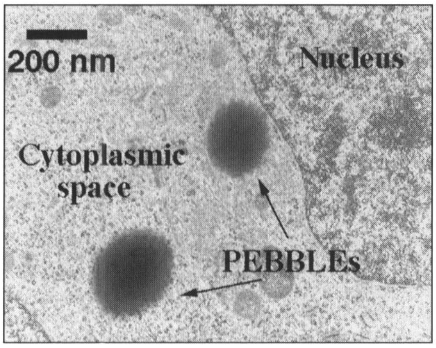
## Polymer Biosensors Developed

Raoul Kopelman, Kasimir Fajans Professor of Chemistry, Physics and Applied Physics at the University of Michigan, and his research team have fabricated polymer biosensors called PEBBLEs (Probes Encapsulated By BioListic Embedding). PEBBLEs were designed to work inside mammalian cells where they can detect subtle changes in concentrations of ions and small molecules.




*Transmission electron micrograph shows PEBBLEs in the cytoplasm of a human neuroblastoma cell.*

Heather Clark, a graduate student in chemistry who presented her research results at PITTCON '98 in New Orleans in March, has made PEBBLEs 20 nm in diameter. The polymer spheres contain many surface pores. When Clark adds dyes to a polymer microemulsion suspension during PEBBLE fabrication, the dyes are naturally taken up by the PEBBLE's pores. According to Clark, each dye is specific for, or will bind to, just one type of ion or molecule. So far, she has produced PEBBLEs specific for calcium, oxygen, magnesium, and pH. When a PEBBLE is exposed to its target substance, the dye in the PEBBLE glows when activated by a specific wavelength of light. As the concentration of the targeted substance changes, the intensity of the PEBBLE's fluorescence increases or decreases. Once the PEBBLEs are ready, Clark uses picoinjection techniques to fire them randomly into human or mouse cells in a culture dish, rarely damaging the cell.

## Tools Developed for Evaluation of Microindentation in Functionally Graded Materials

Subra Suresh, R.P. Simmons Professor of Materials Science and Engineering at the Massachusetts Institute of Technology, and Antonios E. Giannakopoulos, research scientist at MIT, have developed a general theory for the mechanics and micromechanics of indentation of functionally graded materials. They, in collaboration with several other colleagues, have also developed an experimental tool for microindentation, which works with standard mechanical testing machines, for continuous, quantitative measurements of indentation load ($P$) versus depth of penetration of the indenter ($h$), for any indenter geometry at the microscopic and macroscopic testing levels. Their research will be published in the *International Journal of Solids and Structures* and in the *Journal of the American Ceramic Society.*

The theory for indentation provides closed-form analytical solutions for $P$-$h$ curves in a manner which can be directly checked with experiments. The theory can provide a quantitative relation between $P$ and $h$, (and equivalently between $P$ and the indentation contact area $A$) for any blunt or sharp indenter, taking into account the pile-up or sinking-in around the indenter for the following cases: (1) the Young's modulus of the elastic indented medium increases or decreases as per an exponential function of the distance beneath the indenter; (2) the Young's modulus of the elastic indented medium increases or decreases as per a power law function of the distance beneath the indenter; and (3) the indented material is elastic, with the yield strength of the indented material varying monotonically with depth below the indented surface.

According to Suresh, the analyses and experimental devices developed in this work have a variety of general applications. If the monotonic variation of elastic properties with distance in a material are known, the analyses can be used to determine the conditions for the onset of cracking and failure during, for example, indentation, impact, and penetration in a graded material. If the gradients in elastic properties of the material are not known *a priori*, the analyses in conjunction with the experimental device can provide quantitative information about the elastic property gradients in the material. Thus, a new material characterization tool is developed for gradient materials with the present research. Suresh also said that the analyses can be used to design new surfaces with purposely introduced gradients in elastic and plastic properties where the surfaces are tailored to have superior resistance to contact, penetration, and tribological damage. Such beneficial effects of grading, as revealed by the analyses, have been experimentally tested in this research to design new surfaces which are tribologically superior to currently used surface treatments.

According to the researchers, applications of this work include case-hardened gears, quality control of case-hardening processes, improved design of dental implants, improved articulating surfaces for hip and knee prosthesis, functionally graded surfaces for armor plates, functionally graded polymeric composite laminates for ship hull structures, and sporting goods.

## Software Used to Evaluate Reliability of Cast Metal Part Designs

R. Allen Miller, professor of industrial, welding, and systems engineering at Ohio State University, has developed a method of analysis called a "binary voxel model" to identify potential defects that may form in die-cast metal parts. Miller and his colleagues built their method into software that simulates die casting.

As reported in *Computer-Aided Design*, the software produces an image of what a part will look like after die casting, and color-codes bright red the areas that will take longest to solidify. If engineers see too much red, or see red in an area of the part where the strength of the material is critical, they will know to redesign the part before they cast it. The method breaks three-dimensional pictures of metal parts into tiny cubic sections called voxels. The software counts how many voxels away from the surface an area of the part is, and uses this distance to depict roughly how long solidification will take. If a part contains porosity, it may break easily. Or, if the pores are near holes where nuts and bolts secure the part, it could come loose.

The simulation occurs within seconds as opposed to the numerical process used, for example, for a transmission case which takes six weeks to two months to complete. The binary voxel model performs essentially the same function as a numerical analysis, only with geometry. It is based on the idea that regions of a part with more material in them will contain more heat, and take longer to cool.

Gary Kinzel, professor of mechanical engineering, said, "We tried to do the same thing with more complicated numerical analyses, and we got the same results. It just took longer."

In another type of analysis method, Miller said that someone looks at each new set of computer aided design (CAD) models and tries to guess from experience whether a problem will occur within that part. Kinzel said, "It takes a lot of experience to do that right. We intended this software for someone who doesn't have that much experience."

## Nanoscale Conductive Silver Wire Fabricated on DNA Substrate

In response to the problem of achieving inter-element wiring and electrical interfacing to macroscopic electrodes in nanoscale circuits, researchers at the Technion-Israel Institute of Technology in Haifa have used a DNA template to fabricate a nanoscale conductor. Because DNA recognizes specific sequences in other DNA molecules and is capable of self-assembly, Uri Sivan and his colleagues were able to stretch the strand between two gold electrodes, set 12–16 $\mu$m apart, and coat it in a silver solution, enabling it to conduct electricity.

To construct the DNA bridge, the researchers wet the gold electrodes with two different oligonucleotide sequences and connected them "by hybridizing two distant surface-bound oligonucleotides with a 16-$\mu$m and fluorescently labelled $\lambda$-DNA that contains two 12-base sticky ends," as reported in the February 19 issue of *Nature*. Because the single DNA bridge held a negative charge, the researchers deposited silver ions by $Na^+/Ag^+$ ion exchange using a 0.1 M $AgNO_3$ basic aqueous solution, and then formed small metallic silver aggregates bound to the DNA template. With an acidic solution of 0.05 M hydroquinone and 0.1 M silver ions, they completed the 100-nm wide silver wire.

## Masumoto Received 1998 Acta Metallurgica Gold Medal

Tsuyoshi Masumoto, Professor Emeritus of Tohoku University and Director of The Research Institute for Electric and Magnetic Materials (Foundation), has received the 1998 Acta Metallurgica Gold Medal for his outstanding and numerous achievements in research on nonequilibrium metallic materials, especially amorphous, quasi-crystalline, and nanocrystalline alloys. The medal was presented to him on April 1st at the spring meeting of The Physical Society of Japan in Tokyo.

Masumoto's research contributions include the discoveries of three characteristics of amorphous alloys: their high mechanical strength, which can exceed several times the strength of conventional materials while combined with high ductility; their extremely high corrosion resistance which is about $10^6$ times better than that of a 18–8 stainless steel; and their potential high magnetic permeability, exceeding those of soft magnetic materials in practical use. He also developed new types of materials, such as nanogranular soft magnetic alloys with high electric resistance, high specific strength Al-based amorphous alloys, high specific strength Mg-based amorphous alloys, high strength Al-based amorphous alloys containing dispersed Al-nanocrystals, and soft magnetic nanocrystalline Fe-based alloys. Masumoto has also established the principles for the fabrication techniques which make possible the mass production of amorphous metallic materials in the form of sheet, wire, and powder by rapid quenching from liquid.

After receiving his BA degree in 1958 and his PhD degree in 1960 at Tohoku University, Masumoto remained at the university as a member of The Research Institute for Materials Research as research associate, associate professor, and professor until his retirement in 1996. He is author or co-author of over 1,000 papers and has received over 250 patents. He was President of the Japan Institute of Metals (1991) and President of the Japan MRS (1996), and he organized in Japan the 4th International Conference (1981) and the 8th International Conference (1993) on Rapidly Quenched Metals. He has received many honors including the Japan Academy Prize (1983) and the Purple Ribbon Medal (1987) from the Japanese government, and the Japan Institute of Metals Gold Medal (1998).





https://doi.org/10.1557/S0883769400030360 Published online by Cambridge University Press

## Incorporation of Photoluminescent Polarizers Brightens LCDs

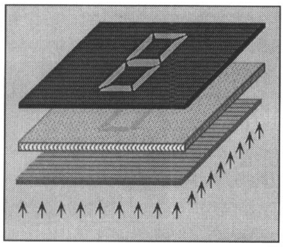
Researchers at the Department of Materials ETH Zürich have produced highly photoluminescent (PL) polymer films that can replace standard polarizers and color filters in conventional colored liquid-crystal displays (LCDs). In the February 6 issue of *Science*, the team led by Christoph Weder of the Polymer Technology Group reports the principle of the devices and shows single- and multicolored demonstrators.

The films consist of an oriented blend of polyethylene and a semiconducting, conjugated polymer that luminesces when irradiated with ultraviolet (uv) light. Because the films have been highly oriented to align the polymer molecules into one direction, the photoluminescent films emit highly polarized bright light. Thus, the films efficiently combine the functions of a linear polarizer and color filter in only one element, and can be used without losses in standard LCDs.

Initially, the researchers have fabricated yellow-green and orange-red single- and bicolor demonstrators. The poly(2,5-dialkoxy-*p*-phenylene-ethynylene) (PPE) based polarized PL layers that emit yellow-green light were about 2-$\mu$m thick as opposed to the 10-$\mu$m thick LC layer used in standard devices. The orange-red light-emitting polarized PL layers were based on blends of 1% (w/w) poly(2-methoxy-5-(2′-ethyl-hexyloxy)-*p*-phenylene-vinylene) (MEH-PPV) and ultrahigh molecular weight polyethylene. The light emitted from the PL layer or used to photoexcite the PL layer can be switched by a twisted nematic electro-optical (EO) light valve. The researchers said, "The light radiated by the light source is at least partially absorbed in the polarized PL layer, so that polarized light is emitted. This emitted light either passes the combination of EO light valve and polarizer (switching state 'bright') or is blocked (switching state 'dark')." According to the researchers, increasing the optical density of the PL polarizer creates brighter devices.

### SBIR Update

**Essential Research, Inc.** (Cleveland, Ohio) has been awarded a Phase II SBIR grant of $600,000 from the National Aeronautics and Space Administration (NASA) to develop high-efficiency, monolithic tandem solar cells to provide on-board power for NASA spacecraft and communication satellites.




*Schematic structure of a photoluminescent polymer film.*

While in most flat-panel displays conventional, back-lit, colored LCDs are of low brightness because less than 20% of the light reaches the human eye and the rest is converted into heat, incorporation of the new films can lead to brighter and more efficient colored displays. The new PL polymer films also allow improved viewing angles in the design of the displays. The researchers credit this advantage to "the limited transparency of the commercial uv sheet polarizer that was used (about 22% at 365 nm) and the slightly lower dichroic ratio of the polarized PL layer in absorption relative to emission."

## NAE Elects 84 Members and 7 Foreign Associates

The National Academy of Engineering (NAE) has elected 84 engineers and 7 foreign associates to membership in the Academy; seven are members of the Materials Research Society. This brings the Academy's total U.S. membership to 1,941 and the number of foreign associates to 155.

Election to the NAE is among the highest professional distinctions accorded an engineer. Academy membership honors those who have made "important contributions to engineering theory and practice, including significant contributions to the literature of engineering theory and practice," and those who have demonstrated "unusual accomplishment in the pioneering of new and developing fields of technology."

Among the new members are **Roman F. Arnoldy** (Triten Corp., Houston) for the industrial use of chromium carbide wear-resistant materials and the processes to produce them; **John H. Bruning** (Tropel Corp., Fairport, N.Y.) for deep-ultraviolet photolithography and associated manufacturing methods; **Dennis M. Bushnell** (NASA, Langley Research Center) for viscous flow modeling and control, turbulent drag reduction, and advanced aeronautical concepts; **John W. Cahn** (National Institute of Standards and Technology) for work on the kinetics and thermodynamics of phase transformations, interfacial phenomena, and quasi-crystals; **Michael L. Corradini** (University of Wisconsin, Madison) for the safety of commercial nuclear power plants worldwide and safety in emerging waste-processing technology; **Wallace H. Coulter** (Coulter Corp., Miami) for the discovery of the method that has become the most widely used for counting and sizing microscopic particles suspended in a fluid; **David E. Crow** (Pratt & Whitney, East Hartford) for leadership in the engineering design of high-bypass-ratio gas turbine engines for aircraft; **Robert C. DeVries** (independent consultant, Burnt Hills, N.Y.) for applications of phase equilibria to the synthesis and characterization of diamond, boron nitride, and related materials; **J. Larry Duda** (Pennsylvania State University) for research on molecular transport in polymers and on tribology, and for leadership in engineering education; **James A. Dumesic** (University of Wisconsin, Madison) for experimental and theoretical research on the microkinetics of catalytic processors; **James A. Fay** (Massachusetts Institute of Technology) for contributions to fluid and plasma dynamics, combustion, environmental technology, and recent creation of the first hypermedia fluid mechanics text; **David W. Fowler** (University of Texas, Austin) for the development and application of concrete-polymer materials; **Wolfgang G. Knauss** (California Institute of Technology) for engineering work on time-dependent fracture of polymers, at interfaces and under dynamic loading; **Alan Lawley** (Drexel University) for the science and practice of powder metallurgy processing; **William J. Macknight** (University of Massachusetts, Amherst) for structure-property relationships in polymer materials; **I. Harry Mandil** (MPR Associates Inc., Alexandria, Va) for engineering design and development of materials for naval and commercial nuclear reactors; **Dan Maydan** (Applied Materials Inc., Santa Clara) for development and commercialization of plasma etching and vapor deposition systems for semiconductor processing; **John H. McElroy** (University of Texas, Arlington) for the development and applications of laser technology to space-based geodesy, atmospheric science, and communications; **Eugene S. Meieran** (Intel Corp.) for the manufacturing of integrated circuits; **D. Bruce Montgomery** (MTechnology Inc., Wayland, Mass.) for the development, design, and construction of high-magnetic-field devices for conventional and superconducting applications; **Duncan T. Moore** (Office of Science and Technology Policy) for the design and fabrication of optical systems and imaging lenses; **Donald W. Murphy** (Bell Laboratories, Lucent Technologies) for research on a variety of electronic materials; **Un-Chul**


https://doi.org/10.1557/S0883769400030360 Published online by Cambridge University Press

**Paek** (Kwangju Institute of Science and Technology, Korea) for the practical production of optical fibers; **Subbiah Ramalingam** (University of Minnesota, Minneapolis) for machining and tool-life theories, coating-design algorithms, and invention of novel automation sensors and steered-arc coating technology; **Alberto Sangiovanni-Vincentelli** (University of California, Berkeley) for computer-aided design of integrated circuits; **Martin B. Sherwin** (Chemven Group Inc., Boca Raton, Fla.) for technical leadership in the development of artificial organs, environmentally friendly insecticides, gas-separation membranes, and important petrochemical processes; **Richard P. Simmons** (Allegheny Teledyne Inc., Pittsburgh) for engineering in the specialty steel industry; **Jack M. Sipress** ( Tyco Subsystems Ltd., Holmdel, N.J.) for the development and implementation of international communications facilities via undersea lightwave cables; **Edgar A. Starke Jr.** (University of Virginia) for research and teaching in the field of light metals; **Thomas G. Stockham Jr.** (University of Utah) for contributions to the field of digital audio recording; **Theofanis G. Theofanous** (University of California, Santa Barbara) for nuclear reactor safety, including incorporation of deterministic principles into risk assessment; **Charles H. Townes** (University of California, Berkeley) for the development of the maser and laser; **Jan A. Veltrop** (consulting engineer, Skokie, Ill.) for engineering design of concrete arch dams and development of hydroelectric projects; **John T. Watson** (National Institutes of Health) for enabling human mechanical artificial heart research and developing the related NIH program, including industrial implementation; **James E. West** (Bell Laboratories, Lucent Technologies) for electret transducers and their applications to microphones; and **Kensall D. Wise** (University of Michigan, Ann Arbor) for sensors and microelectromechanical systems.

Among the NAE foreign associates are **Kunmo Chung** (Ajou University, Korea) for contributions to plasma heating methods, advanced nuclear power generating systems, and Republic of Korea science and technology capabilities; **Leo C.M. De Maeyer** (Max Planck Institute for Biophysical Chemistry, Goettingen) for the development of innovative experimental methods and instrumentation for investigating molecular mechanisms of faster chemical reactions; **Zvi Hashin** (Tel Aviv University, Israel) for contributions to the theory and technology of advanced composite materials; and **Manfred Rühle** (Max Planck Institute for Metals Research, Stuttgart) for use of electron microscopy in the study of structure-property relations of materials.

## Munir Receives Medal from Int'l Organization for Self-Propagating High-Temperature Synthesis

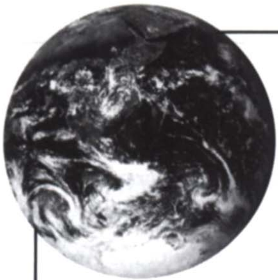
Zuhair Munir, professor of materials science and engineering at the University of California—Davis, has been awarded a Medal of Honor by the International Organization for Self-Propagating High-Temperature Synthesis in recognition of his worldwide contributions to the field of combustion synthesis.

Munir received his PhD degree in materials science, specializing in ceramics, from the University of California—Berkeley in 1963. From 1964 to 1968 he worked at IBM and General Electric with the Research Summer Faculty. Before joining the faculty at UC—Davis, Munir worked for Florida State University and San Jose State University. He is a Fellow of the American Ceramic Society and the American Society for Metals, and a member of the Materials Research Society. He serves as Editor-in-Chief of the *Journal of Materials Synthesis and Processing*, Principal Editor of the *Journal of Materials Research*, Associate Editor of the *Journal of the American Ceramic Society*, and as a member of the editorial board of the *International Journal of Self-Propagating High-Temperature Synthesis*. He has co-edited five books and has published more than 200 papers. He holds seven patents. □

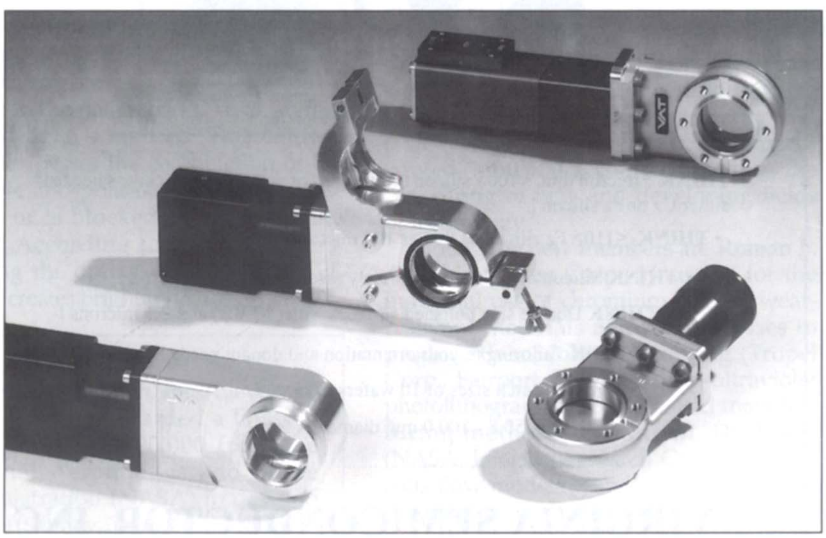




https://doi.org/10.1557/S0883769400030360 Published online by Cambridge University Press










https://doi.org/10.1557/S0883769400030360 Published online by Cambridge University Press