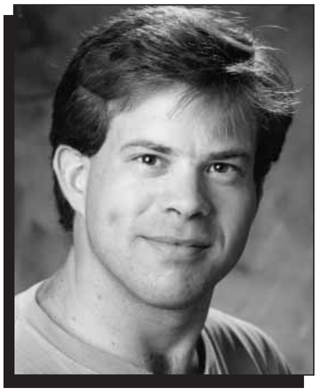
Timothy Deming Named 2003 Outstanding Young Investigator for Work in Polymers



Timothy Deming

Timothy Deming, an associate professor of materials and chemistry at the University of California—Santa Barbara, has been named the 2003 Materials Research Society Outstanding Young Investigator (OYI). He is cited for his "discovery of synthetic methods to produce polypeptide homopolymers and block copolymers with exquisite control of block length, sequence, and secondary structure and the interdisciplinary exploitation of these materials to yield unique hydrogels and inorganic materials." The OYI Award recognizes outstanding interdisciplinary materials research by a young scientist or engineer. Deming will present his award talk during the 2003 MRS Spring Meeting on April 23 at 12:45 p.m. in Salon 7 of the San Francisco Marriott Hotel. The title of his presentation is "Synthetic Polypeptides: New Developments in an Old Field."

Deming's pioneering research on transition-metal initiators for the synthesis of copolypeptides has provided a new approach to the 50-year-old established method of preparation. His polymerization schemes have implications for chemistry, physics, biology, and biomedical engineering. The potential applications range from biomedical materials (e.g., tissue-engineering scaffolds and drug carriers) to models for protein folding and assembly.

By careful choice of metal and ligand, Deming prepared nickel, cobalt, and iron catalysts for living polymerization of *N*-carboxy α-amino acid anhydrides (NCAs) to form polypeptides with controlled lengths, narrow molecular-weight distributions, and predetermined sequences. In multidisciplinary work, Deming used block copolypeptides to direct the synthesis of SiO_2 at neutral pH into spheres or columns in a manner that mimics the silica-producing protein silicatein. A similar block copolypeptide has subsequently been used to assemble 10-nm-diameter hollow nanoparticles in which the inner layer is Au and the outer is SiO_2. The assembly principle makes use of the polyelectrolyte nature of one block in water that attracts the negatively charged SiO_2 and the –SH groups on the other block that bind to Au. These layered hollow spheres are porous but robust, surviving calcinations that remove the block copolypeptide at temperatures of up to 1100°C.

In another interdisciplinary collaborative work led by Deming, hydrogels were formed from exceptionally low concentrations of block copolypeptide in water. The hydrogels can be broken down under large shear strains but reform very rapidly when shearing has ceased.

Deming received his BS degree in chemistry from the University of California—Irvine in 1989 and graduated with a PhD degree in chemistry from UC—Berkeley under Bruce Novak in 1993. After a National Institutes of Health postdoctoral fellowship at the University of Massachusetts—Amherst with David Tirrell, Deming joined the Materials Department faculty at UC—Santa Barbara in 1995. He currently holds a joint appointment in the Materials and Chemistry Departments, where he was promoted to associate professor in 1999. His research interests include polypeptide synthesis, self-assembly of block copolypeptides, and biological activity in polypeptides, for which he has received young investigator awards from the National Science Foundation, the Office of Naval Research, the Arnold and Mabel Beckman Foundation, the Alfred P. Sloan Foundation, and the Camille and Henry Dreyfus Foundation. Deming has over 60 publications. MRS

Don't miss the Plenary Session at the 2003 MRS Spring Meeting!

Plenary Speaker: **David A. Tirrell**, California Institute of Technology
Talk Presentation: *Opportunities at the Materials-Biology Interface*

Wednesday, April 23, 6:00 p.m. • Metropolitan Ballroom, Argent Hotel

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MRS Graduate Student Award Finalists Announced for 2003 MRS Spring Meeting

The Graduate Student Award (GSA) finalists have been named for the 2003 Materials Research Society Spring Meeting. They have been chosen for authoring or co-authoring symposium papers which exemplified significant and timely research. Each finalist is scheduled to give a presentation at the GSA Special Talk Session at the meeting on April 22. The finalists are **Jason B. Baxter**, University of California—Santa Barbara, (Q7.9) Growth and Characterization of ZnO Nanowires and Columns; **Seth Coe**, Massachusetts Institute of Technology, (L10.6) Visible and 1.55 μm Quantum Dot Organic Light-Emitting Devices and (P10.7) Using Phase Segregation of Organic Molecules and Inorganic Nanocrystals in Layered Optoelectronic Device Fabrication; **Ruxandra Costescu**, University of Illinois—Urbana-Champaign, (S5.3) Thermal Conductance of Epitaxial Interfaces; **Cindi L. Dennis**, University of Oxford, United Kingdom, (V2.7) "High" Current Gain Silicon-Based Spin Transistor; **Ana Filipa Nogueira Fixe**, INESC-MN, Portugal (A21.2) Optoelectronic Detection of DNA Molecules on Thin-Film DNA Chips Using an Amorphous Silicon Photoconductor and (N10.5) Electric Field Pulse Assisted Covalent Immobilization and Hybridization of DNA in the Nanosecond Time Scale; **Chee Lip Gan**, Singapore-MIT Alliance, Singapore, (E1.5) Experimental Characterization of the Reliability of Multi-Terminal Dual-Damascene Copper Interconnect Trees; **Eric P. Guyer**, Stanford University, (E9.2) Effect of Chemically Active Environments on Subcritical Crack-Growth in Low-*k* Dielectric Materials; **Terri L. Haskins**, University of Rochester, (L5.3) Photoluminescence Quenching in Doped Alq_3 Organic Light-Emitting Diodes; **Robin L. Hayes**, University of California—Los Angeles, (U8.5) Two Branch Universal Binding Energy Relationship for Relaxed Surfaces; **Jiaxing Huang**, University of California—Los Angeles, (Q9.2) Polyaniline Nanofibers—Facile Synthesis and Chemical Sensors; **James F. Hulvat**, Northwestern University, (L9.4) Enhancing Performance of Polymer LEDs Through Nanoscale Self Assembly; **Matthew Law**, University of California—Berkeley, (Q7.5) The Thermomechanical Behavior of Bilayer Nanocantilevers; **Ki-Bum Lee**, Northwestern University, (N4.5) Biomolecular Arrays Formed by Dip-Pen Nanolithography (DPN); **Minjoo L. Lee**, Massachusetts Institute of Technology, (G1.10) Hybrid Valence Bands in Strained Layer Heterostructures Grown on Relaxed SiGe Virtual Substrates; **Tae-Hee Lee**, Georgia Institute of Technology, (K9.4) Single Molecule Light-Emitting Diodes; **Liang-shi Li**, University of California—Berkeley, (P9.20) Permanent Dipole of CdSe Nanorods Measured by Transient Electric Birefringence; **Sen Liu**, University of Washington, (L10.48) Focused Microwave-Assisted Synthesis of 2,5-Dihydrofuran Derivatives as Highly Efficient Electron Acceptors for Nonlinear Optical Chromophores; **Olivier Noel**, Université Haute Alsace, France, (U4.7) Surface Mechanical Property Determination of Soft Materials Through an AFM Nanoindentation Experiment and (U4.11) Decoupling of the Chemical and Mechanical Surface Contributions in a Force Curve Measurement with AFM; **Prita Pant**, Cornell University, (W5.25) Strain Relaxation by Misfit Dislocation Arrays; **Alexandra E. Porter**, University of Cambridge, United Kingdom, (O4.8) A Potential Mechanism by which Silicon Increases the Rate of Bone Apposition to Hydroxyapatite *In Vivo*; **Pavle Radovanovic**, University of Washington, (V3.9) Spectroscopy of Colloidal Diluted Magnetic Semiconductor Quantum Dots—From Synthesis to Spintronics; **Brandon Seal**, Arizona State University, (O3.8) Polysaccharide-Based Self-Assembling Hydrogels; **Yulong Shen**, Cornell University, (L10.13) Charge Injection in Doped Organic Semiconductors; **Eli D. Sone**, Northwestern University, (O8.8) Magnetic Iron Oxide Mineralization of Peptide-Amphiphile Nanofibers; **Iris Visoly-Fisher**, Weizmann Institute of Science, Israel, (B3.6) Affecting CdTe/CdS Solar Cell Performance via Grain Boundary and Surface Chemistry and (B5.3) High-Resolution Characterization of a Single Grain Boundary and the Various Layers in CdTe/CdS Solar Cells; and **Erich C. Walter**, University of California—Irvine, (Z4.6) Metal Nanowires by Electrodeposition. MRS

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MRS Invites Nominations for the Von Hippel Award, Turnbull Lectureship, and MRS Medal

The Materials Research Society is seeking nominations for the Von Hippel Award, the Turnbull Lectureship, and the MRS Medal. The deadline for nominations is **June 1, 2003**. These awards will be presented at the 2003 MRS Fall Meeting, December 1–5, in Boston.

The MRS Awards Program recognizes outstanding contributors to the progress of materials research. Nomination forms and details about eligibility and nomination criteria are available from Materials Research Society, 506 Keystone Drive, Warrendale, PA 15086-7573, USA; phone 724-779-3004 ext. 102, fax 724-779-8313, or the MRS Web site at www.mrs.org.

Von Hippel Award Acknowledges Outstanding Interdisciplinary Work in Materials Research

The Von Hippel Award, first presented to Arthur R. von Hippel, whose interdisciplinary and pioneering research typified the spirit of the award, is the Materials Research Society's highest honor. The recipient is recognized for brilliance and originality combined with vision that transcends the boundaries of conventional scientific disciplines. The award includes a $10,000 cash prize, honorary membership in MRS, and a unique trophy—a mounted ruby laser crystal symbolizing the many-faceted nature of materials research.

The Board of Directors selects the recipient from a list of nominees rank-ordered by the Von Hippel Subcommittee. The recipient will be invited to speak at the Awards Ceremony.

Turnbull Lectureship Honors Career of an Outstanding Researcher and Communicator

The David Turnbull Lectureship recognizes the career of a scientist who has made outstanding contributions to understanding materials phenomena and properties through research, writing, and lecturing, as exemplified by the life work of David Turnbull. While honoring the accomplishments of the recipient, the Turnbull Lectureship is intended to support and enrich the materials research community.

The recipient will give a technical lecture of broad appeal at a designated session of the 2003 MRS Fall Meeting. The Turnbull Lecturer will receive a $5,000 honorarium and a citation plaque, along with travel expenses paid to enable the recipient to address MRS Sections and University Chapters and/or participate in the production of a video version of the lecture.

MRS Medal Recognizes Recent Discovery or Advancement in Materials Science

The MRS Medal offers public and professional recognition of an exceptional recent achievement in materials research. A medal will be awarded for a specific outstanding recent discovery or advancement that is expected to have a major impact on the progress of any materials-related field.

The award consists of a $3,000 cash prize, an engraved and mounted medal, and a citation certificate. MRS

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MRS Workshop Explored Zinc Oxide Research

The 2nd International Workshop on Zinc Oxide, held as part of the 2002 MRS Workshop Series, was convened in Dayton, Ohio, on October 23–25, 2002. Organized by David C. Look (workshop chair) of Wright State University, Robert F. Davis of North Carolina State University, Cole W. Litton of Wright-Patterson Air Force Base, Yicheng Lu of Rutgers University, Bruno Meyer of University of Giessen (Germany), Chris G. Van de Walle of the Xerox Palo Alto Research Center, and Takafumi Yao of Tohoku University (Japan), the workshop had 52 talks and 42 posters presented from 19 countries. More than 150 scientists from academia, industry, and government laboratories attended the workshop.

Chair and Co-organizers of the MRS Workshop on Zinc Oxide (front row, left to right): ***Yicheng Lu*** *(Rutgers),* ***Chris Van de Walle*** *(Xerox Palo Alto Research Center),* ***Takafumi Yao*** *(Tohoku University); (back row, left to right):* ***Bruno Meyer*** *(University of Giessen),* ***Cole Litton*** *(Wright-Patterson Air Force Base), and Workshop Chair* ***David Look*** *(Wright State University). Not shown is co-organizer* ***Robert Davis*** *(North Carolina State University).*

There has been great progress in ZnO research since the first International Workshop on Zinc Oxide was held in Dayton in 1999. As one of the most rapidly developing areas in materials, research in ZnO has quickly expanded from photonics and electronics into several emerging areas such as nanostructures and spintronics. The goal of the workshop was to enhance ZnO research by exchanging up-to-date information and assessing the current status and future potential of ZnO. The workshop consisted of sessions on growth, characterization, processing, and device applications.

The session on crystal-growth covered bulk and epitaxial film growth of ZnO and its alloys. GaN, the primary wide-bandgap semiconductor, lacks a lattice-matched substrate for heteroepitaxial growth, and availability of large GaN substrates for homoepitaxial growth. In contrast, ZnO bulk growth technology has been developed by Eagle-Picher Technologies, Cermet, and other companies, to provide commercially available native ZnO substrates. In this workshop, J. Nause (Cermet, Inc.) reported high-quality ZnO bulk crystals grown by a pressurized melt process, which has the advantages of high growth rate and scalability (Figure 1). E.V. Kortounova (Russian Research Institute for the Synthesis of Materials) also reported a ZnO crystal of 45 mm × 45 mm × 20 mm grown by the hydrothermal technique. The resistivity of a 2-in.-diameter ZnO wafer can be controlled from 10 Ω cm to 10^{12} Ω cm. A large size and low cost semi-insulating ZnO substrate technology will be beneficial to high-quality epitaxial growth and device manufacturing.

Growth of hetero- and homoepitaxial ZnO and its $(Mg,Cd)_xZn_{1-x}O$ alloy films were reported by various groups using plasma-assisted molecular-beam epitaxy, metalorganic vapor-phase epitaxy, pulsed laser deposition, and rf-magnetron sputtering. For ZnO to become a primary wide-bandgap photonic and electronic material, a controllable bipolar doping technology has to be developed. The workshop presentations indicated that while *n*-type doping has been well developed with a wide range of doping concentrations up to the transparent conductive oxide level, *p*-type doping remains a focus of active research. D.B. Eason (Eagle-Picher Technologies) reported a nitrogen-doped *p*-type ZnO layer grown by molecular-beam epitaxy (MBE) on a semi-insulating ZnO substrate (presented by C.W. Litton), with a hole concentration of 9×10^{16} cm^{-3} and a hole mobility of 2 cm^2/Vs. B.B. Claflin (Wright-Patterson Air Force Base) presented details about the electrical and optical properties of these homoepitaxial MBE *p*-type ZnO films. The dominant low-temperature photoluminescence peak occurs at 3.318 eV, and shows an excitonlike nature. Significant progress in *p*-type doping has been made in the last two years; however, much work still needs to be done to achieve controllable, reliable, and device-quality *p*-type doping, including the development of growth and measurement techniques, as well as theoretical studies.

A. Hoffmann (Technical University of Berlin) discussed the advantages of using nitrogen, which forms as a shallow acceptor in ZnO. Binding energies of approximately 16 meV for the exciton and 165 meV for the nitrogen acceptor were reported. However, secondary-ion mass spectrometry showed a correlation between the concentration of incorporated nitrogen and unintentional hydrogen, an indication of the origin of compensated acceptor states. C.G. Van de Walle provided a theorist's insight on the role of hydrogen in ZnO. Until recently, hydrogen's character as a shallow donor in ZnO was not appreciated. Based on first-principles calculations, Van de Walle described the various configurations that hydrogen can assume in ZnO. Hydrogen strongly interacts with native defects. It activates oxygen vacancies, but it passivates acceptor defects (Figure 2). The calculations show that zinc vacancies may give rise to green luminescence, and that hydrogenation suppresses this luminescence, consistent with experi-

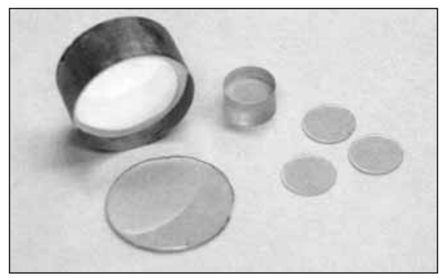

Figure 1. Melt-grown ZnO ingots and wafers. Courtesy Cermet, Inc.

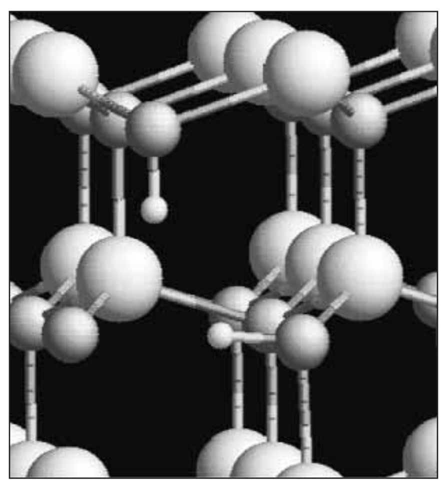

Figure 2. Atomic structure of a hydrogenated zinc vacancy in ZnO, based on first-principles calculations. Zinc atoms are the largest, oxygen atoms are medium-sized, and hydrogen atoms are the smallest. Image courtesy Xerox Palo Alto Research Center.

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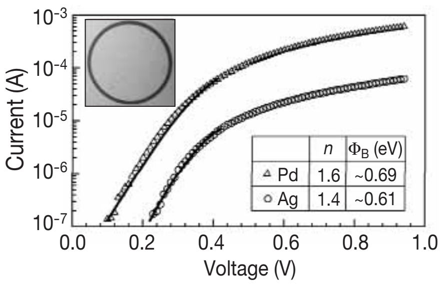

Figure 3. Current–voltage characteristics of Pd and Ag Schottky contacts on ZnO thin film deposited by pulsed laser deposition on r*-plane (01$\bar{1}$2) sapphire substrate prepared at Leipzig University, Germany. The inset chart shows the ideality factors* n *and barrier heights Φ_B of the two contact metals and the geometry of the contacts in face-to-face configuration. An ideality factor of 1 indicates ideal diode behavior, with larger factors indicating deviations from ideality. The Schottky diode is shown in the inset.*

mental observations. First-principles calculations are a powerful tool for understanding the structural and electronic properties of ZnO. For instance, they have also shown that hydrogen acts as an electrically active donor in ZnO, in contrast to hydrogen's behavior in other semiconductors.

There has been significant progress in the development of key ZnO processing technologies, including metallization and etching. The development of Schottky contacts is critical for Schottky diodes and field-effect transistors. Since the first reported Schottky diode on (11$\bar{2}$0) ZnO,* Schottky contacts have been successfully developed on *c*-plane ZnO. In this workshop, B.J. Coppa (North Carolina State University) reported Au Schottky contacts on *n*-type ZnO. Au was deposited *in situ* on remote oxygen plasma treated (0001) Zn-ZnO surfaces, resulting in a Schottky barrier height of 0.71 ± 0.05 eV and an ideality factor of 1.17 ± 0.05. The leakage current was ~24 nA at −8.5 V with hard breakdown at −8.75 V. M. Lorenz (University of Leipzig) reported Schottky contacts to *c*- and *a*-plane ZnO using Pd and Ag as the contact metal (Figure 3). These Schottky contacts were used successfully for deep-level transient spectroscopy measurements to study defect states in ZnO. For ohmic contacts, including both nonalloyed and alloyed contacts, low, specific contact resistances of ~10^{-5} Ω cm^2 were reported by several groups. Although the achieved ohmic contact techniques satisfy metal-semiconductor-metal type device requirements, the exact contact mechanisms still need to be fully understood in order to further develop reliable ohmic contacts with lower contact resistances. One of the advantages of ZnO over GaN is that it can be easily etched using wet chemical solutions. In the workshop, K. Ip (University of Florida) presented a dry-etching technique using an inductively coupled plasma (Figure 4). Noncorrosive gases were used to achieve a fast etching rate, with no measurable change in near-surface stoichiometry of bulk ZnO. Further work in the area will aim to develop fully controllable ZnO etching technology, including isotropic and anisotropic etching, etch rate, and selectivity.

ZnO shows great potential for broad device applications, as it is a multifunctional material. The workshop presentations covered recent results in UV photonics, transparent electronics, high-frequency piezoelectric devices, nanoelectronics, and spintronics. M. Kawasaki (Tohoku University) reported ZnO-based thin-film transistors (TFTs). The research goal for this device was to beat the mobility of amorphous silicon TFTs (0.5 cm^2/Vs) using a comparable processing temperature (300°C), and to achieve comparable mobility using a maximum processing temperature of 150°C so that polymer substrates could be used. The transparent devices and circuits show promise for replacing amorphous silicon TFTs in liquid-crystal displays (Figure 5). R.D. Vispute (University of Maryland) reported the use of $Mg_xZn_{1-x}O$ to realize visible-blind (transparent to visible light) ultraviolet photoconductive detectors. The detectors exhibited a high responsitivity of 1200 A/W at a wavelength of 308 nm with 5 V bias, which was comparable with that of its GaN counterpart. Furthermore, Vispute described the fabrication of monolithic multichannel UV detector arrays, and mapping of continuous phase evolution in epitaxial $Mg_xZn_{1-x}O$ composition spreads. The composition across the chip linearly varied from ZnO to MgO. The resulting continuously changing bandgap was used as a basis for an array of UV photodetectors with a range of detection wavelengths separately activated at different regions on the spread film (Figure 6).

The growing interest in ZnO doped with magnetic impurities for room-temperature spintronics was reflected in the workshop

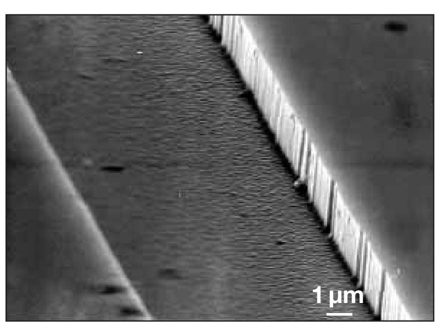

Figure 4. Scanning electron micrograph of inductively coupled plasma-etched ZnO. The features were patterned with photoresist that was removed prior to taking the micrograph. Image courtesy University of Florida.

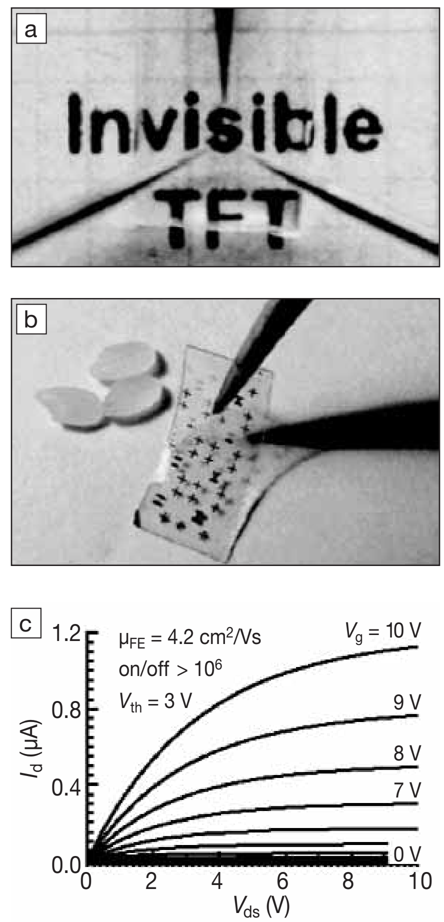

Figure 5. (a–b) "Invisible" ZnO transistors: (a) a thin-film transistor (TFT) with transparent electrodes (source, drain, and gate) grown on a glass substrate and under inspection by probe needles; (b) TFTs with Al electrodes grown on a flexible polymer substrate. (c) Typical device characteristics, where V_g is the gate voltage, V_{ds} is the drain-source voltage, V_{th} is the threshold voltage, and μ_{FE} is electron mobility. The device characteristics are measured for a V_g varied from 0 V to 10 V with 1 V increments. Image courtesy Tohoku University.

*H. Sheng, S. Muthukumar, N.W. Emanetoglu, and Y. Lu, *Appl. Phys. Lett.* **80** (12) (2002) p. 2132.

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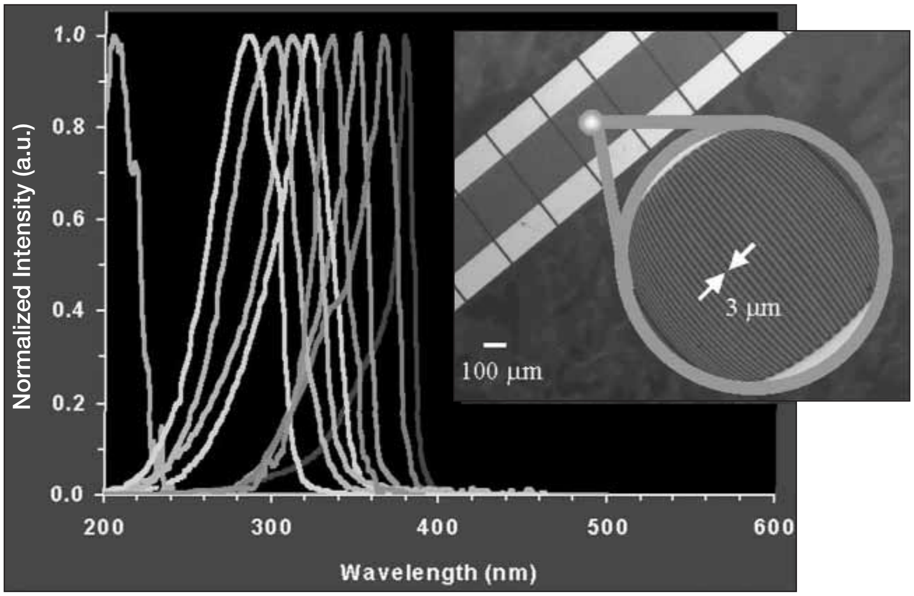

Figure 6. Visible-blind (transparent to visible light) UV detectors fabricated using compositionally tuned MgZnO thin-film alloys grown on a sapphire substrate. The graph shows the optical response in different regions of the linearly graded UV detector array, demonstrating the ability to tune the optical response. The inset image shows the linearly graded UV detector array. Courtesy of CSR, University of Maryland, and Blue Wave Semiconductors, Inc.

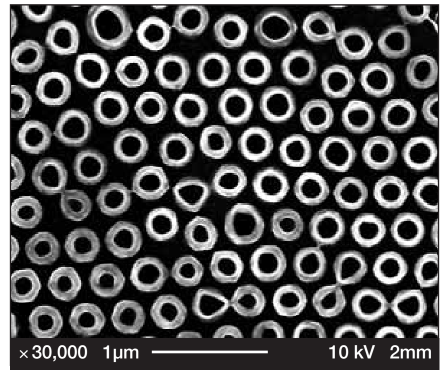

Figure 7. Scanning electron micrograph of ZnO "donuts" on a sapphire substrate generated using nanoporous polymer membranes (polymer template prepared by H. Xu, W. Goedel, M. Moeller). The diameter of these rings is ~300 nm and the wall thickness is ~100 nm. Image courtesy University of Ulm.

program. D.P. Norton (University of Florida) reported the magnetic properties of Mn-implanted *n*-type ZnO single crystals codoped with Sn. Ferromagnetism in ZnO, with a Curie temperature of ~250 K, was observed. This exciting research field needs exploratory work in both theory and experiments. According to an estimate from the National Science Foundation (NSF 02-036), the expected market is over $50 billion annually.

ZnO-based nanostructures have become another important emerging research field. K. Thonke (University of Ulm) described a self-organization process for making ZnO nanodots, nano-rings and nanopillars with self-assembling polymers (Figure 7). These nanostructures were produced with sizes of only a few nanometers, far beyond the limits of conventional photolithography processes. S. Fujita (Kyoto University) reported the synthesis of self-organized ZnO nanodots and nanorods by metal-organic chemical vapor deposition. The photoluminescence at 10 K showed a broad shoulder at the higher energy side of free-exciton emission, indicating the quantum size effect, a new and important result for ZnO nanoscale structures.

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