of campus activity. Both felt the trade-off of some green space on the existing quad was necessary to ensure that Duffield was used to its highest potential. And the Cornell trustees agreed.

The building is not simply "new space"; it's a new kind of space, the likes of which Cornell has never really seen before. On a recent tour of the site, Robert P. Stundtner, Duffield project director, described the high-tech features of the facility. It includes 18,000 square feet of state-of-the-art clean rooms that will accommodate both the Cornell Nanoscale Science and Technology Facility (CNF, formerly the Cornell Nanofabrication Facility) and the Nanobiotechnology Center (NBTC) in adjacent yet isolated spaces to avoid contamination. The nanocharacterization suite, designed to minimize vibration and electromagnetic fields, will house three of Cornell's most powerful electron microscopes. Two floors of flexible research laboratories will support the most demanding research in lasers, microelectromechanical systems, polymer chemistry, and advanced materials. Extensive environmental and health risk analysis was undertaken to assure that building systems will keep the Duffield population and the community safe when researchers work with gases and chemicals, Stundtner said. But beyond all of the technological aspects of the building lies a new approach to research and academia in general: collaborative, managed space.

The west side of both the 2nd and 3rd floors of Duffield is reserved for graduate student offices, but there isn't a door or cubicle in sight. Instead, the open space with views of west campus and Cayuga Lake will be outfitted with a series of moveable desks, chairs, and tables enabling students to position themselves in groups that make sense for the project they're working on. Not only will this allow for easy reorganization at the completion of projects, but also it opens up the potential for collaboration with other students not directly related to the project at hand. In fact, the project architects, the Los Angeles branch of Portland, Oregon–based Zimmer Gunsul Frasca Partnership, liked the idea of the open offices and impromptu collaboration so much that they decided to implement it in their own office.

In addition to this shared office space, Duffield is also equipped with ten study alcoves in the atrium, collaboration space at the north end of the top two floors and on bridges connecting Duffield to Phillips and Phillips to Upson at the second and third floors, and a lounge above the atrium at the third-floor level—all of which are wired for Internet access and were built with a sense of openness to encourage what the Duffield project team calls "intellectual collisions." We are really trying for the effect of having only one coffee pot in the building," says Pollock. "One of the greatest benefits to the college will be the clustering of good people—you always get good things when that happens." Pollock is very confident that having places where faculty and students can bump into one another outside of the direct work environment will bring a host of diverse conversations and points of view that can only expand academic and research possibilities.

In keeping with the interdisciplinary focus, the labs in Duffield will not be assigned to one faculty member on a permanent basis. Instead, researchers who have need of the facilities will have the opportunity to use a lab for the duration of a given project; the intent being that they will clear the space upon completion. Engineering Dean Kent Fuchs explains that Duffield Hall facilities director William Bader will be responsible for the hands-on administration of both the building and the people in it. In addition to managing facility operations and administering safety and security programs, Bader will be working with a faculty committee to handle the space allocation aspect as well. Fuchs is keenly aware of the fact that Duffield is an experiment in this regard, but he believes it will be successful. "It's a challenge," he says. "But it's a good one."

The first task the committee faces is coming up with a process for allocating labs. Faculty members seeking space in Duffield Hall will likely be asked to provide a plan of their proposed use of the lab, detailing such things as the amounts and types of chemicals and equipment they will need and estimating the time it will take to complete the research. Pollock, who is a member of the space allocation committee, says that any allocation process drafted at this stage may need to be revised as unforeseen needs arise. "The real challenge," he says, "is that Duffield doesn't belong to any one department. All of the rules and experiences we've had in space management are moot." In addition to handling the changing expectations of the engineering college, Pollock hopes that the facility will be open to anyone on campus who has need of the type of laboratory space available in Duffield. Ideally, he'd love to see the building housing grad students in a one-to-one ratio of engineering to other disciplines. Hopcroft concurs. "One of the principles of Duffield is that we said we would make space available to anybody—independent of their unit."

But what about the undergrads? How do the bulk of Cornell's engineers stand to benefit from this facility? There's obvious undergraduate student interest in the field. The college already teaches two freshman-level classes in nanotechnology—Engr 111, "Nanotechnology" and Engr 130, "Introduction to Nanoscience and Nanotechnology"—both of which were full in the fall of 2002. "Out of 720 freshmen, nearly 200 of them took the nano classes," says Fuchs. "Duffield will provide appropriate facilities—a unique set of tools and labs—for these courses." Hopcroft says from the beginning the vision was that undergrads would use a state-of-the-art teaching lab in the clean room, where they will be able to suit up and actually fabricate things as a training ground for graduate level work. "It's very important to expose undergrads, even freshmen, to this kind of technology," he says.

Duffield Hall is scheduled to get its first occupant—the Cornell Nanoscale Facility—in the fall of 2003. The move from CNF's existing space in the Lester B. Knight Laboratory is estimated to take three months. A national user facility, CNF will make the delicate transition with almost no interruption of services to its clients. Speaking at the facility's annual meeting last fall, CNF director Sandip Tiwari said, "Our aim is not to have any capability down for any significant amount of time."

The old and new locations will be functioning simultaneously, and during the move, most capabilities will be available in one space or the other or both. When the complex move is completed—including the transfer of the Knight Lab name to the new space—CNF's former quarters will be demolished to make room for the final section of three connected atria that will stretch from Campus Road south to Upson Hall.

The atria, already an impressive vaulted space at less than half-completion, will be home to a coffee shop and varying kinds of study and social space and will connect Phillips, Duffield, and Upson Halls, making it possible to move between buildings without stepping outside.

Going outdoors, however, will have fresh appeal: This summer, local firm Cayuga Landscape Inc. will re-grade the Engineering Quad to provide a level surface for outdoor activities and put in trees and shrubs, plus a series of benches, bridges, terraces, lighting, sidewalks, and bike racks, making the space far more pleasant and usable than in the past. The thirty-foot change in elevation across the quad will be pushed up against Duffield, sprinkled with Llenroc boulders, and planted with native species, creating a landscape inspired by nearby Cascadilla Gorge. And, of course, the sundial, removed from the quad in 2001 and stored in Upson Hall for the duration of quad construction, will be restored to its rightful, prominent place in the hub of all things engineering.

Dean Fuchs, who came to Cornell from Purdue in July 2002, cites Duffield as high on his list of reasons for choosing the Big Red. "The fact that Cornell was two to three years ahead of other universities in the country was one of the motivating factors for me to accept the position. My vision for the facility is that it will secure us in a top leadership position in nanofabrication and nanoengineering."

Lisa Cameron-Norfleet is a freelance writer working in Ithaca.

To learn more about Duffield Hall or take a virtual tour, visit the project on-line at http://www.duffield.cornell.edu.

User Profile:

Jason Slinker

Jason Slinker is currently a graduate student in the School of Applied and Engineering Physics at Cornell University. Originally from Oklahoma, he received his bachelor's degree in Physics, Chemistry, and Math from Southern Nazarene University in Bethany, Oklahoma.

In the summer of 2000, Jason participated in the National Nanofabrication Users Network Research Experience for Undergraduates Program as an intern at the Cornell Nanofabrication Facility. During that summer, he worked under Professor George Malliaras, making organic thin film transistors through photolithography. That summer greatly contributed to his decision to pursue graduate study at Cornell University.

"In short, it was obvious that Cornell was a leader in nanoscale technology," notes Jason, "and that George was one of the best professors on the planet."

Since returning to Cornell as a graduate student in the summer of 2002, his work has shifted from organic transistors to organic light emitting devices based on transition metal complexes. Transition metal complexes, such as ruthenium trisbipyridine $[Ru(bpy)_3]2^+$, shown in Figure 1, have recently prompted

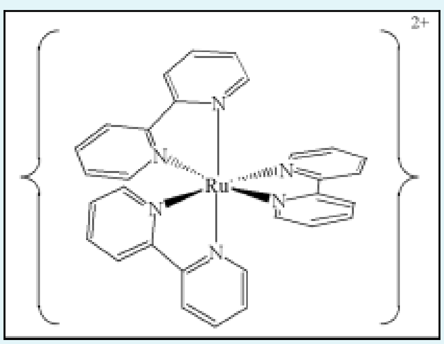


Figure 1: The structure of $[Ru(bpy)_3]2^+$

extensive photophysical and electrochemical study. Motivated by their high photoluminescence efficiencies in solution, light-emitting devices based on transition metal complexes have been developed as potential candidates for flat-panel display and lighting applications. Devices from these compounds are among the most efficient devices from organic compounds.

Contributing to the high efficiencies of these devices is their ionic nature, which significantly alters their operational mechanism from that of traditional organic light emitting diodes. Due to large numbers of mobile ions, devices from these compounds instead follow a mechanism similar to that of electrochemical cells. $[Ru(bpy)_3]2^+$ and other related compounds carry a net positive charge, which is compensated by a negative counter ion, such as PF_6^-. These counter ions are mobile under the influence of an applied bias, leading to accumulation of negative ions near one electrode and depletion at the other

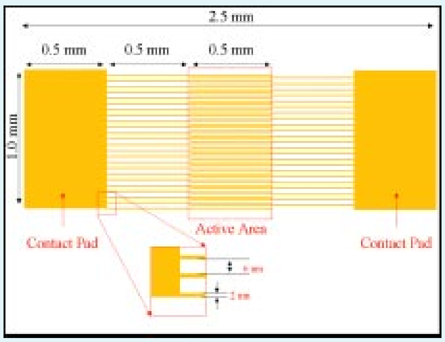


Figure 2: Interdigitaed microelectrode device structure (not to scale). In the active area, electrode "fingers" of 2 μm width are separated by 2 μm. The actual device of the same total size would have many more "fingers" than shown (not shown for clarity).

electrode. The resulting high electric fields at the electrodes enhance charge injection into the transition metal complexes, which leads to low operating voltages and high luminescence efficiency.

Devices of this sort are typically made in a sandwich configuration. The transition metal complex is spin coated onto a transparent electrode on a transparent substrate, such as glass. A second electrode is then deposited on top of the organic surface, typically by thermal evaporation. Devices of this sort are relatively simple to make and do not necessarily require photolithography. However, these devices have their drawbacks.

"If you want to know what is happening within the organic, a planar configuration is much more advantageous," says Jason.

Motivated by the distinct operational mechanism of these devices, Jason has been working with fellow Malliaras group members Man Hoi Wong, Ahmed Hosseini, and Yulong Shen to fabricate planar devices with interdigitated microelectrodes (see figure 2). The devices are defined by two electrodes with interlocking "fingers" that are 2 μm wide, with 2 μm separating adjacent electrodes in the area of overlap. Due to the proximity of the electrodes, it is necessary to pattern them by photolithography.

Devices in this configuration have already been used to image the electroluminescence profile across the channels. The emission profile reveals underlying device physics, such as the relative mobilities of the elementary charge carriers within the semiconducting material.

The Malliaras group has already achieved success with sandwich structure devices from transition metal complexes. One of their most successful devices, made from an Iridium complex, attained a power efficiency of 10 lumens per watt, among the highest efficiencies reported for a single layer device. This efficiency equals that of some commercial light bulbs. Furthermore, the Malliaras group recently contributed and invited review article to Chemical Communications concerning light emitting devices from transition metal complexes.

"With regard to these planar devices, however, we are just getting our feet wet," explains Jason, who just completed his first year of graduate study. "Hopefully we can achieve the same level of performance with our interdigitated devices that we have with the sandwich structure devices."

Figure 3: A sandwich structure device in operation with air stable electrodes.

Connecting Experiences: The CNF REU Program

For Michael Campolongo, currently a student at Rowan University, the opportunities in nanotechnology around his campus were slim to none. The mid-sized school in Glassboro, NJ, is just beginning to purchase instruments for thin film deposition and etching, but nothing too substantial. For Jason Slinker, prospects of small-scale research were even less abundant at his undergraduate, liberal arts school, Southern Nazarene University, in Bethany, OK.

"Many smaller universities can offer comparable or even superior teaching in the classroom, but often the resources for conducting experimental research are extremely limited," notes Jason. "Much of the equipment necessary to achieve micro- or nanoscale features is simply too expensive for such universities."

The National Nanofabrication Users Network Research Experiences for Undergraduates Program, made possible by the National Science Foundation, offered both Michael and Jason the unique possibility of working in a world-renowned nanofabrication facility. The ten week program selects distinguished students for internships at Cornell University, Howard University, The Pennsylvania State University, Stanford University, and the University of California at Santa Barbara. The NNUN is currently fulfilling its third 3-year NSF REU contract, hosting 48 diverse interns from across the nation, across fields, and representing intimate community colleges and ivy league institutions.

Jason, presently a graduate student in Applied and Engineering Physics at Cornell University, learned of the NNUN REU program through his older brother Keith, who was a CNF REU intern in 1998. Due to his brother's positive experiences and Jason's own interest in integrating his chemistry and physics background, he accepted a position at the Cornell site in the summer of 2000. He worked under Assistant Professor George Malliaras, Materials Science and Engineering, on organic thin film transistors. In addition to the rewards of meeting and interacting with other rising scientists from around the country, Jason's research contributed to a publication in the Applied Physics Letters (vol. 79, p. 1300). Ultimately, his experiences both at the CNF and with Professor Malliaras' group led to his return to Cornell as a graduate student following his graduation.

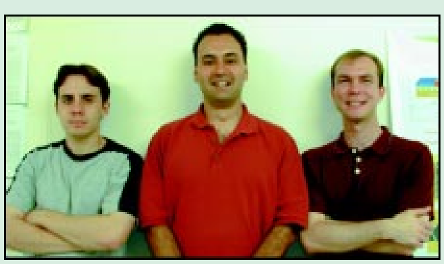
Michael, who is entering his junior year at Rowan University, was informed of the program by one of his professors familiar with CNF. He applied for the 2003 NNUN REU program and accepted a CNF internship. Given his interest in the physics and fabrication of semiconductor devices, he was also selected to work under (now Professor) Malliaras.

The purpose of Mike's CNF REU project is to investigate the operational characteristics of organic light emitting devices by developing interdigitated microelectrode arrays.

Each student in the NNUN REU program is assigned both a faculty mentor and a graduate student mentor to oversee their project. Given his past experiences, Jason was a natural fit for the job and volunteered for the role of Mike's student mentor. With Jason's assistance, Mike is fabricating devices at CNF, using processes including mask design, photolithography, plasma etching, and thin film metal deposition.

"The REU program is a rewarding experience," says Michael. "Yet, Jason's background as a former REU student has certainly given me a higher level of appreciation."

Michael plans to continue on to graduate school and eventually work in the field of nanoscale electronics. His summer at the CNF will undoubtedly strengthen his graduate application and future resume. And who knows—perhaps he may, in turn, mentor another nanoscale hopeful in the future.



The 2003 CNF REU Malliaras team: Michael Campolongo, George Malliaras, and Jason Slinker

The 2003 NNUN REU Program

The 2003 NNUN REU Program is already drawing to a close with excitement rising as students plan for the NNUN REU Convocation at the University of California at Santa Barbara. Each year, a special event for the program is the network-wide convocation which is rotated among the five sites so that a majority of each year's interns have the opportunity to experience two sites—working for ten weeks at one, and touring the facilities and seeing a few sights at the other. Of course the main focus of the convocation is the REU intern presentations, which year after year are noted on the intern evaluations as a valuable learning experience for everyone. Over the past few years, we have added a poster session so that the faculty and staff at the convocation site have a chance to look over the progress of our interns in a concentrated setting.

After the convocation, while the interns from the East coast sites just go home, their programs finished, the West coast sites get to return to work for two, sometimes three, more weeks, energized by the research accomplishments of their fellow interns and full of ideas gained from four days of intense discussions.

The joint convocation is not the only opportunity for discussions across sites though. The NNUN joined up for video-conferences through-out the summer, giving the interns yet another outlet for sharing their experiences and research issues with their peers.

This is our seventh NNUN REU Program and we are proud to say we continue to grow and improve along with our interns.

Melanie-Claire Mallison
NNUN REU Program Coordinator

Video-conferencing as seen at the CNF site

Full information on the 2003 NNUN REU Program along with the research accomplishments from past years can be found on the web at www.nnun.org

The 2003 CNF Annual Meeting, September 25th

Information and registration forms for the 2003 Cornell NanoScale Facility's Annual Meeting are now on the web at: www.cnf.cornell.edu/2003cnfam.html

The CNF Annual Meeting is an excellent opportunity for our colleagues to learn of the exciting research carried out by CNF users over the past year through:

- Talks and poster presentations by CNF student users on their recent research and discoveries.
- Informal lunches offering one-on-one discussions with students and faculty members.
- An evening dinner; a more formal occasion to meet, and enjoy an invited talk.

The date for our Annual Meeting is selected to coincide with the Cornell Career Services Fair, September 22-24, 2003. For details on Career Fair 2003, contact Ms. Jennifer DeRosa at Cornell Career Services.

We strongly encourage companies attending the Cornell Career Fair to stay in Ithaca one more day and attend the CNF Annual Meeting. Come and hear what our users are up to, gather a few resumes over mealtimes and enjoy a great day of nanotechnology.

Outline of Events:

Thursday, September 25, 2003

Oral Presentations, 8:30 a.m. - 3:30 p.m.
Poster Session & Reception, 5:00 - 7:00 p.m.
Dinner, 7:00 p.m. - 10:00 p.m.

We look forward to welcoming you to CNF!

Duffield Move Schedule

(all dates subject to change)

Tool	*Down Target Date*	*Return to Service Target Date*
New CNF Lab Tools		
Aura 1000 # 2		1-Mar-04
FIB		To be determined
Furnace 701		1-Oct-03
Furnace 702		1-Oct-03
Furnace 703		1-Oct-03
Furnace 704		1-Mar-04
Furnace 705		1-Mar-04
Fusion 150 UV cure		1-Mar-04
Hammatech 1203		1-Feb-04
Hammatech 1204		1-Feb-04
Hammatech 1205		1-Feb-04
Hammatech 1206		1-Feb-04
Hammatech 1209		1-Feb-04
Hammatech 1210		1-Feb-04
Heidelberg PG		1-Sep-03
JEOL 9300		1-Dec-03
Oxford 80 (extra one)		1-Sep-03
RCA wet decks		1-Oct-03
Spin Rinse Dryers		various
Suss RC8 #1 Spinner		15-Aug-03
Suss RC8 #2 Spinner		1-Mar-04
Suss RC8 #3 Spinner		1-Mar-04
Various new wet decks, spinners and hot plates		various
YES #2 vapor prime		1-Mar-03
Existing Knight Lab Tools installed as part of the Duffield Project		
Leica VB6	11-Jul-03	19-Nov-03
LEO SEM	5-Aug-03	1-Sep-03
CHA SE600	6-Aug-03	26-Aug-03
Autostep 200	7-Aug-03	4-Sep-03
CVC 601 Sputter	8-Aug-03	16-Sep-03
PT72	13-Aug-03	9-Sep-03
Strasbaugh CMP	15-Aug-03	2-Sep-03
PT720	19-Aug-03	2-Oct-03
CVC4500	22-Aug-03	17-Sep-03
Applied Mat. RIE	26-Aug-03	18-Sep-03
GCA 5x Stepper	27-Aug-03	25-Sep-03
YES Polymide	28-Aug-03	10-Sep-03
Veeco Ion Mill	1-Sep-03	25-Sep-03
Unaxis 770	3-Sep-03	8-Oct-03
LEO (other one)	5-Sep-03	2-Oct-03
EVG Bonder	5-Sep-03	19-Sep-03
IPE PECVD	9-Sep-03	8-Oct-03
Plasma Quest ECR	10-Sep-03	31-Oct-03
SC4500	15-Sep-03	8-Oct-03
EVG620	16-Sep-03	30-Sep-03
PT770	18-Sep-03	28-Oct-03
YES vapor prime	22-Sep-03	10-Oct-03
GSI	24-Sep-03	10-Nov-03
Glen 1000	29-Sep-03	15-Oct-03
PG	3-Oct-03	22-Oct-03
10x	8-Oct-03	4-Nov-03
Aura 1000	10-Oct-03	28-Oct-03
HTG	17-Oct-03	30-Oct-03

A Selection of CNF Presentations & Publications

“Confinement-Induced Entropic Recoil of Single DNA Molecules in a Nanofluidic Structure”; S.W.P. Turner, M. Cabodi and H.G. Craighead, Physical Review Letters, 88, 128103-1 - 128103-4, 2002.

“Fluorinated Dissolution Inhibitors for 157-nm Lithography”; A.H. Hamad, Y.C. Bae, X.-Q. Liu, C.K. Ober, F.M. Houlihan, G. Dabbagh, A.E. Novembre, Proceedings of SPIE-The International Society for Optical Engineering, 2002, 4690, Pt. 1, Advances in Resist Technology and Processing XIX), 477-485.

“Infrared Sensing Microbolometers on Flexible Substrates”; A. Yaradanakul, Z. Çelik-Butler and D.P. Butler, IEEE Transactions on Electron Devices 49, 930, 2002.

“The Interactions Between Mammalian Central Nervous System Cells and Topographically Modified Surfaces”; A.M.P. Turner, Cornell University Thesis, August 2002.

“Investigation of the Temperature Coefficient of Resistance and Crystallization of YBaCuO Thin Films using Pulsed Laser Annealing”; A. Yildiz, Z. Çelik-Butler, D.P. Butler and C.-U. Kim, Journal of Vacuum Science and Technology B 20, 548, 2002.

“Nanomechanical Resonant Structures as Tunable Passive Modulators of Light”; L. Sekaric, M. Zalalutdinov, S.W. Turner, A.T. Zehnder, J.M. Parpia and H.G. Craighead, Appl. Phys. Lett. 80, 3617, 2002.

“Nanomechanical Resonant Structures in Nanocrystalline Diamond”; L. Sekaric, J.M. Parpia, H.G. Craighead, T. Feygelson, B.H. Houston and J.E. Butler, Appl. Phys. Lett. 81, 4455, 2002.

“Nanomechanical Resonant Structures in Silicon Nitride: Fabrication, Operation and Dissipation Issues”; L. Sekaric, D.W. Carr, S. Evoy, J.M. Parpia and H.G. Craighead, Sens. Actuators A 101, 215, 2002.

“Nanometer-Scale Scanning Sensors Fabricated using Stencil Lithography”; A.R. Champagne, A.J. Couture, F. Kuemmeth and D.C. Ralph, Appl. Phys. Lett. 82, 1111, 2003.

“Nanoscale Pattern Transfer using Sputter-Induced Corrugations Formed at the Si/SiO2 Interface”; C.G. Allen, M. Daniels, C. C. Umbach and J. M. Blakely, Mat. Res. Soc. Sympo. Proc., 2002.

“Nucleation of Copper on TiN and SiO2 from the Reaction of Hexafluoroacetylacetonate Copper(I) Trimethylvinylsilane”; P. F. Ma, T.W. Schroeder and J. R. Engstrom, Appl. Phys. Lett. 80, 2604-2606, 2002.

“Operation of Nanomechanical Resonant Structures in Air”; L. Sekaric, M. Zalalutdinov, R.B. Bhiladvala, A.T. Zehnder, J.M. Parpia and H.G. Craighead, Appl. Phys. Lett. 81, 2641, 2002.

“Organoelement Resists for EUV lithography”; J. Dai, C.K. Ober, L. Wang, F. Cerrina, P.F. Nealey, Proceedings of SPIE-The International Society for Optical Engineering, 2002, 4690, Pt. 2, Advances in Resist Technology and Processing XIX, 1193-1202.

“Oxidation Studies or Ultra-Low-Atomic Step Density Si(111)”; A. Oliver, Cornell University Thesis, 2002

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