Rectification Suppression in Magnetic-Ge Heterojunction Diode Shown to Be Magnetization-Dependent

The potential for spin-polarized electronics to advance solid-state electronics by enabling logic and memory to be integrated into a single device or chip has prompted research efforts focused on spin-dependent effects in semiconductors. While electronic spin devices have previously shown relatively small effects, a team of researchers from the Department of Physics and Astronomy at the University of North Carolina in Chapel Hill has demonstrated the viability of producing multifunctional spin devices.

As reported in the August 4 issue of *Applied Physics Letters*, F. Tsui, L. Ma, and L. He have observed magnetization-dependent diode behavior in a heterojunction consisting of a CoMn-doped *p*-type Ge magnetic semiconductor grown epitaxially on a lightly doped *n*-type Ge substrate. Under electrical bias, the current rectification of the diode can be suppressed by applying a magnetic field. The researchers grew magnetic germanium (M-Ge) films of the form $Co_{2x}Mn_xGe_{1-3x}$ on Ge(001) substrates using molecular-beam epitaxy (MBE) techniques to create heterojunctions with $x < 0.05$ (see figure). However, the researchers only achieved smooth two-dimensional M-Ge growth and created heterojunctions with a good low-temperature, magnetization-dependent rectification effect for doping concentrations of $x < 0.03$.

Below the 150°C Curie temperature (T_c) of this M-Ge film, a magnetization-dependent suppression of the current rectification effect, which was shown to be a consequence of the film's ferromagnetic order, was reported. Under reverse bias and zero magnetic field ($\mathbf{B} = 0$), the diode operated in the "on state" whereas, at either high magnetic field or under forward bias, the diode operated in the "off state" causing suppression of electron injection into the Ge substrate. At low temperature and a bias of −2 V, a current ratio of 30 was observed, which corresponds to a field-dependent current ratio, $\Delta I/I_0$, of 97%, that is, the ratio of the difference between the zero-field current and the current with an applied magnetic field, $\Delta I = I_0 - I(\mathbf{B})$, to the zero-field current, $I_0 = I(\mathbf{B} = 0)$. With a field on the order of 100 Oe, the current rectification was suppressed to half of its zero-field value. According to Tsui, "the low magnetic field required to cause the rapid and large suppression of current rectification makes this Ge-based magnetic heterojunction diode a technologically important device."

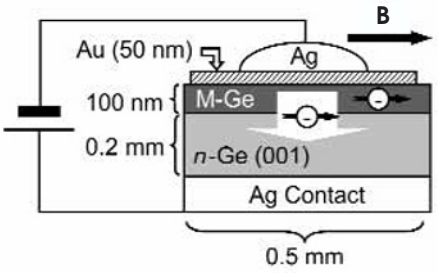


Figure. Schematic of the heterojunction with a doped magnetic Ge (M-Ge) film grown epitaxially on an n*-type Ge(001) substrate (*n*-Ge). Reproduced with permission from* Applied Physics Letters ***83*** *(2003); © 2003 American Institute of Physics.*

By examining the field-dependent current ratios as a function of the state variable for magnetization-dependent phenomena, $\mu_B\mathbf{B}/k_BT$ (where μ_B is the Bohr magneton and k_B is the Boltzmann constant), the researchers demonstrated that the low field current ratios of the device behave differently than those of nonmagnetic Ge depending on the bias directions. These observations differ from previously reported phenomena including magnetoresistance effects in magnetic multilayers or field-dependent carrier trajectory effects, both of which would result in the same field dependence regardless of bias direction. In their initial description of the rectification-suppression phenomena observed in this study, the researchers speculate that there exists a nearly half-filled impurity band in the *p*-type M-Ge film, which is spin-split below T_c such that it is half-metallic in zero field and insulating in high field.

"This magnetization-dependent diode is exciting," said Tsui, "because it not only exhibits a large field-dependent suppression of current rectification at low temperature, but it is also based on a materials system that is structurally and electronically compatible with current Si-based device technology. This work is a result of our intense effort on materials synthesis."

STEFFEN K. KALDOR

Coated Microcantilevers Detect Plastic Explosives

High explosives such as pentaerythritol tetranitrate (PETN) and hexahydro-1,3,5-triazine (RDX) exhibit very low vapor pressures, in the range of parts per trillion at ambient temperatures. Currently, the most sensitive detection techniques report limits on the order of hundreds of picograms, but the technologies involved are often expensive and not easily miniaturized. A team of researchers from the Oak Ridge National Laboratory and the University of Tennessee has recently employed coated microcantilevers in a detection method that offers limits of detection of a few femtograms and has the potential to be portable and reusable.

As reported in the August 18 issue of *Applied Physics Letters*, the researchers took advantage of the ability of microcantilevers to sensitively respond to surface-analyte interactions. These interactions induce large surface forces and, if limited to one surface, lead to bending of the cantilever. The team used silicon microcantilevers, which were coated on one side with gold. Each cantilever was immersed in a solution of 4-mercaptobenzoic acid (4-MBA) to produce a uniform, self-assembled monolayer of acid molecules on the gold surface. This carboxyl-terminated monolayer was selected because of its ability to interact with nitro-substituted explosive molecules through hydrogen bonding.

The coated cantilever was held in a vacuum-tight flow cell, and a vapor stream with a trace concentration of PETN or RDX was passed over it. The light of a laser diode was reflected by the gold surface of the cantilever and used to determine both bending response and resonance frequency. Response of the cantilevers to both explosive compounds was clear and fast, with maximum bending observed in 20–25 s. After the stream containing explosive vapors was turned off, the cantilever quickly relaxed to its starting position and could be used for further detections. For both PETN and RDX, the limit of detection was determined to be on the order of several femtograms.

These results demonstrate direct vapor detection of plastic explosives at parts-per-trillion levels. Because of the small size of the cantilevers as well as the speed and reversibility of this detection method, the team said that this work "can lead to the development of a portable detection device for rapid and sensitive detection of explosive vapors."

CATHERINE OERTEL

Ga-Filled Single-Crystalline MgO Nanotube Serves as Thermometer with a Wide Temperature Range

Tubular metal oxide nanostructures combine the multifunctionality of carbon nanotubes and the industrially important applications of oxides. However, established template methods for fabricating oxide nanotubes produce polycrystalline structures, which form weaker nanostructures than do single-crystalline nanotubes. In addition, while carbon nanotubes filled with liquid metals have been previously studied, the encapsulation of liquid metals

within oxide nanotubes heretofore has not. Researchers from Y. Bando's group at the National Institute for Materials Science, Ibaraki, Japan, have synthesized single-crystalline MgO nanotubes and demonstrated that such a structure filled with Ga serves as a nanothermometer with a very wide temperature range. The synthesis of the nanotubes and *in situ* Ga filling was accomplished using a one-step process.

As reported in the August 4 issue of *Applied Physics Letters*, National Institute for Materials Science researcher Y.B. Li and co-workers used Ga_2O_3 and Mg powders in a vertical induction furnace to obtain *in situ*-filled oxide nanotubes. With the Ga_2O_3 placed in the high-temperature (1300–1400°C) zone and the Mg placed in a lower-temperature (800–900°C) zone, a white powder was collected from the surface of a graphite inductor, used as a heating element, located near the Mg. An x-ray diffraction pattern shows that the product is composed of only two crystal phases: cubic MgO and orthorhombic Ga. The researchers performed a chemical composition analysis by means of an energy-dispersion spectrometer attached to a transmission electron microscope to confirm that the nanotubes are composed of Mg and O in an atomic ratio of 1:1.

In addition to verifying that the nanostructures are Ga-filled MgO nanotubes, transmission electron micrographs (TEMs) show that the nanotubes are several micrometers long, have an outer dimension of ~30–100 nm, and have a uniform inner dimension ranging from 20 nm to 60 nm. Most nanotubes are closed at both ends but are not entirely filled with Ga. In one frequently observed morphology, a continuous column of Ga fills the nanotube except for a short section near one tip; in another, a central portion of the nanotube is left unfilled.

Unlike polycrystalline oxide nanotubes, the MgO nanotubes produced by Li and co-workers have square cross sections. A high-resolution TEM shows that the spacing between two neighboring parallel fringes both in the longitudinal and transverse direction is 2.10 Å, which is equal to the spacing between the [200] planes of cubic MgO. The researchers deduced that the nanotubes' growth direction, and therefore the nanotube axis, is the [100] direction of cubic MgO.

The researchers used a heating holder in a transmission electron microscope to investigate the thermal expansion of liquid Ga columns inside MgO nanotubes. After plotting the distance between the tips of two Ga fragments within a MgO nanotube as a function of temperature and obtaining a linear relationship with no hysteresis, the researchers realized that they had fabricated a virtually perfect nanothermometer. The researchers said that carbon nanotubes degrade quickly in air as the temperature approaches 600–700°C, while MgO, by contrast, is an extremely temperature-stable refractory compound. The researchers calibrated one particular nanothermometer by expressing the temperature as a function of two independent parameters—the total length of the column of Ga in the nanotube and the distance between two fragments of Ga at some reference temperature. Although the ultimate range of the nanothermometer is limited only by the melting and boiling points of Ga (about 30°C and 2205°C, respectively) the two parameters determine the working temperature range; for a typical Ga-filled MgO nanotube, it is about 30–800°C.

Li and co-workers said that MgO nanotubes filled with In were prepared by a similar process whereby In_2O_3 powder was substituted for Ga_2O_3 powder. They therefore believe that their method may be universal for preparing metal-filled oxide nanotubes.

STEVEN TROHALAKI

100-Fold X-Ray Source Brightness Improvement Possible with Liquid-Metal-Jet Anode

Compact electron-impact x-ray sources dominate diagnostics and imaging in medicine, industry, and science. Their key figure of merit, the source brightness, is proportional to the electron-beam power density at the anode. Higher brightness results in higher-resolution imaging. In this respect, the current industry standard—rotating anode and microfocus technologies—show little potential for further improvement due to their intrinsic thermal heat-transfer limitations. Recently, O. Hemberg and co-workers of the Hertz Group at the Royal Institute of Technology in Stockholm have developed an x-ray source based on a liquid-metal-jet-stream anode potentially allowing a more than 100-fold brightness increase for such devices, as reported in the August 18 issue of *Applied Physics Letters*.

The experimental system consisted of a liquid-metal-jet system with a high-pressure tank enclosed in an IR heater, a 75-µm ruby pinhole nozzle, and a sintered stainless-steel particle filter. The chosen Sn/Pb metal alloy was heated to 250°C and forced through the nozzle by applying pressure up to 200 bars, producing a laminar jet with a speed of up to 60 m/s. The electron beam was focused onto the liquid-metal jet to give a 150-µm full width at half maximum focal spot, exhibiting about 100 W power. The jet absorbed 42% of the electron beam, leading to a maximum x-ray brightness of 1.4×10^{10} photons/(mm^2 sr s eV) at the Sn K_α peak with an average electron-beam power density of 3 kW/mm^2. Boiling and evaporation were observed at very high electron-beam powers, relative to the jet speeds.

The ideal jet materials for this application are metals and alloys with a low melting point, due to their high electric conductivity, high thermal heat capacity, and high Z. In particular, the thermal heat capacity is crucial to achieve high-brightness operation. The selected material was a Sn/Pb solder with a melting point of 183°C, which combines favorable thermodynamic properties with a Sn x-ray line emission that is particularly suitable for mammography.

The unique feature of this anode technology is the possibility of tailoring the system to high-brightness operation, primarily because a stable liquid-metal jet has the potential to achieve a higher speed than a rotating anode, and its regenerative nature results in a higher thermal heat capacity and heat-transfer rate due to the achievable high mass throughput.

ALFRED A. ZINN

AlGaAs Microcooler with 2°C Maximum Cooling at 100°C Demonstrated

Cooling of semiconductor laser diodes can enhance performance by reducing threshold currents, increasing power output, and enhancing spectral stability. Cooling can also boost GaAs integrated-circuit performance in power microwave and millimeter wave applications, since it lowers noise and increases gains. Integrated microcoolers are, in many cases, the most efficient approach to such cooling tasks. Conventional thermoelectric coolers such as Bi_2Te_3-based systems, however, are fundamentally incompatible with the most common semiconductor phases Si, GaAs, and InP, rendering them impractical for integrated applications. J. Zhang and N.G. Anderson at the University of Massachusetts, Amherst, and K.M. Lau at the Hong Kong University of Science & Technology have fabricated a stand-alone AlGaAs-based superlattice microcooler, which represents an important step toward monolithically integrated microcooler structures for GaAs-based microelectronic devices.

Even though Si, GaAs, and InP are not considered thermoelectric materials, recent investigations have shown that significant improvements of their thermoelectric figures of merit can be

achieved in their respective thin-film structures, opening the door to *in situ* cooling of semiconductors. As reported in the July 14 issue of *Applied Physics Letters*, the researchers used low-pressure metalorganic chemical vapor deposition to grow 100-period Si-doped superlattices with 10-nm AlGaAs barriers and 10-nm AlGaAs wells. The group chose the AlGaAs system for its compatibility with GaAs, and the particular low-Al barrier and well phases, because of their low thermal conductivity compared to GaAs, while exhibiting comparable electrical conductivity. In addition, they can be doped to a very high level.

The scientists fabricated stand-alone microcoolers using standard lithography techniques and Ni/Au/Ge/Au as wire bonding contacts, and they mounted the device on a copper heatsink for analysis. The specific series resistance including contact and superlattice resistance was determined to be 3.2×10^{-6} Ω cm^2. In the measured temperature range of 25–100°C, the cooling effect increased from 0.8°C to 2°C, indicating increasing efficiency with higher temperatures, according to the researchers. Size reduction from 120 μm^2 × 120 μm^2 to 60 μm^2 × 60 μm^2 increased the cooling effect from 0.67°C to 0.8°C, but the trend did not continue with further size reduction. The researchers expect significant improvements in cooling performance through optimization of contact resistance doping level, superstructure, and geometric parameter adjustment.

ALFRED A. ZINN

Nanocomposites Made from Renewable Resources Exhibit Good Mechanical Properties

Interest in preparing polymeric materials from renewable, plant-based resources has grown in recent years. Plant oils are particularly attractive raw materials because of their worldwide abundance, and "green" polymers are already being used in inks and coatings. However, these materials do not offer the mechanical properties necessary for structural applications. A group of researchers at Kyoto University and Toyota Central R&D Labs has now used plant oils and clay to prepare nanocomposites that show strength, flexibility, and biodegradability. They report their results in the July 1 issue of *Chemistry of Materials*.

The team prepared the nanocomposites by cross-linking either epoxidized soybean oil (ESO) or epoxidized linseed oil (ELO) in the presence of montmorillonite clay modified with organic groups. Wide-angle x-ray diffraction and transmission electron microscopy were used to characterize the insoluble polymeric network. Dynamic viscoelasticity measurements showed that the storage moduli of the nanocomposites increased as a function of clay content. In the absence of clay, only a very soft film was obtained, while nanocomposites with 5–15% clay content displayed flexibility and good mechanical strength. The storage modulus of the ELO clay nanocomposite was greater than that for ESO clay, probably due to a higher cross-linking density in the ELO polymer, according to the researchers.

CATHERINE OERTEL

Si/TiB_2 Microcomposite as Li-Ion Battery Anode Material Yields High and Stable Discharge Capacity

Graphite is currently the main anode material for lithium-ion batteries, the power source of choice for portable electronics such as cellular phones, laptop computers, and video cameras. However, the performance of graphite anodes suffers from a relatively low theoretical maximum capacity of 372 mAh/g and irreversible capacity loss in the first cycle. P.N. Kumta, I.-S. Kim, and G.E. Blomgren of Carnegie Mellon University have found that the use of a microcomposite material consisting of TiB_2 as an inactive host matrix and Si as the finely dispersed active phase minimizes the detrimental stresses during the charge/discharge

cycles. The Si/TiB_2 microcomposite Li-ion battery anode avoids mechanical failure when compared with silicon and tin-based systems such as SnFeC, Cu_6Sn_5, and SnSb systems. The latter have become of recent interest due to their high initial capacities of up to 4000 mAh/g. However, their capacities quickly drop to about 1/20 of their initial values and they suffer from cracking or crumbling caused by the large volume change in the material during repeated charging and discharging.

As described in the June issue of *Electrochemical and Solid State Letters*, the researchers used high-energy mechanical ball milling to mix and grind the two components, Si and TiB_2, into a fine micron- to nano-sized powder. Their process yielded a nanostructured material consisting of 300–3000-nm size grains composed of 3–10-nm TiB_2 crystallites and amorphous silicon. An anode fabricated using this material exhibited a stable capacity of ~400 mAh/g after 15 cycles (with a current rate of ~C/25). Phases consisting of larger particles led to materials with higher discharge capacities (726 mAh/g), but with larger losses per cycle, while materials containing smaller particles show a lower initial capacity, but with a much higher overall charge retention (<0.4% loss per cycle). The group examined the anodes using scanning electron microscopy and high-resolution transmission electron microscopy, but could not detect any cracking or other structural damage, indicating that the small TiB_2 particles reduce the stresses caused by the volume change to a tolerable level. The researchers said that these properties make the anode material a viable alternative to the currently used graphite.

ALFRED A. ZINN

Simulations Indicate That Controlled Vertical Manipulation of Individual Molecules by Scanning Probes Is Possible

The idea of controllable modifications of surface structure on the atomic scale using scanning tunneling microscopy (STM) and atomic force microscopy (AFM) has attracted considerable attention from researchers in the last decade. Manipulation of single molecules is usually classified as lateral or vertical. Lateral manipulation has been extensively studied, while vertical manipulation is now in the beginning stages of research. A group of researchers from Tel Aviv University, Israel and the Donetsk Institute for Physics and Engineering, Ukraine has proposed a method of controlled vertical manipulation of individual molecules with scanning probes. The method is based on the different probabilities of transfer of molecules to the STM tip depending on both tip velocity and the distance of closest approach to the surface. The surface–tip transfer time competes with the tip's velocity; consequently, the adsorbate cannot always follow the motion of the tip.

As reported in the June issue of *Nano Letters*, M. Urbakh of Tel Aviv and coworkers performed detailed modeling of manipulations of molecules by STM or AFM tip by using a "pick-up-and-put-down" (vertical) mode. As a result of their simulations, the researchers presented a map giving the probability of trapping a given number of particles ranging from 0 to 8 for a given driving velocity of the tip. They also calculated histograms for the number of trapped particles for various values of velocity, which indicate that picking up 1, 3, 5, or 8 particles is much more likely than picking up 4, 6, or 7 particles.

The researchers found that the number of molecules picked up by the tip can vary over a wide range, and the number of trapped molecules decreases with an increase in tip velocity. Furthermore,

according to their simulations, trapping of different numbers of molecules occurs with different probabilities. The researchers discuss this fact in terms of the geometry of the tip. According to their modeling conditions, the most energetically preferred configurations of molecules around the tip correspond to either five particles—a tetragonal pyramid—or eight particles in which six form a hexagon in the plane of the tip and two are out of plane. The researchers said that the configurations and the number of particles are determined by the radius of the tip, molecule conformation, and the tip geometry among other factors.

The research team concluded that changing the pulling velocity enables control of the number of molecules transferred from the surface layer to the tip and vice versa.

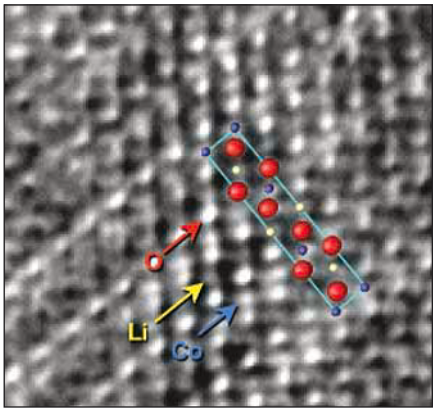
ANDREI A. ELISEEV

Focal Reconstruction Produces TEM Images of Individual Lithium Atoms

In work that could aid the development of batteries for products from laptop computers to electric cars, an international team of researchers has taken images of individual atoms of lithium, a key element in state-of-the-art rechargeable batteries.

"The atomic resolution imaging of lithium atoms is a novel and significant achievement, with implications for better understanding not only of lithium-ion battery materials but of many other electroceramic materials as well," said Yang Shao-Horn, an assistant professor at the Massachusetts Institute of Technology.

Shao-Horn and colleagues M.A. O'Keefe and E.C. Nelson from Lawrence Berkeley National Laboratory used a specially modified transmission electron microscope to simultaneously resolve columns of lithium, cobalt, and oxygen atoms in the lithium battery material lithium cobalt oxide ($LiCoO_2$). They accomplished this through focal-series reconstruction of the electron wave at the specimen exit surface (see figure).



Experimental image of lithium atoms reconstructed from 20 component images obtained over a range of focus. The image shows the arrangement of lithium ions among cobalt and oxygen atoms in the battery material lithium cobalt oxide—strong white peaks occur at the positions of oxygen atom columns, strong fuzzy peaks at cobalt sites, and the weak white peaks show lithium positions. Reproduced with permission from Nature Materials ***2*** *(7) (July 2003), p. 464; © 2003 Nature Publishing Group.*

As reported in the July issue of *Nature Materials*, the researchers obtained series of 20 differently focused images of individual crystals from a $LiCoO_2$ powder sample synthesized and characterized by conventional x-ray diffraction in collaboration with colleagues L. Croguennec and C. Delmas from CNRS and the University of Bordeaux I. Using a reconstruction program and their measurements of the microscope parameters, the researchers worked backwards to assemble the focal series of images into one image that is a representation of the electron wave leaving the exit surface of the specimen. At the thin edge of a $LiCoO_2$ crystal, this reconstructed experimental image matched the image previously predicted by a simulation program.

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www.mrs.org/gateway/matl_news.html

News of MRS Members/Materials Researchers

Reza Abbaschian, Vladimir A. Grodsky Professor of Materials Science and Engineering at the University of Florida, has received the **Donald E. Marlowe** Award from the American Society for Engineering Education in recognition of his extraordinary vision and leadership in administration, education, and research, and for significant ongoing contributions to engineering education.

Kenneth T. Barry has been named President of Unaxis Semiconductors. Barry brings with him more than 15 years of global semiconductor experience.

Stephen P. Ellis, laboratory manager at Ecolochem, Inc., has been awarded a **2003 ASTM International Award of Merit** for his technical contributions to the objectives of ASTM Committee D19 on Water.

Helen Garnett, presently chief executive of the Australian Nuclear Science and Technology Organisation (ANSTO) and a representative to the United Nations International Atomic Energy Agency, has

Jeff Wadsworth Named Director of Oak Ridge National Laboratory

UT-Battelle has announced the selection of Jeff Wadsworth as director of the U.S. Department of Energy (DOE) Oak Ridge National Laboratory (ORNL). He succeeds Bill Madia, who has joined Battelle as Executive Vice President of Laboratory Operations. Wadsworth, who began his new duties on August 1, joins ORNL after years of distinguished service as a senior leader at Lawrence Livermore National Laboratory, as well as service at Battelle's world headquarters in Columbus, Ohio as a senior executive in areas such as DOE science programs, technology transfer, and homeland security.

"Jeff [Wadsworth] is an internationally respected scientist, outstanding leader, and innovator in such fields as materials science and homeland security," said Raymond L. Orbach, director of DOE's Office of Science.

Wadsworth holds BS, PhD, and DMet degrees in metallurgy from Sheffield University. In 1987, he was elected a Fellow of the American Society for Metals, and in 2000 a Fellow of The Minerals, Metals, and Materials Society. Most recently, in 2003, he was elected a Fellow of the American Association for the Advancement of Science for "distinguished contributions in developing advanced materials and superplasticity, and in determining the history and origins of Damascus and other steels, and for broad scientific leadership supporting national security."

been appointed as Vice-Chancellor of the new Charles Darwin University at Northern Territory University in Australia. She will begin in October 2003.

Yuri Gogotsi, professor of materials science and engineering and associate dean of the College of Engineering at Drexel University, has been chosen to be the director of the newly formed A.J. Drexel Nanotechnology Institute (DNI). The DNI is being established as a university research center to conduct and coordinate education and basic and applied research in the field of nanotechnology and nanostructured materials.

Raymund Singleton, president of Singleton Corp., has been awarded the **2003 ASTM Award of Merit** in honor of his service contributions to ASTM Committee G01 on Corrosion of Metals.

Stuart A. Solin, professor of physics at Washington University in St. Louis, has been awarded an honorary doctor of science degree from Purdue University. Solin, a Principal Editor of the *Journal of Materials Research*, is a leading figure in condensed-matter physics and materials science, focusing on fundamental physical phenomena in ordered and disordered solids.

Shyamkumar Surthi, a postdoctoral fellow at North Carolina State University, has received the **2001–2002 Outstanding Dissertation Award** from the College of Engineering at the University of Alabama in recognition of his dissertation titled "Integration of Colossal Magnetoresistive Materials with Ferroelectrics."

Jerry M. Woodall, D. Baldwin Sawyer Professor of Electrical Engineering at Yale University, was awarded the **National Materials Advancement Award** from the Federation of Materials Societies for his work in advancing the effective and economic use of materials and the field of materials science and engineering in general.

The **U.S. National Academy of Sciences** has announced the election of 72 new members and 18 foreign associates in recognition of their distinguished and continuing achievements in original research, including:

Praveen Chaudhari, director of Brookhaven National Laboratory;

Herbert Kroemer, professor of electrical engineering and materials at the University of California, Santa Barbara (Nobel Prize in physics, 2000), as a foreign associate;

Sidney R. Nagel, professor of physics, University of Chicago;

William D. Nix, Lee Otterson Professor of Engineering Emeritus in the Department of Materials Science and Engineering at Stanford University;

Ryoji Noyori, professor of chemistry and director of the Research Center for Materials Science at Nagoya University, Japan (Nobel Prize in chemistry, 2001), as a foreign associate;

Robert J. Silbey, professor of chemistry and dean of science, Massachusetts Institute of Technology;

Bruce D. Smith, senior scientist and curator of North American archaeology, director of the archaeobiology program, Smithsonian Institution;

Dale J. Van Harlingen, professor of physics, University of Illinois at Urbana-Champaign; and

Eli Yablonovitch, professor of electrical engineering, University of California at Los Angeles.

The **Society of Plastics Engineers (SPE)** has announced the recipients of its 2003 awards presented at the Society's 61st Annual Technical Conference:

Glen L. Beall, president of Glenn Beall Plastics, Ltd., has received the **2003 SPE International Award** for his plenary presentation titled "The Importance of Plastic Production Design";

Robert A. Weiss, the A.T. DiBenedetto Distinguished Professor of Engineering at the University of Connecticut, has received the **2003 SPE Plastics Engineering/Technology Award**; Weiss has centered his research on ionomers, liquid-crystalline polymers, and polymer blends;

Jimmy Carter, former U.S. President, has received the **2003 SPE John W. Hyatt Award** for administering the use of a special nylon monofilament cloth filter that has largely eradicated Guinea worm disease by filtering out the worm's larva from drinking water;

Donald G. Baird, the Harry C. Wyatt Professor of Chemical Engineering and co-director of the Center for Composite Materials and Structures at Virginia Polytechnic Institute and State University, has received the **2003 SPE Research Award**; Baird is known for his work in polymer rheology and its application to polymer processing, especially for liquid-crystalline polymers;

Charles L. Beatty, professor in the Materials Science and Engineering Department at the University of Florida, has received the **2003 SPE Education Award**; Beatty was instrumental in establishing a plastics engineering curriculum at the University of Florida and has developed eight core polymer courses for undergraduate and graduate students including specialty courses on plastics product design engineering and rapid prototyping;

William S. Stavropoulos, Chair of the Board of Directors, President, and CEO of the Dow Chemical Co., has received the **2003 SPE Business Management Award**.

The **State University of New York** has announced the recipients of its **SUNY Chancellor's Awards for Excellence**. The following Alfred University students received the award for their academic success at the School of Ceramic Engineering and Materials Science:

Carlos C. Chang, an Alfred University December 2002 graduate, received his BS degree in ceramic engineering, as well as a Bachelor of Fine Arts degree from Alfred University's School of Art and Design;

Shawn M. Allan received his BS degree in materials science and engineering from Alfred University in December 2002;

James F. Carroll III received his BS degree in ceramic engineering from Alfred University in May; and

Nathanael Lawton received his BS degree in materials science and engineering from Alfred University in May. □