

## Giannelis begins first year as Director

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**E**mmanuel P. Giannelis, the Walter R. Read Professor of Engineering, was appointed director of the department for a five-year term beginning January 1.

Giannelis has an active research program with funding from industry and government agencies. Current research includes polymer nanocomposites, polymer/inorganic interfaces, nanocomposite electrolytes for batteries, fuel cells and photovoltaics, nanohybrids for drug delivery, random lasers and materials for electronic packaging. (For more information on his research program, see [www.ccmr.cornell.edu/~giannelis](http://www.ccmr.cornell.edu/~giannelis).)

He previously served as director of undergraduate studies in MS&E and as a member of the executive board of the Cornell Center for Materials Research. For the past several years, Giannelis taught the popular ENGR 111 *Nanotechnology* course which attracts over 160 freshmen each fall.

Before coming to Cornell in 1987 Giannelis was a post-doctoral associate at Michigan State University's Center for Fundamental Materials Research (1985-86) and Composites Center (1986-87). He earned his Ph.D. degree there in 1985 and

his B.S. degree in 1980 at the University of Athens. In 1994 he was awarded the Dean's Prize for Excellence in Teaching and in 2001 he was recognized as one of the top 25 cited authors in nanotechnology by the Institute of Scientific Information. He is a member of several scientific societies, including the American Chemical Society, American Ceramic Society, and Sigma Xi, and he has served on the editorial boards of *Chemistry of Materials* and *Macromolecules*. He is a corresponding member of the European Academy of Sciences.

Giannelis' views on the state of the department and its expectations are outlined on page 2 in his first column for *MS&E News*.



Emmanuel P. Giannelis

## Chekesha Liddell joins the faculty

**I**n November 2003, MS&E welcomed Chekesha Liddell to the faculty. Liddell's education and research plans focus on nanotechnology, which is a strategic focus of the department.

Liddell's research encompasses the synthesis and characterization of uniform monodispersed nano- and mesoscale inorganic colloids with tailored morphology and composition as well as the fabrication of novel three-dimensional structures derived from these colloidal building blocks. Such lattices are necessary for the enhanced

*continued on page 2*

*Assistant Professor Chekesha Liddell (seated) with research group members (left to right) Daniel Preston, Yanning Song, Kevin Huang, Stephanie Lee, and Poorna Praveen Rajendran.*



## FROM THE DIRECTOR

I am pleased to be writing to you as the new director of Materials Science and Engineering. Chris Ober completed his four year term as director in December. Chris brought about many important changes during his term as director, including establishing an MS&E Advisory Board, developing a strategic plan and facilities plan, securing research space for MS&E faculty in Duffield Hall, establishing a process of continuous improvement in the undergraduate curriculum and implementing many facilities renovations in Bard Hall including the development of the Hudson Mesoscale Processing Facility. He is also responsible for hiring professors Bruce van Dover, Kit Umbach and Chekesha Liddell. He is now shifting his considerable energy to his research program (see article on p. 4) and teaching.

This is an exciting time for MS&E in many areas.

■ The department is working to advance a college-wide effort focused on research and teaching related to energy and environmental technology. This is a key component of our strategic plan and that of the College of Engineering. The interdisciplinary research opportunities are numerous.

■ We plan to hire three new faculty members over the next two years in the areas of biological materials, energy and computational science.

■ Our undergraduate student population will reach well over 100 students by January. The program has been most recently ranked #3 in the nation by *U.S. News and World Report*. Enhancements to the undergraduate curriculum, including more hands-on learning with state-of-the-art equipment, were made possible by the generous contributions of individual and corporate donors.

■ Our graduate recruitment efforts this year included the creation of a new brochure highlighting the research activities of MS&E as they relate to our four strategic focus areas of energy and environmental technology, nanotechnology, biotechnology and the life sciences, and information and telecommunications technology. You can view this beautiful brochure on our main web page at [www.mse.cornell.edu](http://www.mse.cornell.edu).

■ Duffield Hall is open and six MS&E faculty and their research groups will be moving into labs and student seating space by the fall semester. The Liddell, Malliaras, Ober, van Dover, Wiesner, and Giannelis groups will be conducting research alongside the Cornell Nanofabrication Facility, the Nanobiotechnology Center and Cornell Center for Materials Research facilities, as well as researchers from across the College of Engineering.

■ The renovation of Bard Hall will continue with plans to create this fall the North Wing Nanotechnology Research Suite as the first phase of a renovation of the subbasement (see page 8). In addition, a new world-class Energy Filtered Transmission Electron Microscope (EFTEM) has been installed in the CCMR facility adjacent to this space (see page 5).

I hope to see you at our Reunion Weekend event on June 12. We always enjoy hearing from our alumni and friends, so please stop by to see us when you are in Ithaca.

—Emmanuel P. Giannelis, Director, Department of Materials Science and Engineering

## Chekesha Liddell continued from page 1

electrooptic properties including low loss waveguiding for all-optical circuits, low threshold lasing, coherent LED emission, and strong dispersion characteristics known as superprism effects.

As the newest assistant professor in the department, Liddell has been busy with the development of her research program on the third floor of Bard Hall. A complete floor to ceiling renovation of her lab spaces is nearly finished. Graduate students Poorna Praveen Rajendran and Stephanie Lee, along with postdoctoral associate Yanning Song, are working with her to expand her research program. In addition, undergraduates Kevin Huang and Tam Ngo have been awarded the Cornell Presidential Research Scholarship and the Learning Initiatives for Future Engineers (LIFE) sponsored funding respectively, practical realization of photonic band gap materials (photonic crystals) operating in the near infrared and visible regions. Photonic crystals offer an unprecedented control of light that is anticipated to enable the production of devices with

to support their research in the Liddell group. Liddell and her research group will also have a laboratory space in Duffield Hall in 2004.

Liddell completed her Ph.D. in materials science from the Georgia Institute of Technology in 2003. Her thesis topic was non-spherical ZnS colloids as building blocks for three-dimensional photonic crystals. She received her B.S. in Chemistry with Highest Distinction from Spelman College (1999) and a Bachelor of Materials Engineering from Georgia Tech (1999). She was awarded the NASA Women in Science and Engineering Scholarship to support her undergraduate work and an Office of Naval Research Fellowship to support her graduate study. Liddell also held internships at NASA, Kennedy Space Center. She is also a fellow of the National Society of Black Engineers and a member of Phi Beta Kappa and the Materials Research Society.

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Recent issues of *MS&E News* are available on the Web.

## HIGHLIGHTING ACCOMPLISHMENTS OF MS&E UNDERGRADUATES

Current students are actively involved in many aspects of the Cornell experience. In addition to leadership roles in student organizations, they are winning awards for their research, contributing to their communities and making plans to continue their education after Cornell. A small sampling includes:

■ Sara Parker, '04, received an NSF Fellowship for graduate study and will attend the University of Illinois - Urbana Champaign. Recently Sara won 2<sup>nd</sup> place in the Intel Student Research Contest for her work on "novel light-emitting devices utilizing ionic liquids" in Assistant Professor George Malliaras' group.

■ Man Hoi Wong, '04, received numerous awards in support of his research including an Intel Research Grant, a Cornell Alumni Research Fellowship and MS&E Nanotechnology Fellowship.

■ Mark Polking, '05, was awarded the prestigious Barry M. Goldwater Scholarship as one of 310 scholars selected from over 1,100 students. The award provides \$7,500 to students committed to a career as a scientist. He also received the MS&E James L. Gregg Prize for the outstanding entering junior. Mark is currently conducting research with Assistant Professor Kit Umbach involving nanoscale patterns on glass fracture surfaces.

■ Tam Ngo, '05, received summer research funding through Cornell's Learning Initiatives for Future Engineers (LIFE) program. She will be conducting research with Assistant Professor Chekesha Liddell.

■ Michael Huang, '05, conducted research with Assistant Professor Kit Umbach this semester with funding from the LIFE program.

■ Jennifer Yu Zhao, '05, is a writer for *Cornell Science and Technology* magazine and does research on organic light emitting diodes with Professor Abruna in the chemistry department.

■ Erica Kaplan, '05, is treasurer of the Bioethics Society and also a jury member of the Academic Integrity Board.

■ Kevin Huang, '06, selected as a Cornell Presidential Research Scholar, will receive up to \$10,000 per year in support of research related expenses. He is doing research with Assistant Professor Chekesha Liddell and Lecturer Alison Shull and is also the new president of the Engineering Student Council.

■ Tim Lau, '06, has also been selected as a Cornell Presidential Research Scholar.

■ Dan Bonner, '06, is co-president of Engineers for Sustainable Development, which brings together students and professionals interested in the development and implementation of appropriate technologies in developing communities.

## MS&E undergraduate enrollment on the rise

The department has seen a tremendous increase in our undergraduate enrollment over the past two years. Our current sophomore and junior classes have over 40 students and we expect this trend to continue. With improved undergraduate laboratory equipment, curriculum revisions which have resulted in more hands-on learning earlier in the degree program, and an increased emphasis on recruiting top students to MS&E, we have seen significant growth in the program.

All of these changes have involved support from our alumni, Advisory Board, current undergraduates, and the faculty and staff in the department. Alumni surveys were used to advise curriculum changes. The Advisory Board provided input and feedback on the strategic plan for the department including the goals for the undergraduate program. Undergraduates have been actively involved in the development of new lab materials and have been engaged in discussions regarding the curriculum and preparation for our upcoming ABET accreditation review in fall 2004. The faculty and staff have invested significant time and energy in implementing changes and recruiting new students to MS&E. As we welcome a truly impressive group of undergraduates to the department, we offer our thanks to all of those involved in these activities.

## Graduate students take top honors

■ Kee Chul Chang, a graduate student working with Professor Jack Blakely, received a \$500 poster award at the Fall 2003 MRS meeting for his poster on "Evolution of Mesas on Si(111) Surfaces Under Sublimation."

Assistant Professor George Malliaras' students are the recipients of several distinguished awards and fellowships:

■ Yuanjia Zhang received a gold award at the Materials Research Society (MRS) Spring 2004 meeting in San Francisco, California, for her symposium paper which exemplified significant and timely research. Yuanjia was also recently awarded an IBM Ph.D. Fellowship for 2004-2005.

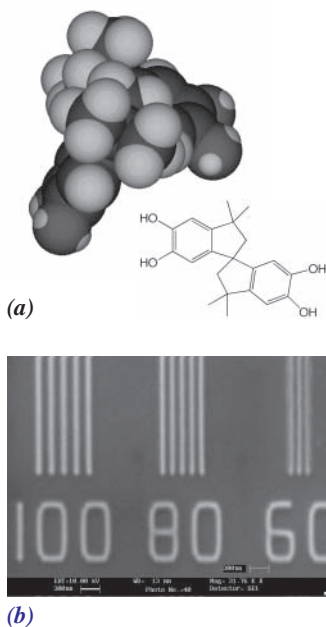
■ Jason Slinker, an Applied and Engineering Physics student of Professor Malliaras, received a 3-year NSF Fellowship.

■ Dan Bernards was selected to receive a 2004-2005 National Defense Science and Engineering Graduate Fellowship. He was selected from over 3,200 applications.

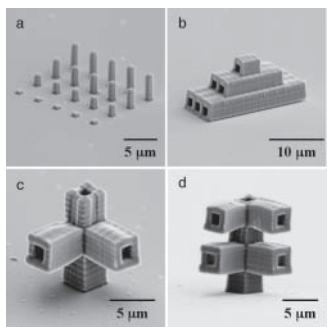


*MS&E Class  
of 2004 in front  
of the nearly  
completed  
Duffield Hall*

## Ober research spotlight: Advances in 2D and 3D Patterning for Nanotechnology



**Figure 1. Molecular glass resist: (a) chemical structure and (b) 100 nm, 80 nm and 60 nm image produced at CNF. These smallest lines are less than 1/1000<sup>th</sup> the diameter of a human hair.**



**Figure 2. 3D structures produced by means of 2-photon lithography. (a) Array of 1 x 1 μm pillars the largest of which is 4 μm tall. (b) A stack of microcapillaries of various lengths with inner diameters of <2 μm. (c-d) Microcapillary intersections.**

Lithography and the processes associated with it are the backbone of the nanotechnology revolution. Several developments are occurring simultaneously: a drive to reduce minimum feature size for advances in microelectronics, the use of lithographically patterned structures to prepare devices for photonics, biotechnology and other forms of nanotechnology, and finally the drive to create 3-dimensional structures for device and new materials creation.

The controlled creation of nanometer-scale structures in 2 and 3 dimensions is of increasing interest in many applications ranging from biotechnology to nanotechnology. Prof. Christopher Ober and his research group are focusing on new approaches for the construction of small-scale structures using a variety of methods ranging from advanced chemically amplified resists to self-assembly to utilizing new tools derived from 2-photon processes for the formation of complex images.

Over the past 30 years the ability to make arbitrarily shaped small-scale structures has progressed enormously. In the days of the first Intel processor features were on the order of a micron (already 1/100<sup>th</sup> the size of a human hair). Today we talk about features only 65 nm in size (the size of a few virus particles) and can contemplate making objects on the order of living or molecular processes. In the future, methods to take the present 2-dimensional world of lithography and transform it to the 3-dimensional world will open up additional frontiers in materials science & engineering.

The nanofabrication of increasingly smaller feature sizes is the ongoing goal for integrated circuits development using advanced lithographic techniques with even higher resolution. In the recent past, researchers invented the concept of chemical amplification in lithography. This process uses the generation of acid by a UV-sensitive small molecule, a photoacid generator (PAG), followed by deprotection of the photopolymer. The resulting change in polarity from a non-polar, base-insoluble polymer to a deprotected, base-soluble polymer provides a remarkable solubility change that permits their use as high resolution resists that are now capable of producing submicron features.

This approach is being studied to create resists capable of forming images smaller than 50 nm. To do this, light of even shorter wavelength (13 nm) is being employed. At these wavelengths, only specific elemental compositions have the transparency needed for a working photoresist. In addition, the

size of the patternable molecule must be small so that any defects are smaller than the structure size. To accomplish both of these ideas, Ober and his group are studying photoresists with compositions that include boron and silicon in addition to the carbon and hydrogen commonly found in photoresists. In addition he and his colleagues are investigating molecular glasses as imaging materials (See Figure 1a). Molecular glasses are small molecules with dimensions only a few nm in size that form a glassy phase similar in organization to window glass. Using such molecules, members of Ober's group have built test structures as small as 60 nm (see Figure 1b) using the advanced tools available at Cornell's Nanofabrication Facility.

In other research, the goal is to take these advanced concepts to build 3D structures. Three-dimensional microfabrication has a wide range of possible applications for micromachining structures such as light-waveguides, microfluidic devices, MEMS and data storage. We are exploring new methods of microfabrication using 2-photon processes. Two-photon lithography not only allows the fabrication of structures that cannot be constructed by conventional single-photon lithography but also exhibits greater spatial resolution than other three-dimensional microfabrication techniques as they are currently practiced. Two-photon lithography is based on the concept that under sufficient illumination intensity, electronic transitions that would normally require absorption of one UV photon for excitation can be accomplished by simultaneous absorption of two IR photons. When this high intensity IR light enters a photoactive material, the excitation reaction is confined to a focal point at a precise depth in a substrate. This occurs because, firstly, the photoactive material is transparent to IR light. Very little absorption occurs in the out of focus area to attenuate the light intensity. Secondly, the quadratic dependence of 2-photon absorption on the incident intensity ensures confinement of the absorption to very small volumes.

The final result is that it is possible to move the focal point of the light beam and to create intricate three dimensional structures. Examples of such structures made just for fun are shown in the electron micrograph in Fig. 2. While these shapes are not as small as those in Figure 1 (in fact they are gigantic (a few μm) compared to the 65 nm lines) they are still too small to be seen by the naked eye. Other activities of our lithography group are the

continued from page 4

patterning of surfaces for study of cell-surface and biomolecules-surface interactions. Such work has made the attogram detection of biomolecules possible. Finally, the group has begun to explore the convergence of lithography with the world of self-assembly through our investigation of block copolymer resists. With these new materials we have been able to pattern materials as small as 20 nm and use the resulting films for separation of protein molecules. Such work makes the dream of devices for photonics, biotechnology and other forms of nanotechnology possible.

The following published and forthcoming papers describe the work by our lithography group:

Mingqi Li, Katsuji Douki, Ken Goto, Xuefa Li, Detlef M. Smilgies, and Christopher K. Ober, "Spatially Controlled Fabrication of Nanoporous Block Copolymers," *Chem. Mater.*, submitted.

Phong Du, Xuefa Li, Katsu Doki, Mingqi Li, Sol Gruner, Detlef Smilgies, Uli Wiesner, and Christopher Ober, "Phase Selective Chemistry in Block Copolymer Thin Films," *Adv. Mater.*, in press.

B. Ilic, H. G. Craighead, S. Krylov, W. Senaratne, C. Ober, and P. Neuzil, "Attogram detection using Nanoelectromechanical Oscillators," *J. Appl. Phys.*, 95, 3694 (2004).

Dai Junyan; Ober, Christopher K.; Kim, Sang-Ouk; Nealey, Paul F.; Golovkina, Victoria; Shin, Jangho; Wang, Lin; Cerrina, Franco. "Synthesis and evaluation of novel organoelement resists for EUV lithography," *Proceedings of SPIE-The International Society for Optical Engineering* (2003), 5039 1164-1172.

V. Jakubek, X. Liu, V. R. Vohra, K. Douki, Y. Kwark, Christopher K. Ober, T. J. Markley, E. A. Robertson III, R. V. C. Carr, J. A. Marsella, W. Conley, D. Miller, and P. Zimmerman, "Strategies for High Transparency Acrylate Resists for 157 nm Lithography," *J. Photopolym. Sci. Tech.*, 16(4), 573-580 (2003).

Tianyue Yu, Christopher K. Ober, Stephan M. Kuebler, Wenhui Zhou, Seth R. Marder, and Joseph W. Perry, "Three-dimensional Microfabrication in a Chemically Amplified Positive System using 2-Photon Lithography," *Adv. Mater.*, 15(6), 2003, 517-521.

Ober, Christopher K.; Douki, Katsuji; Vohra, Vaishali R.; Kwark, Young-Je; Liu, Xiang-Qian; Conley, Will; Miller, Daniel; Zimmerman, Paul. "New strategies for high resolution photoresists," *Journal of Photopolymer Science and Technology* (2002), 15(4), 603-611.

Wenhui Zhou, Stephen M. Kuebler, Kevin L. Braun, Tianyue Yu, J. Kevin Cammack, Christopher K. Ober, Joseph W. Perry, Seth R. Marder, "An Efficient Two-Photon Photoacid and Its Application to 3D Microfabrication in Positive-Tone Resists," *Science*, 296, 1106-1109 (2002).

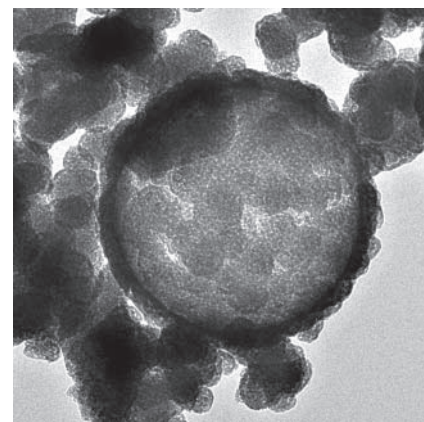
Y. C. Bae, K. Douki, T. Yu, J. Dai, D. Schmaljohann, H. Koerner, C. K. Ober, W. Conley, "Tailoring Transparency of Imageable Fluoropolymers at 157 nm by Incorporation of Hexafluoroisopropyl Alcohol to Photoresist Backbones," *Chem Mater.*, (2002), 14(3), 1306-1313.

## New world class microscope in Bard Hall

MS&E research groups are benefiting from the installation of an Energy Filtered Transmission Electron Microscope (EFTEM) in the Cornell Center for Materials Research Electron & Optical Microscopy Facility located in Bard Hall.

The EFTEM is a versatile tool for the materials scientist, polymer chemist, food scientist, and biologist. Unlike conventional Transmission Electron Microscopy (TEM), the new LEO 922 EFTEM allows the user to separate electrons according to their energy (wavelength) via a spectrometer. The spectrometer is used to select energy and bandwidth. This additional electron selection results in contrast enhancement for all imaging modes and also provides the possibility of selecting electrons with specific scattering effects for imaging. As a result of energy filtering, conventional specimens have more brilliance. Unstained and very thin samples have much higher contrast. Researchers can now obtain new specimen information through structure and element sensitive contrast. Element imaging and comprehensive element analysis with high detection sensitivity with maximum local resolution is now a reality. Optimal depth of focus and individual contrast offers the ability to image thick specimens as well.

Poorna Praveen Rajendran, a graduate student researcher in the Liddell group, is one of many MS&E researchers utilizing the EFTEM in his work. He conducts research on the synthesis of photonic crystals. Such materials offer an unprecedented control of light that will lead to novel electro-optical devices. His current project involves the preparation of core-shell particles and hollow spheres as photonic crystal building blocks. The EFTEM helps Rajendran verify the formation of the desired high refractive index ZnS shell on a polystyrene core. The difference in contrast demonstrates the existence of a coating on the particles. As shown in the figure, the contrast variation also was used in imaging the hollow ZnS spheres which were produced by etching away the core polystyrene bead with toluene. An elemental analysis was performed using the new energy dispersive spectrometer of the EFTEM and the presence of zinc and sulfide was verified.



The Ober research group gets a look at the graduate student office space in Duffield Hall.

# Shefford Baker joins tenured faculty



*Shefford Baker received his Ph.D. from Stanford University researching the mechanical behavior of metal-metal multilayers. From 1993 to 1998, he was a staff scientist at the Max Planck Institut für Metallforschung in Germany. He received an NSF CAREER Award; both the Robert Cowie and the Sonny Yau '72 Excellence in Teaching Awards from the College of Engineering, and the Merrill Presidential Scholar Outstanding Educator Award from Cornell University.*

We are pleased to announce that Shefford Baker was promoted to the position of associate professor with tenure in November. His contributions to research, teaching and outreach since joining Cornell in 1998 are numerous.

Shef's research in recent years has focused on the mechanical properties of materials with microscopic dimensions, and techniques to measure those properties. He has also investigated relationships between microstructure and mechanical properties through both experiments and simulation. His current research includes measurements and modeling of the thermomechanical behavior of thin metal films on substrates, adhesion of thin films to substrates, and investigations of mechanical-property distributions in materials with complex micro-structures.

Shef is an enthusiastic and highly rated teacher. One course that he teaches is the popular MS&E 261, *Mechanical Properties of Materials: From Nanodevices to Superstructures*, which is one of two courses by which undergraduates may affiliate with the MS&E major. Students and TAs

alike consistently comment on the enthusiasm and dedication to teaching that Prof. Baker displays in his courses.

Shef is active in several professional societies, particularly the Materials Research Society (MRS). He is one of four co-chairs of the MRS 2004 Fall meeting in Boston. In addition, he has organized five MRS symposia, co-edited the January 2002 MRS Bulletin *Mechanical Properties in Small Dimensions*, and has taught MRS tutorials on nano-indentation and mechanical behavior of thin films.

Shef is also active within the department, having served in numerous administrative capacities. He has recently been appointed the MS&E Director of Undergraduate Studies for the department.

Shef and his family celebrated this exciting event by hosting a large party for family, friends and colleagues at the ScienCenter in Ithaca. Guests were treated to a saxophone solo by Shef, accompanied on piano by his wife Julie (both were professional musicians in the past). The Bakers have been active supporters of the ScienCenter and its educational mission for many years.

## Patent for YBCO superconductor issued to Professor Bruce van Dover and Bell Labs colleagues

Prof. Bruce van Dover, along with two former colleagues at Bell Labs, Robert Cava (Princeton) and Bertram Batlogg (ETH, Zurich), was issued the US patent rights (patent #6,635,603) to yttrium barium copper oxide (YBCO) after a protracted and intense dispute. YBCO is one of the most important high-temperature superconductor materials, and the race to identify it was highlighted in a 1987 NOVA television special. The race was also narrated from the point of view of one of the participants, in the book *The Breakthrough—Race for the Superconductor*, by Robert Hazen.

The field of superconductivity had been reignited in 1986 when Alex Müller and Georg Bednorz, two researchers at IBM, discovered a copper oxide-based ceramic that showed signs of superconductivity at 30 K, work for which they received a Nobel Prize. The next year Paul Chu (U. Houston) and M. K. Wu (U. Alabama) discovered a variant that stayed superconducting up to 90 K, significantly above the temperature of boiling liquid nitrogen. When they announced the ingredients (Y, Ba, Cu and O) it set off a race to

identify the magical material. Teams at Bell Labs, IBM, the University of Houston, and the Naval Research Laboratory identified the superconducting compound (the first three almost simultaneously) and filed patents. The US patent system then conducted an 'interference' procedure to determine which team had actually discovered the compound first. After years of deliberation a panel of four patent judges ruled that van Dover and his colleagues were the discoverers of the exact composition: YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> (known as the "1-2-3" compound because of the cation subscripts.) The patent was finally granted on 21 October 2003, surely one of the longest intervals between patent application and issuance.

Lucent Technologies, which inherited the patent from its parent, AT&T, has licensed the patent to various companies, including American Superconductor (Westborough, MA). Prof. van Dover did not become rich on royalties since he, as is usual for industrial researchers, signed away patent rights as a condition of employment. He feels that the opportunity to have worked at the forefront of such an exciting field was a rich reward in itself.

### Alumni:

☛ Are you coming for Alumni Weekend? MS&E will hold its annual breakfast for alumni and their families and friends on Saturday, June 12 from 8:30 to 9:30 in Bard 210. Please RSVP to Carol Armstrong: ca20@cornell.edu or 607/255-9617

☛ Please send your email address, with your degree and year of graduation, to matsci-web@cornell.edu. To view alumni addresses on mse.cornell.edu, click on People and then Alumni; the user name is "alums" and the password is "bardthurston".

# CCMR announces new IRG on photonics

**C**ollaborative, interdisciplinary, group research efforts are supported through Cornell's MRSEC. The Interdisciplinary Research Groups (IRGs), are chosen by internal competition. The team participants are drawn from approximately 100 faculty in ten Cornell academic departments that are members of the Cornell Center for Materials Research (CCMR).

A new IRG titled "Photonic Building Blocks from Nanoscale Materials" is being led by MS&E Professor Uli Wiesner and Professor Alex Gaeta (A&EP.) This group investigates the development of a novel class of radiative nanoparticles (known as CU dots) and their application to photonic structures and devices. In addition to the synthesis of novel particle architectures and studies of the fundamental photonic properties of individual dots,

these optical elements will be incorporated into index-matched waveguiding structures prepared by a variety of advanced 2D and 3D lithographic methods. The aim is to develop enabling technologies through fundamental research that will allow for suitable control of light in a broad variety of different fields and applications. These efforts are strengthened through an inter-MRSEC collaboration as well as an international collaboration with experts in the field. This program makes effective use of shared experimental facilities on campus, such as the Cornell Nanofabrication Facility (CNF) as well as facilities of the CCMR.

In addition to IRGs, smaller groups, called Seeds, are supported through the CCMR to perform initial investigations in new areas that look highly promising. It is hoped that Seeds will become integrated into IRGs or may grow into new IRGs. At present there are six Seed projects in the CCMR funded through a combination of NSF and Cornell University resources and two of those include MS&E faculty. These include: "An Advanced Materials Approach to Molecular Sensors", with Prof. Hector Abruna (C&CB), Prof. Paul Houston (C&CB), Prof. George Malliaras (MS&E), and Prof. Tyler McQuade (C&CB); and "Novel Thin-Film Optical Materials", with Prof. Bruce van Dover (MS&E) and Prof. Alex Gaeta (A&EP).

## MS&E hosted Upson visiting Professor Sir Richard Friend

**T**he Department of Materials Science and Engineering hosted Professor Sir Richard H. Friend as The Mary Shepard B. Upson Visiting Professor during the fall 2003 semester. Richard Friend has been on the faculty in the Department of Physics, University of Cambridge, since 1980, where he is the Cavendish Professor of Physics. Friend was recently knighted by Queen Elizabeth II.

Friend pioneered the study of conjugated polymers as semiconductors, and has demonstrated that these materials can be used in a wide range of semiconductor devices, including light emitting diodes, transistors and photovoltaic cells. He has been very active in the process of technology transfer of this research to development for products. He cofounded Cambridge Display Technology Ltd. in 1994, where he is currently Chief Scientist. Light emitting polymer displays developed by Cambridge Display Technology are now being manufactured under license and are used in a number of consumer products. He cofounded Plastic Logic Ltd. in 2000 to develop directly-printed polymer transistor circuits, and holds the posts of Director and Chief Scientist. He has published more than 600 papers on organic semiconductors and related research areas, and is a named

inventor on more than 20 patents and patent applications. Over the period 1990-1999 he was the most-cited scientist based in the United Kingdom in the field of the physical sciences.

During his residence Dr. Friend gave three lectures and collaborated with faculty throughout campus on teaching and research. His lectures were titled: "Organic semiconductor heterojunctions: electricity to light and light to electricity;" "Self-organization in polymeric semiconductors: novel architectures for semiconductor devices;" and "Polymer electronics: technology transfer and company start-up."

The Mary Shepard B. Upson Visiting Professorship was established in 1966 through the bequest of the widow of the late Maxwell M. Upson, who graduated from Cornell University with a degree in mechanical engineering in 1899 and was a member of the Board of Trustees for thirty-five years. Upson was a frequent benefactor of the university; among his many gifts is the building that bears his name, Upson Hall, on the engineering quadrangle. The late Mrs. Upson, who was born in Concord, Massachusetts, shared her husband's lifelong interest in Cornell. In her will, she directed that the majority of her estate be used to further the goals of Cornell's College of Engineering.



*Professor Sir Richard Friend was hosted by the Department of Materials Science and Engineering as the Mary Shepard B. Upson Visiting Professor. Recently knighted by Queen Elizabeth II, Friend pioneered the study of conjugated polymers as semiconductors.*

# North wing nanotechnology research suite planned

Over the past year MS&E has created strategic and facilities plans focusing on goals for the next decade in the areas of research, teaching and outreach.

These plans will guide and support the efforts of MS&E as we build on the considerable strengths of the department. The first phase of the MS&E facilities plan includes the renovation of laboratory space to create the North Wing Nanotechnology Research Suite beginning in fall 2004.

The plan includes renovation of outdated existing labs into a suite of flexible, multipurpose research spaces, which will accommodate our growing need for vibrationally and acoustically quiet research space. We plan to create and furnish six distinct lab spaces that will include both wet labs with chemical fume hoods and dry labs with isolation tables that will accommodate temperature and vibration sensitive experimentation. The result will be a modern, flexible laboratory space ideal for the high precision equipment, measurements and synthesis associated with nanoscale materials research.

Our ability to measure, manipulate and modify materials at the nanometer scale is expanding dramatically. Imagine generating devices by placing individual molecules, or even individual atoms, at specific sites on a surface, or measuring the mechanical behavior of a nanometer scale object by contacting it with a nanoscale probe. These tasks require an extraordinarily stable environment. The proposed research space will provide this environment and significantly enhance our ability to work with materials at these very fine length scales.

The pace of change in materials science research is accelerating. The ability to directly measure, manipulate and modify materials at the nanometer length scale will provide access to new phenomena and control

of properties in ways which previously were simply not available. This in turn allows us to invent new materials and to refine old ones for applications ranging from telecommunications, to energy production and storage, to medicine. We are particularly excited by the prospect of being able to apply the tools and methods of materials science and engineering to the properties of living systems, which are controlled by phenomena at this length scale.

The renovated space will particularly benefit the faculty members in the department who have growing, world-renowned efforts to expand our ability to measure, manipulate and modify materials at the nanoscale. This includes, in part, professors Baker, Malliaras, Ober and Wiesner. In particular, these renovated labs will support sensitive measurements that require very low vibration such as atomic force microscopy, nanomechanical contact measurements, electron microscopy, and a host of others. This is also valuable space for photonic or optoelectronic research. An additional benefit of this particular project is its proximity to the Cornell Center for Materials Research (CCMR) Electron and Optical Microscopy Facility, which is also located in Bard Hall adjacent to the proposed renovation.

The North Wing Nanotechnology Suite will be the first important step in MS&E's facilities plan. The department will be launching a fund raising effort in support of this new project, which is estimated to total \$500,000. We look forward to providing you with an update in the spring 2005 newsletter.

If you are interested in learning more about the plans for this new research suite, please contact Director and Professor Emmanuel Giannelis.

## ALUMNI NOTES

■ Astronaut and materials science researcher **Donald Thomas, Ph.D. '82**, was recently named NASA's new International Space Station (ISS) program scientist. Based at the Johnson Space Center in Houston, Texas, Thomas works to ensure that scientific and engineering requirements for research on the ISS are clearly communicated among all participants. He also serves as the science spokesperson for the ISS program to scientific and international research communities as well as the general public. A veteran of four space flights, he has logged over 1,040 hours in space.

■ **Bill Edwards, Ph.D. '96**, is on military leave from his position with Hewlett Packard. As a member of the Army National Guard, 2nd Battalion, 162nd Infantry, Edwards has been deployed to Iraq for one year as part of Operation Iraqi Freedom.

■ **Chinedum Osuji, B.S. '96**, will travel to Athens in August 2004 to

compete at the Olympic Games in Taekwondo. Chinedum qualified his country, Trinidad and Tobago, by placing second in the welterweight (80kg) category at the Pan American Olympic Qualification tournament in Queretaro, Mexico, in February. In 2003, Osuji completed his Ph.D. in materials science and engineering at M.I.T. See [www.cwtkd.com/cosuji-athens2004](http://www.cwtkd.com/cosuji-athens2004).

■ **Linlin Wang, Ph.D. expected '04**, joined Applied Materials, manufacturer of semiconductor equipment, in February of 2004, joining her former office mates **Jean (Jungting) Liu, Ph.D. '02**, and **Sergei Krasulya, Ph.D. '02**. Krasulya has enrolled in the company sponsored MBA program.

■ **Ersan Ustundag, Ph.D. '96**, is leaving Caltech and joining the Department of Materials Science and Engineering at Iowa State as an Associate Professor and Glen Murphy Chair of Engineering with a joint appointment at the Department of Energy Ames Laboratory.