the world. It will take fellows out of their own comfort zones, intrude them into some policy comfort zones, and maybe increase the well-being of the international community. It is more than worth considering. The experience of future fellows will mirror mine only in its unpredictability, but it will almost certainly be highly rewarding.

The upcoming application deadline is December 31, 2006 for fellowships starting in August 2007. Details about the Jefferson Science Fellowship program can be accessed at Web site http://www7.nationalacademies.org/Jefferson/.

For me, it's back to "real life" at Purdue University for the fall semester, but real life will never be quite the same again.

ALEX KING
2005–2006 Jefferson Science Fellow
U.S. Department of State

RESEARCH/RESEARCHERS

Dye-Sensitized Solar Cells Fabricated with Liquid Organic Semiconductor Achieve Relatively High Efficiencies

Since their introduction 15 years ago, solar cells based on dye-sensitized mesoporous layers of TiO_2 have attracted attention as a potentially greener alternative to silicon-based solar cells. However, a major stumbling block in the path toward more efficient dye-sensitized solar cells (DSCs) is the difficulty of infiltrating solid-state semiconductor material into the TiO_2 to carry away liberated charge. Now, H.J. Snaith and colleagues from École Polytechnique Fédérale de Lausanne, Switzerland, have used a liquid organic semiconductor in the construction of DSCs, finding that the resulting devices have relatively high efficiencies.

As reported in the September issue of *Nano Letters* (p. 2000; DOI: 10.1021/nl061173a), the researchers first characterized the liquid organic semiconductor tris-[4-(2-methoxy-ethoxy)-phenyl]-amine (TMEPA), finding the highest occupied molecular orbital at −5.34 eV below vacuum, suitable for hole transfer from the oxidized dye molecule K51. To fabricate the solar cells, they screen-printed a 2.5-µm-thick mesoporous layer of TiO_2 nanoparticles with ~20-nm average diameters on a fluorine-doped SnO_2 glass sheet. The nanoparticles were coated with K51 dye molecules and overlaid with a 20-µm Surlene spacer and a gold-coated conducting cathode. These "empty" cells were then filled with 20 µl of *p*-doped TMEPA by pumping on them under vacuum to remove air bubbles and returning them to air pressure to force the TMEPA into the cell. The finished cells showed solar power conversion efficiencies of 2.4–3% for illumination intensities between 10 mW/cm^2 and 100 mW/cm^2. The incident photon-to-electron quantum efficiency was very high (over 50%), but this value fell off at higher illumination intensities and thus did not translate to a high power-conversion efficiency. The team is currently working to cross-link the semiconductor after fabrication to convert the solar cell to a fully solid-state device. Given these results, liquid organic semiconductors rather than those in the solid state may become the standard for dye-sensitized solar cell fabrication and may one day help replace silicon photovoltaics with DSCs.

COLIN MCCORMICK

Artificial Muscles Employed to Build Tunable Diffraction Gratings

Until now, the most successful tunable diffraction gratings with applications in telecommunication and display devices relied on standard hard materials. A. Stemmer and M. Aschwanden from the Nanotechnology Group of the Swiss Federal Institute of Technology have demonstrated a low-cost, electrically tunable diffraction grating based on soft electroactive polymer actuators, also known as artificial muscles. As reported in the September 1 issue of *Optics Letters* (p. 2610), the researchers developed a polymer-based device with an angular tuning range of 118 mrad for the first diffraction order, in comparison with the 486 µrad achieved with analog tunable diffraction gratings based on hard piezoelectric actuators. In this device, light diffracts in gratings whose grating period can be changed up to 32%. When combined with white light sources, they can be used as wavelength-tunable luminous sources that may lead to the development of inexpensive, natural color displays when integrated into optical microelectromechanical systems.

The researchers fabricated the dielectric elastomer actuator by pre-straining and mounting on a holder an acrylic elastomer film and contact printing compliant carbon electrodes with a poly(dimethylsiloxane) stamp coated with carbon black. They spin-coated a 20-µm-thick elastomer film onto a holographic diffraction grating master with 1000 lines/mm to create the elastomeric diffraction grating. This film was placed onto the dielectric elastomer actuator, where it remained bonded after curing at 50°C for 60 min. The grating master was then peeled off of the elastomeric film, and a 6-nm-thick, reflection-enhancing gold layer was then evaporated onto the diffraction grating.

When the researchers applied a voltage between the two compliant electrodes, the charges that built up at the elastomer–electrode interfaces established an electric-field pressure that induced a compression in thickness and an elongation of the elastomer film in the planar directions. When white light from a collimated tungsten halogen lamp with a spot size of 0.5 mm was directed at a fixed incidence angle onto the center of the tunable diffraction grating, the researchers observed that they were able to tune the wavelength of the first-order diffracted spot from 446 nm to 585 nm (a tuning range of 139 nm) over a voltage range from 0 kV to 4.5 kV. Stability tests (30,000 cycles) showed no degradation in reflectivity and no peeling of the gold layer.

The researchers said, "because of the wide tuning range, the demonstrated device is not only interesting for display applications but also for other optical systems such as low-cost tunable lasers."

JOAN J. CARVAJAL

Carbon Nanohorns Made Soluble through Covalent Chemical Modification

Laser ablation of graphite produces carbon nanohorns (CNHs) in high yield. CNHs not only differ from single-walled carbon nanotubes (CNTs) in their shape; CNHs are free from impurities and do not require purification that results in degradation and reduced mechanical and electronic properties. Like CNTs, however, CNHs are completely insoluble in organic solvents and in aqueous media. Recently, N. Tagmatarchis and graduate student G. Pagona at the National Hellenic Research Foundation in Athens, Greece, together with J. Fan and co-researchers from the Japan Science and Technology Agency and NEC Corp., both in Ibaraki,

Japan, functionalized CNHs, making them soluble.

As reported in a communication published in the August 22 issue of *Chemistry of Materials* (p. 3918; DOI: 10.1021/cm0604864), Tagmatarchis and coresearchers treated CNHs with O_2 at 0.1 MPa and 580°C for 10 min to remove the strained hemispherical tip and introduce carboxylic acids at the cone ends. These mild conditions retain high purity and, unlike a previously published tip-opening procedure for CNTs, do not substantially shorten the CNHs. The carboxylic acid-terminated CNHs were converted to acylchloride-terminated CNHs by treatment with thionyl chloride together with a dimethylformamide catalyst or by refluxing with oxalyl chloride. Subsequent functionalization with a variety of amines, alcohols, and thiols possessing long or short hydrophobic alkyl chains, polar oligoethylenes, aromatic chromophores, or masked active groups suitable for further functionalization, was performed in dry, anaerobic conditions. The functionalized CNHs displayed expected solubilities; for example, polar derivatives are soluble in polar solvents while apolar derivatives are soluble in apolar solvents. The researchers used high-resolution transmission electron microscopy to show that functionalized CNHs in solution retain their characteristic morphology. Fourier transform infrared spectroscopy was used to verify the covalent cone-end functionalization. UV–vis spectra of CNHs functionalized with chromophores were very similar to the spectra of the chromophores themselves; red-shifted and somewhat collapsed transitions of the functionalized CNHs suggested to the researchers that electronic intramolecular communication occurs between the CNHs and the chromophores. The researchers point to the quenching of the strong fluorescence emission of pyrene by more than 90% in the CNH–pyrene hybrid as verification of this intramolecular electronic communication.

The researchers said that their procedure "opens new avenues for the synthesis of a plethora of nanohorn-based hybrid materials suitable for nanotechnology applications, particularly in the context of solar energy conversion, photovoltaics, and photosynthesis biomimetic systems where CNHs play a role as efficient electron acceptors."

STEVEN TROHALAKI

TEM Imaging during Quantitative Nanoindentation of Aluminum Grains Challenges Conventional Ideas of Plasticity Onset

Scientists have long assumed that a crystal needs to be perfect to sustain stress at its theoretical limit. At this point, dislocations in the crystal lattice occur, and the crystal undergoes a non-reversible change in shape, or plastic deformation. In a study on the nanoindentation of aluminum, A.M. Minor of Lawrence Berkeley National Laboratory, E.A. Stach of Purdue University, S.A. Syed Asif and O.L. Warren of Hysitron Inc., and their colleagues have gained new insight into the onset of plasticity. Minor said, "We found that plenty of defects accumulate before the point that would usually be interpreted as the initial yield point….Surprisingly, even when the material [under study] had a high defect density, it could withstand near-theoretical shear stresses."

The research team used nanoindentation techniques that feature real-time movies, which can be studied frame by frame, taken inside the transmission electron microscope (TEM). As reported in *Nature Materials* (DOI:10.1038/nmat1714; published online: August 13, 2006), the

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researchers built a quantitative *in situ* nanoindenter by developing and integrating a miniature capacitive force and displacement transducer into a sample holder in their TEM. With this setup, data and movies documenting nanoscale deformation events could be made simultaneously and directly.

A typical nanoindentation experiment with the new setup involves a three-sided diamond indenter approaching the apex of a target grain of aluminum, a single crystal within a thin polycrystalline film of aluminum deposited on a silicon substrate. As the indenter loads the crystal, the load and displacement of the indenter are plotted on a graph. Simultaneously, the video comprised of consecutive frames of TEM images shows corresponding changes in the crystal.

In the evolving graph of one such experiment, two small transients are observed that correspond to video frames (TEM images) showing the sudden appearance of dislocations in the crystal. In the first event, the crystal (initially apparently flawless) instantly becomes filled with defects. In the second event, the defect configuration abruptly shifts. These changes show dislocations breaking free, gliding over other sections, interacting, and then coming to rest at their new equilibrium positions.

The researchers said that, although consumed with dislocations, the crystal is enduring shear stresses nearly equal to the calculated ideal strength of the material. Still, the large yield response known as "pop in" to the nanoindentation community is yet to come. When it does, the event is clearly visible in both graph and video frame. The graph shows a sustained rise in force, then a sudden relaxation of load as the crystal gives way. The video frame shows a new pattern of defect contrast and a different geometry of the defect-riddled crystal grain.

Shan said, "These results challenge the traditional concept of the initial deformation of crystalline materials. The discovery poses many new questions about other kinds of nanoscale materials, including thin films, nanowires, and individual nanoparticles."

News of MRS Members/Materials Researchers

Cathy A. Fleischer, formerly the R&D director for polarizer films at Eastman Kodak Co., has been appointed chief technology officer at NaturalNano Inc.

Alice P. Gast, formerly vice president for research and associate provost at the Massachusetts Institute of Technology, has been named president of Lehigh University. She stepped into the position in August. Gast succeeds outgoing president Gregory C. Farrington, who announced in fall 2005 that he would conclude his eight-year term at Lehigh's helm in June 2006.

Teruo Kishi, president of the National Institute for Materials Science (NIMS) in Japan, has received the **Japanese Society for Non-Destructive Inspection Award** in recognition of his research achievements in the field of non-destructive inspection over the course of many years, ranging from basic research to practical applications, and particularly his work on acoustic-emission detection of fractures and their quantitative evaluation.

Albert Polman has been appointed by the Foundation of Fundamental Research on Matter (FOM) as director of the Institute of Atomic and Molecular Physics (AMOLF), the Netherlands.

Mas Subramanian has joined the Department of Chemistry at Oregon State University (OSU) as the Milton Harris Professor of Materials Science. This move also makes him the first Signature Faculty Fellow in the Oregon Nanoscience and Microtechnologies Institute (ONAMI), which is a major collaborative effort of OSU, other Oregon universities, government agencies, and private industry.

Eicke R. Weber has been named director of the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany. He succeeds Joachim Luther, who has headed the research institute since 1993 and is now retiring.

Subra Suresh Honored with 2006 *Acta Materialia* Gold Medal

The 2006 *Acta Materialia* Gold Medal has been awarded to Subra Suresh, Ford Professor of Engineering and head of the Department of Materials Science and Engineering at the Massachusetts Institute of Technology. He also holds appointments as a professor of biological engineering and of mechanical engineering at MIT and affiliated faculty of the Harvard–MIT Division of Health Sciences and Technology. The Medal recognizes Suresh's demonstrated ability and leadership in materials research.

During a career spanning three decades, Suresh has made pioneering contributions to metallurgy, materials science and engineering, engineering mechanics, fracture mechanics, fatigue of materials, thin films, and cell and molecular biomechanics. His students and associates now occupy prominent positions in academia, industry, and government around the world.

The 2006 *Acta Materialia* Gold Medal will be presented to Suresh at the 2006 Materials Research Society Fall Meeting in Boston during the awards ceremony on November 29. During the conference, Suresh will deliver the first *Acta Materialia* Gold Medal Lecture, "Cell and Molecular Mechanics at the Crossroads of Nanotechnology, Life Sciences, and Medicine" on November 27 at 12:05 pm in the Grand Ballroom at the Sheraton Boston Hotel.

Praveen Chaudhari Honored with 2006 J. Herbert Hollomon Award

Praveen Chaudhari, director of Brookhaven National Laboratory, has been named to receive the *Acta Materialia* 2006 J. Herbert Hollomon Award in recognition of his outstanding contributions to understanding the relations between materials technology and society, and contributions to materials technology that have had major impact on society. The award will be presented to Chaudhari at the 2006 Materials Research Society Fall Meeting in Boston during the awards ceremony on November 29.

Correction

In the September 2006 issue of *MRS Bulletin* **31** (9) p. 683, the statement, "...the weak binding of benzene on graphite becomes progressively stronger as the nanotube diameter narrows," should read "...the binding of benzene on graphite becomes progressively weaker as the nanotube diameter narrows."

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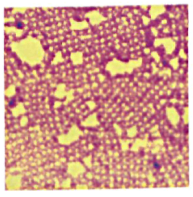
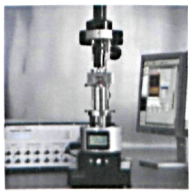
Mach V.

AFM image of mini-circle DNA with approximately 340 base pairs. 130nm scan.



10nm wide AFM image of RNA tectosquares. Scan size 600nm.



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Frank Reginald Nunes Nabarro, professor emeritus of physics at the University of the Witwatersrand, South Africa, died on July 20, 2006, at the age of 90, after a distinguished career in materials science spanning almost seven decades. He was best known for his pioneering contributions to the theory of crystal lattice dislocations and their role in plasticity and work hardening. He had a profound influence on the field through his monumental book, *Theory of Crystal Dislocations* (Oxford University Press, 1967), his extensive editing activities, and innumerable personal ties.

Frank Nabarro was born and raised in the United Kingdom and by the late 1930s had obtained degrees in mathematics and physics from Oxford University. Initially guided by Neville Mott, he undertook calculations of the dependence of the flow stress of a crystal on solute atoms and precipitates, highlighting the role of the flexibility of the dislocations involved. With Herbert Fröhlich, he investigated the orientation of nuclear spins in a metal. In 1940, he published four papers on these topics, and was well launched into his research career. During the Second World War, he worked for the British Army Operational Research Group, for which he was later named a Member of the Order of the British Empire (MBE). After the war, Nabarro resumed his academic career at Bristol University and later at Birmingham University, the latter conferring the degree of DSc on him in 1953. During this period, Nabarro wrote a number of seminal papers and rose to a leadership position in his field. His research output continued almost unabated throughout his life. He contributed essential ideas to many topics, including the elastic theory of dislocations (which forms the basis of his book), work hardening, Harper–Dorn and diffusional creep, the Peierls–Nabarro stress, the effect of elastic energy on the shape of precipitate particles, crystal whiskers, and the interaction of sound waves with dislocations. In recent years, Nabarro turned his attention to creep-resistant materials and rafting in superalloys, which, with Filmer de Villiers, he surveyed in a monograph.

In 1953, Nabarro moved to South Africa to head the Department of Physics at the University of the Witwatersrand. Within a few years, he built the department to significant strength in a number of areas. He served the university in various capacities, including a term as deputy vice chancellor. During his tenure in that position, Nabarro was responsible for drawing up the academic plan—the first for any South African university—that prepared for the anticipated large influx of black students. He retired in 1984, but remained an active member of the university community, always generous with his time and wise counsel.

Nabarro contributed significantly over many years to the development of physics and science as a whole in South Africa, through the active roles he played in the SA Institute of Physics, the Royal Society of SA, and Academy of Science of SA and in many other ways.

Nabarro's energy and resilience were phenomenal, his intellectual vitality extraordinary. He never stopped being active in research. Two of his papers are currently in press, one written with Sanjiv Shrivastava and Silvana Luyckx on "The Size Effect in Micro-Indentation," (*Philosophical Magazine*) and the other a thoughtful essay on "Creep in Commercially Pure Metals" (*Acta Materialia*). Nabarro was editing volumes 13 and 14 of the definitive series *Dislocations in Solids* (North-Holland; J.P. Hirth, co-editor) when he passed away. Nabarro had traveled extensively, attending conferences and giving lectures wherever he went. Even as recently as May 2006, he visited China and India, and he was planning to attend the Materials Research Society meeting in Boston in November to receive a special issue of *Philosophical Magazine* that was dedicated to him. In November 2004, *MRS Bulletin* published a feature on Nabarro in PROFILES & PERSPECTIVES (p. 875).

Nabarro was the recipient of numerous awards, including the Institute of Materials Platinum Medal and a number of honorary doctorates. He was a foreign associate of the U.S. Academy of Engineering, and a fellow of the Royal Society of the United Kingdom.

Frank Nabarro will be deeply missed by his five children and their offspring, and his many friends and colleagues.

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