Inventing High-Tech Instruments

PROFILE by Jennifer Ouellette

Rewards awaited Venky Venkatesan's risk taking

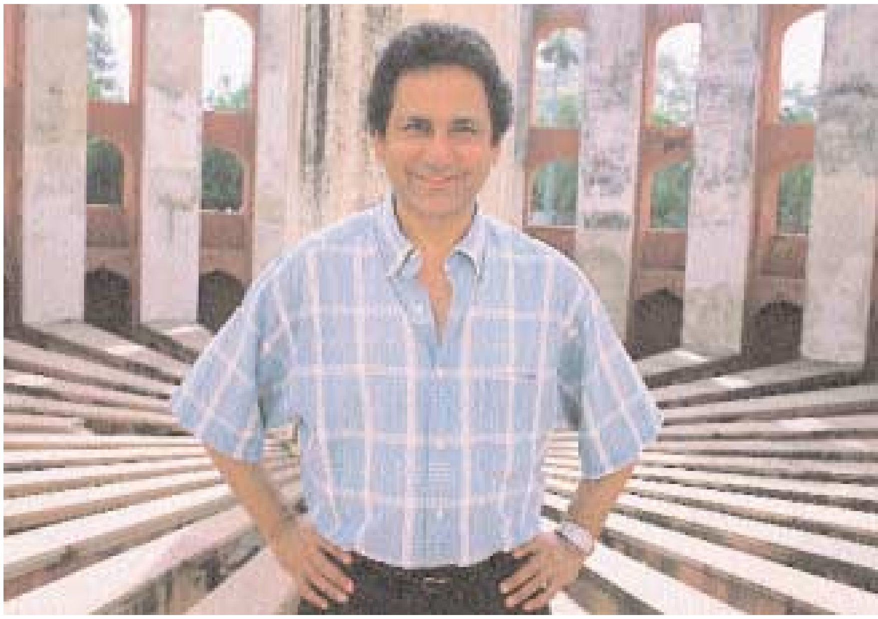

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Figure 1. Venkatesan maintains a home in New Delhi, India, where one of the local attractions is Jantar Mantar, in the heart of the commercial center, near Connaught Place. This was one of several astronomical observatories built by the Maharaja Jai Singh II of Jaipur.

Many physicists dream of the perfect tenured faculty position, and others opt for established positions in industry or government laboratories. But an increasing number of scientists are finding fulfillment in small high-tech start-up ventures. T. (Venky) Venkatesan has carved out his own career path since leaving the established industrial-research environment to set up his own company. Founded in 1989 as a commercial vehicle for conveying his technological expertise in ceramic thin-film materials to the semiconductor industry, Neocera (Beltsville, MD) has developed into a unique microelectronics and sensor-based instrumentation company.

Yet in his academic role as professor of physics and electrical engineering at the University of Maryland (UMD), College Park, Venkatesan also tries to communicate to students what he has learned about matching one's natural skills with what one loves to do. "Our aspirations and inspirations in life come from the people surrounding us, and very often we get into a groove that isn't right for us," he says. "I try to steer my students in directions where they can optimize their skills," whether that turns out to be industry or a more traditional research setting. Indeed, one former student served as vice president of Motorola before striking out as a venture capitalist himself.

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Figure 2. Venkatesan, who finds the pace of life in India refreshing after his multiple roles in the United States, relaxes with his wife, Lakshmi, and daughter, Tara, in the garden of the Taj Man Singh Hotel, New Delhi.

Venkatesan was born in 1949 in Chingleput, India, a small town so remote that making the journey to Madras, 35 miles away, sometimes seemed like a trek to the other end of the globe. Venkatesan's father was largely self-taught in his youth, with no formal education beyond the sixth grade. He managed to join the Indian air force at 15 and eventually became an engineer. His deep love of science—fueled by the writings of George Gamow, Isaac Asimov, and others—influenced his son.

In 1966, Venkatesan enrolled at the Kharagpur campus of the Indian Institute of Technology (IIT), which he describes as "the MIT or Stanford of India." There, he found himself surrounded by brilliant students in the most intense learning environment he had yet encountered. "I soaked up everything like a sponge," he recalls. Despite his fascination with physics, he initially registered to study metallurgical engineering. When he discovered that he had won a prestigious scientific scholarship, which required him to enroll in a less applied field of study, he switched his major to physics. He completed his master's degree at IIT's campus in Kanpur, and found himself at a crossroads. He could have joined the Indian administrative services, a coveted occupation for many of his peers, but he was more inclined to pursue a Ph.D. in the United States. He obtained a teaching position at the City University of New York's Brooklyn College to help finance his graduate studies.

After posting a high score on the university's Ph.D. qualifying exam, Venkatesan was awarded a research fel-

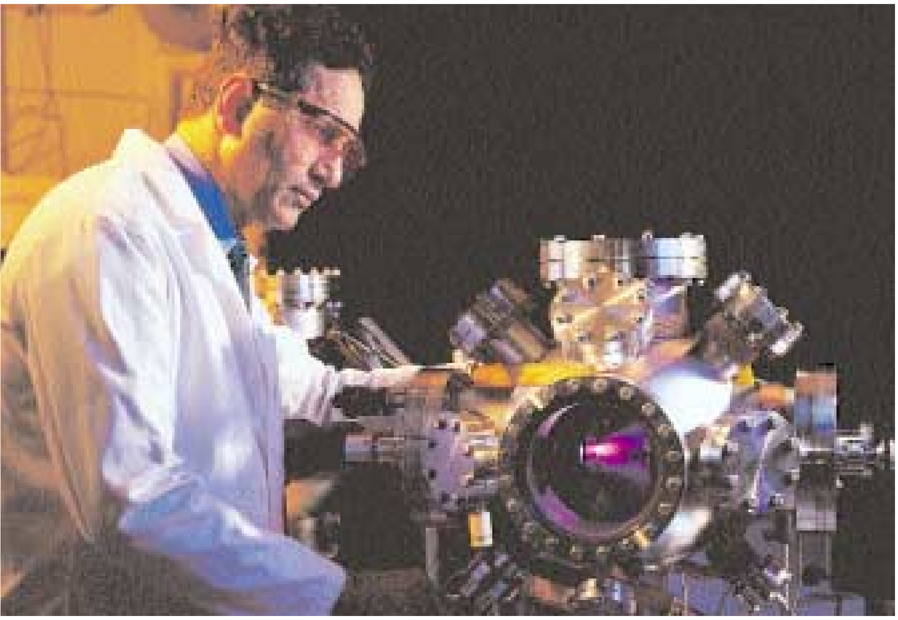

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Figure 3. Adjusting the gas pressure and laser intensity in a pulsed-laser-deposition chamber is essential for obtaining the right shape and color of plasma plume on the oxide target and, hence, ensuring thin-film quality.

lowship in 1972 that enabled him to choose where he wanted to do his thesis research. He opted to work on quantum optics and lasers at AT&T's Bell Laboratories with Hyatt Gibbs (who later became director of the University of Arizona's Optical Sciences Center) and Sam McCall. Gibbs, McCall, and Venkatesan were the first to demonstrate experimentally the optical-transistor effect, although Venkatesan admits that the achievement "was 25 years ahead of its time; optical communication hadn't even been developed yet." He remained at Bell Laboratories after receiving his Ph.D. as a member of the technical staff. When AT&T split up in 1984, Venkatesan went to work for the newly formed research arm of the regional Bell operating companies, Bell Communications Research (Bellcore), as manager of a surface-research division. There he made his mark in 1987 by pioneering the use of pulsed-laser deposition (PLD) (see *The Industrial Physicist*, September 1996, pp. 22–24) for the newly discovered high-temperature superconductors (HTSs). That achievement ultimately formed the roots of Neocera (Figure 3).

John Rowell, an assistant vice president of applied research during his Bellcore tenure, admits that at the time, he never expected Venkatesan to branch out into entrepreneurial pursuits. However, even then Venkatesan displayed a gift for interaction, communication, and collaboration that set him apart from his peers. Shortly after his PLD work, he collaborated with a Japanese research group at NEC to grow films on substrates with incompatible material properties. They succeeded by depositing a few buffer layers between the substrate and a thin film of yttrium-barium-copper to achieve a better match of lattice constants and less chemical interaction—a technique that is now widely used in many places.

Paradigm shift

Venkatesan thought of himself as living "in Shangri-La," leading a wonderful life as a researcher and manager. But then he spent 1984 on sabbatical at Caltech with his friend Amnon Yariv, who not only led an outstanding research group but had also founded several start-up companies, including Ortel (bought by Lucent Technologies in 2000). Yariv also played tennis every morning, spent summers in Israel, and largely set his own schedule. "It was a true paradigm shift in my way of thinking," says Venkatesan. "My life at Bellcore suddenly seemed incredibly narrow and restrictive." He founded Neocera in 1989.

The company became profitable in 1991 on the basis of its research contracts and had a 260% growth rate from 1993 to 1998. The PLD process that Venkatesan pioneered was further refined in Neocera's laboratory, and the first commercial systems were sold in 1992. Since then, says Rowell, "PLD has become an invaluable tool, certainly in a research setting, because you can work with so many different materials, varying the deposition temperatures, deposition pressures, and so on."

Neocera spent its first year as part of the incubator program at Rutgers University. At the time, Venkatesan was still a Bellcore employee and he tried to reach an agreement with that company to stay employed and still run Neocera. However, he soon realized that "from the point of view of freedom, it would be much better for me to work in an academic environment," and he accepted a position with the University of Maryland after a brief stint as a professor in Rutgers University's ceramics and physics departments.

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Figure 4. Venkatesan discusses data on a MgZnO pulsed-laser-deposition film with Ph.D. students in the Center for Superconductivity Research, Physics Department, University of Maryland at College Park.

Venkatesan believes that there are essentially two kinds of personal power in life: extrinsic and intrinsic. "You can't let what you want to do be within someone else's control," he says. "Extrinsic power comes with impressive titles, such as vice president or CEO. Intrinsic power lies in the value you can give to people. You are in complete control of that, and no one can take it away from you."

Richard Greene, a professor of physics and director of UMD's then fledgling Center for Superconductivity Research, hired Venkatesan. He was impressed not only by Venkatesan's thin-films expertise and scientific reputation, but also by his energy and entrepreneurial spirit. The latter meshed particularly well with UMD's growing emphasis on technology transfer through its technology-advancement program (see *The Industrial Physicist*, June 1998, pp. 47–48). "We had just started this incubator program, which provided space on campus and other essential services to assist start-up technology companies, but at the time it was highly unusual to have a faculty member who was so interested in starting a business," says Greene.

In fact, Maryland law prohibited state employees (including UMD faculty members) from participating in the incubator program, citing conflict of interest issues. The president of UMD and other senior administrators lobbied to get the law changed within a year of Venkatesan's arrival, such was their level of commitment to this type of entrepreneurship.

Venkatesan divides his time between running Neocera and maintaining an active research group at UMD, which is focused on the fabrication of thin films and heterostructures of multicomponent films for the study of novel physics and device concepts. The primary materials studied are HTSs, magnetic oxides with high spin polarizations, and wide-bandgap semiconductors based on oxides and nitrides.

Among the novel physics under study is a phenomenon known as electronic phase separation (EPS), exhibited by both HTS cuprates and colossal magnetoresistive manganites. Some physicists believe that EPS is the origin of superconductivity in materials. Venkatesan's group has published more than 400 papers, and the Institute for Scientific Information lists him among the currently 100 most-cited physicists (Figure 4).

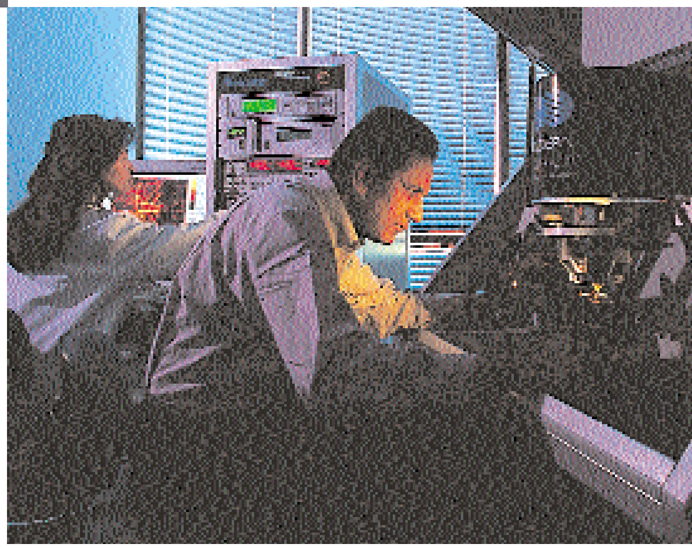

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Figure 5. As chairman and chief technical officer, Venkatesan guided Neocera to produce a magnetic microscope, one of the first tools to offer nondestructive failure analysis of semiconductor devices.

Neocera today

Neocera's early success with PLD systems enabled the company to expand into other areas. In 1997, through acquisition, the company added cryogenic-temperature controllers and began distributing cryogenic sensors. But the product poised to become Neocera's flagship technology is a magnetic microscope, called MAGMA, which is based on superconducting quantum-interference device technology and targeted as a potentially revolutionary device for failure analysis in the semiconductor industry. Failure analysis is critical to the industry's future, and hence, MAGMA has the potential to earn hundreds of millions of dollars in the nondestructive-testing market (Figure 5).

"Magnetic microscopy gives researchers better information about complex devices, and for the first time, it makes it possible to image currents buried deep within the chip circuitry without destroying them," says Lee Knauss, manager of Neocera's MAGMA unit. Developed by UMD researcher Fred Wellstood, the microscope maps the location of short circuits in current-carrying wires by measuring the weak magnetic fields produced by the currents. It can detect fields 2 million times weaker than the earth's magnetic field. This sensitivity and the lack of interaction between the magnetic fields and other materials in these devices sets this technique apart from failure-analysis techniques that rely on thermal or optical effects.

Another new product with commercial promise is a scanning near-field microwave microscope, called EPSCAN, which is based on an instrument developed by UMD researcher Steven Anlage. Still in development, the microscope is a promising tool for nondestructive evaluation of materials and devices at microwave frequencies, which uses the near-field response to overcome the spatial-resolution limitations of traditional microscopy. "In any conventional microscope, the smallest features you can see are defined by the wavelength of the light that you're using," says Andy Schwartz, manager of Neocera's EPSCAN unit.

The developers of near-field scanning optical microscopy, however, discovered that this limitation could be overcome by stretching an optical fiber so that it tapered down to a diameter much smaller than the wavelength, which enabled them to image on smaller length scales. The basic idea behind EPSCAN is the same. The instrument is initially being targeted to the semiconductor industry for materials analysis at microwave frequencies—gigahertz and above, the operating frequency range for most semiconductor devices—but at length scales much smaller than microwave wavelengths.

In the area of PLD, Neocera has built systems for HTSs and electrically tunable ferroelectric films, both of which are important in the cellular and microwave communication markets. It also has licensed a pulsed electron-beam technology from FZK, a research institute in Karlsruhe, Germany. "The electron beam replaces the laser, and this technology promises to be less expensive and also scalable for commercial film applications," says Harsh Harshavardhan, the manager for pulsed-energy-deposition technology.

Shifting the center

Greene cites Venkatesan's "incredible work ethic" and strong communication skills as contributing to the physicist's success at juggling what amounts to two full-time jobs. Although the jury remains out on whether Neocera can maintain its impressive growth rate, Greene has great confidence in Venkatesan. "He certainly has the smarts and innate ability to make it happen," he adds. Further complicating his juggling act, Venkatesan has a wife and seven-year-old daughter in New Delhi, India (Figure 2), and regularly commutes between there and Maryland. "I have to truly compartmentalize my life," he admits. "But I always look for synergies; I try to bridge what I'm doing with what I'm planning to do next."

What is the next step for Venkatesan? At the moment, he is raising venture capital investments for Neocera's next stage of development and focusing on rapidly scaling up the revenues of the company. "I would like to help other budding entrepreneurs in the academic community," he says. Over the next few years, he also wants to focus on technology in his native country.

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Figure 6. Jantar Mantar, which includes several abstract structures that were used for keeping track of celestial bodies, was built in 1724, just after the last great emperor, Aurangzeb, died and the Mughal Empire was rapidly declining.

India, in his view, is emerging as an exciting new location for technology, with thousands of software and hardware companies sprouting up. Today, it is possible for a company such as Neocera to build its products at significantly lower costs there and attract outstanding R&D staff from Indian universities and industry. Venkatesan envisions a future in which he can create sister entities to Neocera in India, although he may have to resign his UMD position to do so. "The one thing I cannot do from a distance is teach," he says. "That fixes your time coordinates, and I need flexibility."

However, given Venkatesan's highly successful proactive approach to tailoring his jobs to his needs and interests, one can assume that some day he will find a way to make it happen. Ω