Roy Receives FMS National Materials Advancement Award

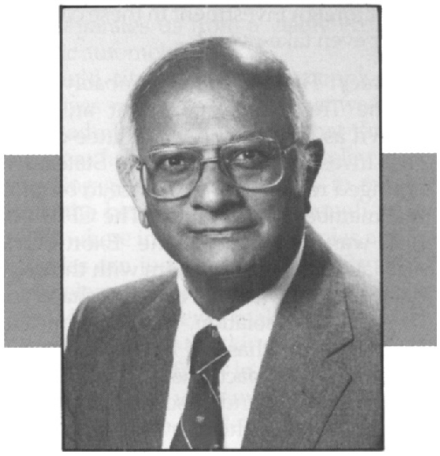
Rustum Roy, a founding member of the Materials Research Society, received the 1991 National Materials Advancement Award from the Federation of Materials Societies (FMS) in Washington, DC on December 11 last year. The award, presented annually at most, honors individuals who advance the effective, economic use of materials specifically, and the disciplinary field of materials science and engineering generally. Those receiving it also "contribute significantly to the application of the materials profession to national problems and policy."

Roy has been associated with Pennsylvania State University's Science, Technology and Society (S-T-S) program since 1969. He began his career at Penn State after receiving his PhD there in 1948. A native of India, Roy is a life fellow of the Mineralogical Society of America, a fellow of the American Ceramic Society, and a fellow of the American Association for the Advancement of Science. A prolific writer in the fields of materials science and engineering education, he has also been honored with membership in the National Academy of Engineering, the Royal Swedish Academy of Engineering Sciences, and the Indian National Science Academy.

The major theme of Roy's keynote address to FMS delivered December 12 at a luncheon in Washington dealt with science education. He believes there should be a major restructuring in the United States in this area, what he calls a "national campaign to redefine science." Roy hopes a "new breed of scientist" will emerge who will be savvy about issues of the day, such as ecological problems.

One emphasis of such a new program should be on proceeding from the concrete to the abstract, rather than vice versa, said Roy. "There is too much emphasis on dull, dreary abstract science such as knowing the spin Hamiltonian theory," he said. "Kids should have hands-on experience with materials. They exist in the real world."

Roy found fault with what he considered the conventional mode of science education, that Science = Physics + Chemistry + Biology, or Science = P + C + B, for short. "We all know that PCBs are dangerous," he observed metaphorically. Instead, he would advocate a more relevant issues-oriented approach. "Science is about all the curiosity right around you," he observed. For example, "Kids are interested in what we do with garbage," said Roy, so that is one thing they should be made familiar with. More emphasis should be placed on how things work; such activities as taking toasters apart should be encouraged, as should course information that explains what happens to cause the light when a switch is turned on.



Young people should also be taught that science proceeds from technology, rather than the reverse, he argued. "Science leads to technology leads to prosperity—believe that, and I have a bridge for you to buy," Roy said. He also took exception to the maxim that research makes better teachers. "There is no evidence, or a slightly negative correlation, between quality of teaching and research."

There are formidable obstacles to changing existing science education and Roy said it would be "romantic" to believe it could be rescoped in less than 25 years. He challenged FMS to begin introducing relevant courses and curricula to include materials.

Roy joins a distinguished list of recipients of the National Materials Advancement Award, including Paul Maxwell, former science consultant to the U.S. House of Representatives Committee on Science, Space and Technology, and currently science adviser to the U.S. Embassy in Buenos Aires; John Wachtman, director of the Center for Ceramics Research at Rutgers University; William Baker, retired chairman of the board of AT&T Bell Laboratories; Morris Cohen, institute professor of materials science and engineering at MIT; Allen Gray, technical director emeritus of ASM International; and Klaus Zwilsky, director of the National Materials Advisory Board of the National Research Council.

Ceramic Society of Japan Honors 14 Scientists

The Ceramic Society of Japan honored 14 international scientists with the Centennial Award at its 100th anniversary dinner.

Scientists receiving the honor were: Paul Hagenmuller, France; K.H. Jack, United Kingdom; K.H. Kim, Korea; G. Petzow, Germany; Shigeyuki Sōmiya, Japan; D.S. Yan, China; and Richard C. Bradt, David Kingery, J. Douglas MacKenzie, Robert E. Newnham, Joseph A. Pask, Rustum Roy, Richard M. Spriggs, and Minoru Tomozawa from the United States.

Kazuo Inamori, president of the Ceramic Society of Japan, presented the awards. Inamori is credited with building Kyocero Ceramics into a $2 billion-a-year corporation.

Laser-Improved Alloys Could Lead to More Efficient Engines

Jyoti Mazumder, a University of Illinois researcher, has successfully raised the melting point of certain alloys crucial to high-performance engines.

Mazumder's work focuses on the creation of laser-improved materials. The process, developed by him and others over the past decade, uses lasers to heat materials thousands of degrees in a second and then lets them cool quickly. This method lets materials with high melting points clad cheaper, low-melting-point engine components. This improves the performance of the cheaper metals, a development that could mean better valve seats and other engine parts that must face the direct impact of gas-air explosions. Mazumder tried to interest American auto manufacturers in the new process, but without success. Representatives from Nissan in Japan have contracted with him to develop a laser-processing method to increase the temperature at which aluminum automobile engines can function. The operating temperatures of ordinary turbine engine materials such as nickel superalloys can be increased by 200°C, with significant increases in structural strength by using the laser processing technique, an effect not possible by ordinary heating.

"Most materials lose strength at half their melting point," Mazumder said. Laser-improved metal remains resilient to almost its former melting point. This is an important development for automakers, because a turbine engine's size is determined in part by how much heat it must dissipate. If turbine engines could be made smaller, the engines would have a better thrust-to-weight ratio.

The Air Force Office of Scientific Research, which has supported Mazumder's research with $775,000 over the past five years, now has applied for a patent on one of Mazumder's processes involving adding hafnium, aluminum, and chromium to nickel. Mazumder is also working on laser-aided synthesis of niobium-based alloys, which have a much higher melting temperature than the more commonly used nickel-based alloys.

Ian Ross Confirmed as New Member of National Science Board

Ian M. Ross has been confirmed as a member of the National Science Board, the policy-making arm of the National Science Foundation, for the remainder of Howard A. Schneiderman's term expiring May 10, 1992. Ross currently serves as president emeritus of AT&T Bell Laboratories.

A fellow of the Institute of Electrical and Electronics Engineers, Ross was elected to the National Academy of Engineering in 1973. He was also elected to the National Academy of Sciences in 1982.

Ross is a member of the board of directors of Sandia National Laboratories. He also served on the boards of directors of the B.F. Goodrich Company and the Thomas and Betts Corporation.

Chairman of the National Advisory Committee on Semiconductors, Ross is also a member of the Council on Competitiveness. He has served on the President's Commission on Industrial Competitiveness, co-chairing its Committee on R&D and Manufacturing.

A native of Southport, England, Ross received his bachelor's degree in electrical engineering from Gonville and Caius College of Cambridge University in 1948. He received his MA and PhD degrees in electrical engineering from Cambridge in 1952.

Hologram Image Captures Hypervelocity Impact

Researchers at Sandia National Laboratories have obtained a hologram of the shattered debris from a hypervelocity impact at 4.2 km/s (9,400 miles per hour). Such holograms would be a valuable diagnostic tool for studying the damage caused by hypervelocity impacts and their fragmentation particulation, aiding in the design of orbital debris shields and in better understanding the breakup of satellites.

Sandia's Pulsed Holography Development (PHD) project is attempting to use extremely short pulses (5 ns) from a very bright laser to obtain pulsed holograms of hypervelocity impacts. In the initial experiment, a 6.4 mm steel ball was fired through a 1.6 mm thick sheet of acrylic plastic using a high-velocity gas gun.

Previous work could holographically image impact events up to 1 km/s, but the new capability allows researchers to review a permanent image of the shape, size, and distribution of impact fragmentation. Other techniques using photographs and flash x-rays don't have the resolution and depth of field to resolve very small fragments, nor do they provide 3-D images.

The utility of the hypervelocity impact event holograms will be to validate computer codes widely used for 3-D simulations of hydrodynamic events. One of Sandia's key project goals for 1992 is to develop techniques for extracting quantitative information from these holograms.

With the first impact hologram, Sandia will begin assembling a library of various impact configurations and materials.

New Engineering Library Planned at the University of Illinois

The University of Illinois at Urbana-Champaign will be constructing a new engineering library scheduled to open in 1994.

The Grainger Engineering Library Information Center (GELIC) will support the instructional and research needs of 12 departments, 16 specialized centers, and 3 allied laboratories. GELIC will store the existing engineering collection of 220,000 volumes and 3,600 periodicals, and accommodate the 6,500 new volumes added each year. It will also contain 120 computer terminals for information retrieval services and academic use by students and faculty.

Serving as a model for science and engineering libraries, state-of-the-art communications and information technologies will provide the College of Engineering, the campus, and the state with access to hundreds of local and remote bibliographic and numeric databases. The databases will include INSPEC, the Aerospace Database, Compendex Plus, Metadex, NTIS, and the complete text of IEEE/IEE publications. The GELIC information services will feature advanced library information workstations, expert system user interface software, advanced bibliographic instruction and multimedia facilities, and full-text electronic document transmission capabilities.

The fiber optics, electronic retrieval services, and high-speed data communication links designed for GELIC will be joined to a developing nationwide information network. Engineering librarian William Mischo will use GELIC as a laboratory to continue development of full text document transmission, advanced information workstations, bibliographic instruction, and user/computer interface.

The facility is funded by the Grainger Foundation of Skokie, Illinois, which pledged $18.7 million to the College of Engineering for GELIC's construction.

Computer Codes Predict How Parts Respond to Manufacturing Processes

Computer codes for analyzing structures help researchers at Sandia National Laboratories predict a part's response to manufacturing processes, without using time-consuming and expensive experimental techniques. Armed with mathematical descriptions of material response, the codes predict the stresses and strains that can occur during production. "A manufactured part often undergoes more severe conditions during its production than it ever sees in service," said John Biffle, supervisor of Sandia's Computational Mechanics and Visualization Division. "The goal is to eliminate process-induced problems before they happen." Manufacturing processes such as welding, forging, sheet forming, brazing, casting, and injection molding subject materials to a wide variety of stresses and strains that can weaken or deform a finished part. Microscopic cracks, shrinkage, and residual stresses can reduce a part's lifetime or performance. Some parts do not even survive the production process.

Understanding stress events can help optimize fabrication methods to produce high-quality parts. Designers commonly rely on prototype development and traditional experimental techniques to develop a production process for manufacturing parts and components. But these empirical techniques can be costly and time consuming, especially for complex parts designed to tight specifications. Fluctuations in process variables often lead to costly rework when their effect on the manufacturing process is not understood and there is no real-time process control. Advances in computational mechanics and mathematical models of materials behavior are allowing analysts to predict a part's response to manufacturing processes before anything is constructed.

Typical codes are two- and three-dimensional finite-element programs for solving nonlinear mechanics equations. The finite-element method is a numerical technique where complicated geometries can be analyzed as an assembly of small regions, called finite elements. The codes can describe quasi static or transient behaviors throughout an object as it responds to mechanical forces and heat. The mathematical model of the material to be analyzed, which must be developed first, is often the most complex part of the equation.

Quantum Well Laser Operates at 28 GHz

A new generation of devices known as strained quantum well lasers has enabled Cornell University scientists to produce a laser with a 28 GHz rate, making it possible to carry more information over fiber optic lines.

The device was made in Cornell's National Nanofabrication Facility. A research associate said that when Cornell reported a speed of 15 GHz last year at a meeting, the scientific community did not believe the results. The researchers reported a speed of 23.5 GHz in the December issue of *Photonics Technology Letters* and reported the 28 GHz results November 7 at the Laser and Electro-optics Society annual meeting in San Jose, California.

The heart of the tiny strained quantum well lasers is a series of three or four quantum wells. No more than 40 atoms thick, a quantum well is a thin layer of material that confines electrons and holes within its boundaries. Electrons flow into the quantum well where they combine with holes to produce the emission of coherent light.

One of the innovations developed by the Cornell researchers is the fabrication of a quantum well using indium atoms in addition to the gallium and arsenic normally used. Putting over-sized indium atoms into the orderly gallium arsenide crystal structure introduces strain. Researchers are studying why the strain creates a better laser.

Strained quantum well lasers could be used in communication, from fiber optics to radar, and navigation via satellite. The application of quantum well lasers as amplifiers for long-distance fiber optic signals is currently being explored. Other researchers are exploring use of the laser in combined optical-electrical devices that could greatly reduce the weight of satellite components or enable aircraft to communicate directly with satellites.

Cornell researchers are working to achieve 44 GHz, a frequency that is particularly desirable for communication because the atmosphere is transparent to electromagnetic radiation in this range. The theoretical limit for the laser materials and the design used by the Cornell group is 60 GHz.

Fabrication begins with molecular beam epitaxy to form a structure one monolayer at a time. This way, a quantum well can be constructed in the middle of a device. Electron beam lithography also defines the features of the device. Finally, vertical planes are created in the device to define the edges of the quantum well using chemically assisted ion beam etching.

Electrolysis Used in Micromachining Silicon

An improved process for uniformly etching silicon to create miniature parts used in micromechanical devices has been developed at Sandia National laboratories. The process involves an intermediate step to controllably produce a porous layer which is then etched away.

Established silicon removal techniques involve photolithography and chemical etching, but it is difficult to precisely control the amount of silicon to be removed. Chemical etching also tends to give the etched area a matte finish rather than the preferred mirror finish.

The new process uses electrolysis of silicon in hydrofluoric acid to first make a very thin porous layer of silicon on a wafer. Since the etching rate is directly proportional to the current passed in the electrochemical cell, the depth of the porous silicon can be easily regulated by controlling the charge passed through the electrochemical cell. The wafer is then removed from the cell, and the porous silicon is etched by immersing it in a hydroxide solution at room temperature. Because of uniform pore depths, the etching leaves a mirror finish.

The new process is compatible with standard wafer fabrication procedures and may be useful for fabricating miniature sensors, motors, accelerometers, and other microdynamic devices. It is particularly promising because it is more precise and repeatable than traditional methods, with variance of no more than 0.3%.

Oak Ridge Marks 300th Run of High Flux Isotope Reactor

A variety of research activities continues at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL), where workers recently marked the completion of the 300th successful fuel cycle of the 85-megawatt facility.

The reactor has been used to analyze arsenic levels in the hair and fingernails of Zachary Taylor and in the future will be used to test for iridium in dinosaur bones to give insight into their extinction.

The job for which HFIR was originally designed, transuranic isotope production and research, should continue well into the 21st century. Practical results of such research could include improved examination of aircraft for corrosion, detection of explosives in luggage, cancer research, and nuclear medical treatment. Also, work continues at HFIR in neutron scattering, materials, and fuel testing and research for a new generation of advanced reactors.

Neutron scattering, which reveals the atomic structures and dynamics of materials, is the focus of one of the longest continuing programs at Oak Ridge. HFIR facilities are available to outside scientists for work in a wide variety of scientific disciplines, including coloids, magnetic materials, and biological materials. The outside-user program is expected to grow rapidly in the next two years.

Currently, the emphasis is on high-temperature superconductors and polymers, but the future of HFIR is expected to lie in materials testing.

Bioceramic Materials Research Institute Formed at Alfred

A Bioceramics Institute has been established at the New York State College of Ceramics at Alfred University. The institute will be dedicated to bioceramic materials research in response to a growing national demand for synthetic biomaterials, and will pursue research and development of new ceramic materials for medical and dental applications. Gary Fischman, assistant professor of ceramic engineering, will be the director of the institute.

Ceramics are suitable for contact with cells, proteins, tissues, organs, and organ systems for long-term use such as artificial hips, or short-term use such as resorbable bone patches. Other biomedical materials considered appropriate for use as devices or prostheses are synthetic polymers, metals, inorganics, and biopolymers.

The institute will be composed of academic researchers with an advisory board of medical and dental professionals and industrial consultants. Initial funding has been provided through a grant from the Center for Advanced Ceramic Technology, a high technology research center established by the New York State Science and Technology Foundation.

Research at the university will be conducted by scientists in atomic modeling, processing of ceramics and glass, scientific characterization of crystalline and noncrystalline materials, spectroscopy, and biology.

Work will take place on biological hydroxylapatites and other calcium phosphate ceramic materials for purposes such as dental repair and correction and on bioresorbable glasses used, for example, to secure a broken bone until it heals.

Hip joint components are in the test stage. Computer modeling and testing of the strength, stiffness, wear, and toughness of biomaterials will be incorporated. Development of infrared transparent fibers for laser-assisted surgery is well under way as a joint project with Rochester General Hospital. Other research areas under way include: design improvement for titanium dental root implants, *in-situ* testing of bioceramic materials for short-and long-term biocompatibility, microstructural evaluation of bioceramic interfaces for bone-ceramic joining and dental decay correction, piezoelectric ceramics for signal detectors and diagnostic and healing biosystems, and carbon-carbon and other composites for bone implants that encourage tissue growth.

Institute director Fischman, a specialist in structural ceramics, was primarily responsible for forming the High Performance Ceramics Laboratory at the College, where his group developed a zirconia femoral endo head for total hip replacements.

High-Performance Microwave Circuits Built on Soft Substrates

New methods for making state-of-the-art, high-performance microwave circuits on a soft, flexible substrate could be used by makers of radar systems, avionics electronics, and other systems where large, high-precision hybrid circuits are needed.

Using the techniques, researchers at Sandia National Laboratories accurately patterned and etched circuit conductors, achieving 1/4 mil tolerances and linewidths as narrow as two mils. Features can be machined into the soft substrate with one-mil accuracies. Precision features were needed in the circuits because of the high-frequency requirements of the synthetic aperture radar (SAR) system for which they were developed.

In developing the higher frequency SAR, Sandia researchers needed a substrate with a lower dielectric constant to reduce potential losses of the radio frequency signal. They also needed a more mechanically forgiving material than commonly used ceramics to allow them to build larger circuits without the substrate cracking. These circuits, up to three times larger than normal hybrid circuits, were needed to accommodate a greater number of functions than found in other SAR systems. The hybrid circuits used in the SAR system are assembled with a combination of silicon circuits and surface-mounted capacitors and resistors, making them similar to a miniature printed circuit board. While previous radars had five to six smaller microcircuits, the new SAR uses 18.

The researchers chose a commercially available laminate substrate called Duroid, a composite material consisting of a ceramic and Teflon matrix with a laminated copper sheeting topside and a laminated brass backplate, giving the materials the rigidity needed for fabrication processes.

Both the tolerances of the conductor linewidths and their edge definitions had to be precisely controlled to permit high-fidelity electrical operation over large bandwidths. To accomplish this, researchers had to develop a more accurate method of removing the extraneous copper. They developed a new "spin-spray" etching technique for use with ferric chloride that controls copper removal while the etchant is being sprayed. They also overetch the copper to partially remove it from under the photoresist pattern resulting in straighter conductor side walls.

Use of a softer, resilient substrate also required the development of new processes to attach components, such as resistors, capacitors, isolators, attenuators, and thermistros to the material—and attach leads to copper conductors. The processes, including welding, epoxy bonding, soldering, and surface mounting, were developed for a reliable attachment to the circuit and were sequenced so that attachment and cleaning processes for one component did not affect the reliability of the previous attachment process. In some instances, the component was mounted through the dielectric directly to the brass backplate for electrical or heat sinking considerations. □

LETTERS TO THE EDITOR

To the Editor:

DOE Center of Excellence for Synthesis and Processing of Advanced Materials

The item entitled "Sandia to Lead Center of Excellence for Synthesis and Processing of Advanced Materials" which appeared in the Research/Researchers section of the November 1991 issue of the *MRS Bulletin* needs some correction and elaboration. This Department of Energy Center is a coordinated effort among the following DOE laboratories: Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, University of Illinois Materials Research Laboratory, Lawrence Berkeley Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest Laboratory, and Sandia National Laboratories.

Sandia is responsible for the overall coordination of the effort. The initial research activities of the Center are grouped under the following five focus areas: (1) atomically-structured materials, (2) complex polymers, (3) advanced ceramics and ceramic films, (4) nanophase materials, and (5) emerging materials and processes.

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