

layer. These results distinguish hydrogenated diamond from other semiconductors.

As reported in the October 16 issue of *Physical Review Letters*, the researchers used 10 different diamond samples, ranging from undoped chemical vapor deposition films, undoped homoepitaxial layers grown on single crystals, to various types of single crystals. The room-temperature (RT) conductance of these samples, in the highly conducting hydrogenated state, was found to be between  $10^{-6}$  and  $10^{-4} \Omega^{-1}$ .

In the first experiment, the homoepitaxial (100) diamond layer in a high conductance state was annealed in ultrahigh vacuum UHV at  $410 \pm 20^\circ\text{C}$  for 15 min. The chemisorbed hydrogen was not desorbed due to annealing, as verified by the negative electron affinity property of the surface, but the conductance of the sample had dropped to  $10^{-10} \Omega^{-1}$ . The researchers then masked half of the sample and removed the hydrogen from the unmasked surface by means of electron-beam-induced desorption. When this sample was brought back to air, the conductance of the masked part increased by four orders of magnitude within 20 min while the other part did not exhibit any change from its nonconducting state.

The researchers also performed an annealing experiment on a plasma hydrogenated IIa C(100) single crystal in air while simultaneously monitoring the hydrogen coverage by looking at CH and  $\text{CH}_2$  characteristic stretching modes using multiple internal reflection infrared spectroscopy (MIRIRS). After the sample had been annealed at  $190^\circ\text{C}$ , they found

that the hydrocarbon adsorbates  $\text{CH}_2$  characteristic modes disappeared, while the sample still exhibited RT conductance of about  $10^{-6} \Omega^{-1}$ . After annealing at  $230^\circ\text{C}$  the CH mode of the hydrogen termination also disappeared, and the RT conductance dropped to  $10^{-11} \Omega^{-1}$ .

Based on these findings, the researchers concluded that hydrogen termination is necessary for high surface conductivity in diamond, while hydrocarbon adsorbates play no role in it. An additional adsorbate from the atmosphere is needed to induce the surface hole accumulation layer, which is proposed to come from a thin water layer formed naturally on the diamond's surface on exposure to the atmosphere. A redox reaction— $2\text{H}_3\text{O}^+ + 2\text{e}^- \leftrightarrow \text{H}_2 + 2\text{H}_2\text{O}$ —transfers electrons from the diamond to the water layer until the chemical potential of the water layer is equal to the Fermi level ( $E_F$ ) at the interface. This results in the accumulation layer of holes in the diamond that is responsible for the surface conductance. In their article, the researchers provide a quantitative account of this model, which also explains why this surface conductivity is observed only in diamond, and not in other semiconductors.

WIRAWAN PURWANTO

### **BaZrO<sub>3</sub> and BaCeO<sub>3</sub> Solid Solutions May Allow the Applicability of Doped Perovskites in Low-Temperature Fuel Cell Applications**

In oxides doped with  $\text{M}^{3+}$  ions and exposed to water vapor,  $\text{H}^+$  becomes the mobile species in both grain boundaries and bulk. Although the protons are always associated with oxygen ions, they

can easily hop from one  $\text{O}^-$  ion to the next and therefore such materials exhibit high proton conductivities. The development of doped perovskites with high proton conductivities is one of the main research interests of Sossina Haile, assistant professor of materials science at California Institute of Technology. Proton conductive oxides have potential for applications as electrolytes in solid oxide fuel cells, sensors, ion pumps, batteries, and other electrochemical devices. "Fuel cells are an alternative cleaner energy source and this is an increasingly important issue in our society," Haile said in her visit to the University of Southern California in October, where she delivered a seminar on this topic.

Haile and her research group use A.C. impedance spectroscopy to measure the conductivity in samples with different grain sizes. They have concentrated their research in Yb-doped  $\text{BaZrO}_3$  and Gd-doped  $\text{BaCeO}_3$ . After studying polycrystalline and single crystal samples, they discovered that transport along grain boundaries was slower than in the bulk and more sensitive to the presence of water vapor. This was despite the observation that grain boundaries dissolved a greater concentration of water than the bulk. In samples with small grain sizes and at low temperatures, results showed that grain boundaries dominate impedance. The possibility that the presence of intergranular phases may be responsible for the low ionic conductivity observed at grain boundaries was disregarded after extensive observations in the transmission electron microscope. Both observations (low grain boundary conductivity and the absence of intergranular amorphous phases) are contrary to previous suggestions found in the literature that grain boundaries might be responsible for the high ionic conductivity in these materials.

One of the disadvantages in the use of  $\text{BaCeO}_3$  in the conditions of a fuel cell environment is that exposure to  $\text{CO}_2$  results in the formation of  $\text{BaCO}_3$ . To reduce the reactivity of  $\text{BaCeO}_3$ , this group of researchers introduced small additions of  $\text{BaZrO}_3$ . The reaction disappears after additions of 20–40% Zr, but at the same time introduction of Zr resulted in a slight decrease in the ionic conductivity. The effectiveness of Zr additions could be enhanced by using chemical synthesis routes rather than conventional solid state reaction. Chemical synthesis was performed by a modified Pechini process, (similar to the sol-gel technique) and increased chemical homogeneity appeared to be responsible for increased resistance to reaction with  $\text{CO}_2$ . This fabrication method

### **Review Articles**

The October issue of *Reviews of Modern Physics* contains the following review articles: D.Y. Alhassid, "The Statistical Theory of Quantum Pairing"; C.C. Tsuei and J.R. Kirtley, "Symmetry in Cuprate Superconductors"; B. van Tiggelen and H. Stark, "Nematic Liquid Crystals as a New Challenge for Radiative Transfer"; T.L. Beck, "Real-Space Mesh Techniques in Density-Functional Theory"; P.H. Roberts and G.A. Glatzmaier, "Geodynamo Theory and Simulations"; and R.L. Jaffe, W. Busza, J. Sandweiss, and F. Wilczek, "Review of Speculative 'Disaster Scenarios' at RHIC."

The November 2000 issue of *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* features two review articles: L. Martinu and D. Poitras, "Plasma Deposition of Optical Films and Coatings: A Review" and T.J. Coutts, D.L. Young, X. Li, W.P. Mulligan, and X. Wu, "Search for Improved Transparent Conducting Oxides: A Fundamental Investigation of  $\text{CdO}$ ,  $\text{Cd}_2\text{SnO}_4$ , and  $\text{Zn}_2\text{SnO}_4$ ."

The November issue of *Reviews of Scientific Instruments* contains a review article on "Photodetachment Diagnostic Techniques for Measuring Negative Ion Densities and Temperatures in Plasmas," by M. Bacal.

The November issue of *Semiconductors* contains a review article on "Silicon-Germanium Nanostructures with Quantum Dots: Formation Mechanisms and Electrical Properties," by O.P. Pchelyakov, Yu.B. Bolkhovityanov, A.V. Dvurechenski, L.V. Sokolov, A.I. Nikiforov, A.I. Yakimov, and B. Voigtländer.

produces materials with high specific surface area, which must be accounted for when comparing reactivities of materials prepared by different routes. Overall, compositions such as  $\text{BaCe}_{0.7}\text{Zr}_{0.2}\text{Nd}_{0.1}\text{O}_3$  provided a good compromise between high stability and high conductivity.

These combinations also show a potential improvement in fuel cell performance, since they allow lower operation temperatures than  $\text{ZrO}_2$  electrolytes. Doped perovskites oxides obtained with different chemical characteristics will make it possible to obtain a range of materials with competitive conditions to be used in fuel cell applications.

SIARI S. SOSA

### Infrared Absorption Measurements Confirm the Existence of an Isolated Hydrogen Defect in a Proton-Implanted Germanium

An international research team from the Institute of Physics and Astronomy of Aarhus University in Denmark and the Department of Physics and Astronomy of Vanderbilt University in Nashville, Tennessee has identified the origin of two isolated hydrogen defects in high-resistivity, ultrapure Ge single crystals implanted with protons at cryogenic temperatures. As reported in the October 2 issue of *Physical Review Letters*, the samples were implanted with protons and/or deuterons at multiple energies, yielding uniform concentration profiles, with widths between 20 and 200  $\mu\text{m}$ . The samples were cooled to either 20 or 80 K during

implantation. During the transportation from the implantation site to the infrared spectrometer, the samples were kept continuously cooled to within 10 K of the implantation temperatures, and the *in situ* infrared absorption (IRAS) measurements were performed at  $\sim 10$  K with a spectral resolution better than 0.8  $\text{cm}^{-1}$ .

From the IRAS measurements, two distinctive lines were obtained: 745  $\text{cm}^{-1}$  and 1794  $\text{cm}^{-1}$ . While the properties of the 1794  $\text{cm}^{-1}$  mode are similar to the stretch mode of bond center H in Si, the 745  $\text{cm}^{-1}$  has no Si analogue. Two different approaches have shown that the two lines originate from different defects. From isochronal annealing, the line at 745  $\text{cm}^{-1}$  starts to decrease at 100 K while the 1794  $\text{cm}^{-1}$  line anneals at 210 K. Varying the H concentration has shown that the intensity of the 1794  $\text{cm}^{-1}$  line is proportional with the concentration of hydrogen over the whole range covered, while the intensity of the 745  $\text{cm}^{-1}$  line maintains the proportionality just below  $2 \times 10^{18} \text{ cm}^{-3}$ , at which it saturates.

From stress measurements and symmetry considerations, the line at 1794  $\text{cm}^{-1}$  is attributed to  $\text{H}_{bc}^{(+)}$  in Ge. For the line observed at 745  $\text{cm}^{-1}$ , the measurement seems to support the idea of an isolated H located on a  $\langle 111 \rangle$  axis of the Ge lattice, and vibrating perpendicular on this axis, corresponding to an isolated  $\text{H}^{(v)}$  near the tetrahedral site. Although predicted by theory more than a decade ago, this work provides direct observation of this isolated hydrogen species in a semiconductor.

CLAUDIU MUNTELE

### Hänsch Receives ICALEO® 2000 Schawlow Award

Theodor W. Hänsch, director of Max-Planck-Institute for Quantum Optics and professor of physics at the University of Munich, Germany, has been named the Arthur L. Schawlow Award recipient by the Laser Institute of America in recognition of his pioneering research in high resolution laser spectroscopy. He is recognized worldwide as the initiator of research testing basic physics laws with techniques of precise laser spectroscopy and the cooling and manipulation of atomic matter with laser light. Hänsch was the Honored Speaker at the Awards luncheon of the 19th International Congress on Applications of Lasers & Electro-Optics (ICALEO®) held October 2–5 in Dearborn, Michigan.

### Chain T. Liu Receives 2001 Acta Metallurgica Gold Medal

The 2001 Acta Metallurgica Gold Medal has been awarded to Chain T. Liu, Senior Corporate Fellow at Oak Ridge National Laboratory. Liu is world renowned for his leadership and outstanding achievements in research on ordered intermetallics based on aluminides and silicides. He has played a key role in advancing the science and developing the technology of intermetallic alloys for use as new structural materials. Liu will be presented with the medal on February 13, 2001 in New Orleans during the 130th TMS Annual Meeting. □

## MRS Future Meetings



506 Keystone Drive, Warrendale PA 15086-7573 USA  
Tel: 724-779-3003 • Fax: 724-779-8313 • info@mrs.org

### 2001 Fall Meeting

November 26-30  
Exhibit: November 27-29  
Boston, Massachusetts

#### Meeting Chairs:

**Bruce M. Clemens**  
Stanford University  
Tel 650-725-7455  
Fax 650-725-4034  
clemens@soe.  
stanford.edu

**Julia A. Kornfield**  
California Institute of  
Technology  
Tel 626-395-4138  
Fax 626-568-8743  
jak@cheme.caltech.edu

**Jerrold A. Floro**  
Sandia National  
Laboratories  
Tel 505-844-4708  
Fax 505-844-1197  
jfloro@sandia.gov

**Yuri Suzuki**  
Cornell University  
Tel 607-255-6429  
Fax 607-255-2365  
suzuki@ccmr.cornell.edu

### 2002 Spring Meeting

April 1-5  
Exhibit: April 2-4  
San Francisco, California

#### Meeting Chairs:

**Zhenan Bao**  
Bell Labs  
Lucent Technologies  
Tel 908-582-4716  
Fax 908-582-4868  
zbao@lucent.com

**Eugene A. Fitzgerald**  
Massachusetts Institute  
of Technology  
Tel 617-258-7461  
Fax 617-253-3046  
eafitz@mit.edu

**Ulrich M. Goesele**  
Max-Planck-Institute of  
Microstructure Physics  
Germany  
Tel 49-345-5582-657  
Fax 49-345-5582-557  
goesele@mpi-halle.de

**Kenneth P. Rodbell**  
IBM T.J. Watson  
Research Center  
Tel 914-945-1012  
Fax 914-945-2015  
rodbell@us.ibm.com

### 2002 Fall Meeting

December 2-6  
Exhibit: December 3-5  
Boston, Massachusetts

#### Meeting Chairs:

**Marie-Isabelle Baraton**  
University of Limoges  
Tel 33-555-457348  
Fax 33-555-778100  
baraton@unilim.fr

**Eric L. Garfunkel**  
Rutgers University  
Tel 732-445-2747  
Fax 732-445-5312  
garf@rutchem.  
rutgers.edu

**David C. Martin**  
University of Michigan  
Tel 734-936-3161  
Fax 734-763-4788  
milty@umich.edu

**Stuart S. P. Parkin**  
IBM Almaden  
Research Center  
Tel 408-927-2390  
Fax 408-927-2395  
parkin@almaden.  
ibm.com