observed kinetic phenomena remarkably analogous to those reported for atomic-scale systems, including parameters for stable nucleation and island growth as well as the existence of step-corner and step-edge kinetic barriers. The researchers said that although atomic-scale kinetic models successfully predict much of the observed behavior, the actual forces governing the behavior are likely to be significantly different due to the change in size scale. This model system has also been artificially constrained to mimic the behavior of atomic monolayers, and the familiar phenomena observed for this system may not apply more generally to other micro- and nanoscale-based materials systems. Nonetheless, this research points the way to more rigorous study of the mechanics behind materials designed at this intermediate size scale.

KRISTA L. NIECE

Radial *p-n* Junction Enhances Light-Trapping in Si Nanowire Solar Cells

When used in combination with inexpensive substrates to reduce the fabrication cost of photovoltaic cells, thin-film semiconducting materials must possess either a high absorption coefficient or excellent light-trapping capabilities to overcome the resulting short optical path length and minority carrier diffusion length. While solar cells with nanostructured radial *p-n* junctions are known to have low reflective losses compared to their planar counterparts, their light-trapping properties have not been measured. E. Garnett and P. Yang at the University of California, Berkeley, however, have recently developed a simple and scalable method to fabricate large-area silicon nanowire radial *p-n* junction photovoltaics (with efficiencies between 5–6%) and have quantitatively measured extraordinary enhancements in the light-trapping path length of up to a factor of 73, which is beyond the randomized scattering (Lambertian) limit.

As described in the January 28 online edition of *Nano Letters* (DOI: 10.1021/nl100161z), the processing of these ordered nanowire arrays involves dip coating *n*-type silicon substrates to self-assemble silica spheres, deep reactive ion etching (DRIE) to form the arrays, bead removal in hydrofluoric acid, and boron diffusion to form the radial *p-n* junctions. The resulting nanowire arrays showed excellent packing and uniformity that extends over large areas (up to 10 cm^2). To mimic the photovoltaic response of very thin (8 μm and 20 μm) silicon solar cells, very highly doped *n*-type silicon wafers topped with a thin, lightly doped epitaxial layer were used as the substrates. In addition, this simple method of varying the thickness of the silicon solar cells enabled quantitative measurement of their light trapping efficiency.

A maximum light-trapping path length enhancement factor between 1.7 and 73 (depending on the nanowire geometry) was recorded using optical transmission and photocurrent measurements. Longer nanowires led to both increased recombination and higher absorption, with the light-trapping effect dominating for the 8-μm thin silicon absorbing layers. Because of the incredible light-trapping effect, the overall efficiency for the 8 μm absorber silicon nanowire array solar cells is ~20% higher than results on 8-μm thick silicon ribbon solar cells. Efficiencies between 5–6% were achieved for the nanowire array solar cells on 8 μm and 20 μm silicon absorber layers. However, it should be noted that no surface passivation (which is known to be important in high-performance planar solar cells) was performed.

The researchers said that it should, in principle, be possible to extend their fabrication approach to multicrystalline silicon (or other semiconductor) thin films deposited on low-cost substrates (such as glass, aluminum, or metallurgical grade silicon). By providing a means to reduce both the quantity and quality of the required silicon semiconductor and with the application of proper surface treatments, this ordered vertical nanowire array geometry represents an economically viable path toward the large scale implementation of high-efficiency, thin-film solar cells.

TIFFANY D. ZIEBELL

News of MRS Members/Materials Researchers

Praveen Chaudhari, former Director and Vice-President, Science, for IBM research laboratories worldwide, passed away at the age of 73 on January 13, 2010, at his home in Briarcliff Manor, New York, after a battle with cancer. He is survived by his widow, Karin, son, Ashok, and daughter, Pia.

Born in Ludhiana, Punjab, India, on November 30, 1937, Praveen was educated at Indian Institute of Technology, Kharagpur, (BTech degree, 1961) and the Massachusetts Institute of Technology (PhD degree, physical metallurgy, 1966). He joined the IBM Thomas J. Watson Research Center in 1966, and enjoyed a long and extremely distinguished career as one of the foremost scientists and scientific directors in an age of extraordinary innovations, many of which he helped bring about. Perhaps his greatest scientific breakthrough, along with two other IBM researchers, was the discovery of magneto-optic materials that significantly impacted the optical data storage industry. In recognition of this seminal work, he was awarded the National Medal of Technology by President Bill Clinton in 1995.

He made important contributions to many other areas of science, including structure and properties of amorphous solids, defects in solids, quantum transport in disordered systems, liquid crystal alignment on substrates, and high temperature superconductivity. Soon after the discovery of superconductivity above liquid nitrogen temperature in the cuprate superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO), Praveen and his IBM colleagues demonstrated the growth of epitaxial films of this material that could sustain very high critical current densities (10^5–10^6 A/cm^2 at 77 K), more than enough for practical applications. This was quickly followed by the conclusive confirmation of the deleterious influence of grain boundaries in YBCO and other superconducting cuprates in limiting the critical current density. Working with a group of talented visiting scientists and colleagues at IBM, Praveen made the ingenious use of bicrystal strontium titanate substrates to show that the superconducting coupling across a grain boundary varies almost exponentially with the misorientation angle, and that large-angle boundaries can be exploited for fabricating superconducting quantum interference (SQUID) devices. Such SQUID devices are currently being used for a number of biomedical and medical imaging applications, while the promising development of high temperature superconducting cables has

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benefited significantly from the fundamental understanding of coupling across grain boundaries.

Praveen published over 160 papers and held over 36 patents. He was elected a member of the U.S. National Academy of Sciences and the National Academy of Engineering, as well as a Fellow of the American Academy of Arts and Sciences and of the American Physical Society.

As important as his direct scientific contributions were, his impact on the science and technology infrastructure and achievements of IBM research laboratories, including those at Yorktown Heights, Almaden, and Zürich, during his tenure as Director, then Vice-President, Science, was even greater. During this time, IBM scientists in Zürich received two Nobel prizes in physics in consecutive years (1987 and 1988).

In addition to the National Medal of Technology, Praveen received several other prestigious awards, including the Institute of Electrical and Electronics Engineers (IEEE) Morris N. Liebmann Memorial Award (1992) for "the discovery of amorphous magnetic films in magneto-optic data storage systems"; the Massachusetts Institute of Technology Harry C. Gatos Distinguished Lecture and Prize (1994) in the field of electronic materials research; and the *Acta Materialia* J. Herbert Hollomon Award, presented at the 2006 Materials Research Society Fall Meeting, in recognition of his outstanding contributions to interactions between society and materials science and technology, as well as for his contributions to materials technology that have had a major impact on society. Praveen was also the recipient of the George E. Pake Prize of the American Physical Society for his personal contributions to science and science management.

He retired from IBM in March 2003 and served as the director of Brookhaven National Laboratory until April 2006, enabling the implementation of the laboratory's new vision and growth. He joined the Applied Physics and Mathematics Department at Columbia University as an adjunct faculty member in 2006, while continuing part-time scientific work at Brookhaven. He also began a collaboration with IBM scientists on new materials for photovoltaic applications and conducted his own experiments in his old laboratory at the Thomas J. Watson Research Center until shortly before his passing. Praveen always had a remarkable ability to combine his outstanding success as a scientist contributing in an extraordinary number of areas, with an equally outstanding career as a scientific director and executive.

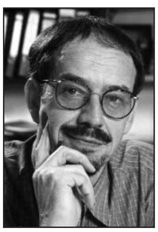
Praveen was active in many committees nationwide and internationally, including the Physics Policy Committee of the American Physical Society, the Governing Board of the New York Academy of Sciences, as chair of the Advisory Board of the Mathematical and Physical Sciences of the National Science Foundation, and of the Scientific Advisory Council of the International Center for Theoretical Physics in Trieste, Italy.

He co-chaired the National Research Council Study on Materials Science and Engineering, with Merton C. Flemings of MIT. This study was the basis of a Presidential initiative in advanced materials and processing programs announced by the White House on January 30, 1992.

Praveen played an active role in the Materials Research Society. Among other contributions, he served as Guest Editor of *MRS Bulletin* with Mildred Dresselhaus (published in November 2005), highlighting the many fields that emerged from the work of Arthur von Hippel, for whom MRS has named its highest award. He also contributed an article to the *MRS Bulletin* feature on 21st Century Materials Challenges (published in July 2000; www.mrs.org/bulletin).

Praveen Chaudhari is remembered with great fondness and appreciation by all who knew or worked with him. With his passing, the materials research community has lost a distinguished colleague, great leader, and wise counselor.

Arunava Gupta
University of Alabama, Tuscaloosa, AL
A. Frank Mayadas
Alfred P. Sloan Foundation, New York, NY



Ulrich M. Gösele passed away unexpectedly on November 8, 2009 in Halle, Germany. He was born in 1949 in Stuttgart, and studied physics at the University of Stuttgart where he also received his PhD degree in conjunction with the Max-Planck Institute for Metals Research, Stuttgart. He started as a theoretician, and in 1975 became interested in defects in silicon. Soon Gösele became one of the leading authorities in the field of defects and diffusion in semiconductors. In 1977 he was awarded the Otto-Hahn Medal of the Max-Planck Society (MPG) for outstanding scientific achievements. He worked in a number of research institutions worldwide (MPI Stuttgart; Physical Metallurgy Division of the Atomic Energy Board in South Africa; IBM Watson Research Laboratories in Yorktown Heights, USA; Siemens Corporation in Munich, Germany) before moving to Duke University, North Carolina, USA, as a full Professor of Materials Science. In 1991, he accepted the position as one of the two founding directors for the newly established Max-Planck-Institute of Microstructure Physics, Halle, and made sure that the former Bethge Institute maintained and extended its strong international position.

As a scientist Ulrich made lasting contributions. The science and technology of wafer bonding cannot be pictured without his work, and his book *Semiconductor Wafer Bonding: Science and Technology* (John Wiley & Sons, 1999)—co-authored with Q.-Y. Tong—is the standard reference in this field. Diffusion and defects in semiconductors remained one of Ulrich's passions, and he not only developed an understanding of new diffusion mechanisms in Si but also in III–V compounds. The new diffusion models he pioneered have now become textbook topics. He invoked quantum effects in microporous Si; his papers triggered thousands of papers in the general area of porous semiconductors and porous alumina. In his later years, he started working on nanowires, nanotubes, and nanodots, again with almost instantaneous international recognition. Ulrich stimulated his whole department: the enthusiasm for doing science, the supreme motivation, the team spirit and the way working together and having fun together was unique. Ulrich Gösele was a supreme motivator and mentor—and a good listener; he was the driving force for innovations.

His work was recognized by many honors and awards, and at the time of his death he was on the short list for more. Ulrich was a much sought-after lecturer and keynote speaker with inspiring presentations. He co-chaired the 2002 MRS Spring Meeting. He was often approached for advice or asked to serve on committees charged with difficult tasks. Prof. Dr. Ulrich Gösele has made lasting contributions to science and enriched the professional and private lives of many people. He died unexpectedly and far too early. He will be missed and remembered as an outstanding scientist and a caring friend.

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