demonstrate the potential of H-TPIP to control the resulting morphology (both domain size and domain distribution) in phase-separated diffractive structures. Because of the nonlinear and local nature of the process, the formation of phase separated-diffractive structures internal to a surrounding medium is also potentially possible. Thus, one might envision writing complex optical structures (such as lenses) in the interior of a surrounding solid material using this holographic technique.

GREG KHITROV

Fullerenes Control Grain Size and Orientation in Nanomagnetic Thin Films

Most investigations into fullerene (C_{60}) applications have involved doping either the interior or exterior of the fullerene cage with other atoms to achieve unique properties. Now researchers at Rice University and the National Institute of Standards and Technology (NIST) have succeeded in synthesizing nanomagnetic thin films of Co, Fe, and CoFe by co-deposition with C_{60} to control the grain size, grain orientation, and magnetic properties of the resulting films. Magnetization curves show high out-of-plane remanence, high coercivity, and fast magnetic switching properties.

As reported in the November 13 issue of *Applied Physics Letters*, samples were prepared by simultaneously subliming high purity C_{60} powder at 500–650°C and evaporating Co and Fe from pure metal rods in an ultrahigh vacuum. Thin films of Co, Fe, Co-C_{60}, Fe-C_{60}, and CoFe-C_{60} of 100 nm thickness were deposited on amorphous-silicon-nitride-coated Si substrates, then analyzed using wavelength dispersive spectrometry (WDS), mass spectrometry, Raman spectrometry, transmission electron microscopy (TEM), and vibrating sample magnetometer (VSM).

Using WDS, the atomic compositions of two promising films were shown to be $Co_{162}C_{60}$ and $Fe_{73}C_{60}$. Mass spectrometry revealed high concentrations of C_{60} in these samples, with very little decomposition product, demonstrating the stability of C_{60} in the metallic matrix. TEM images of the $Co_{162}C_{60}$ sample showed highly columnar Co grains of 11 nm diameter, much finer than the 22 nm grains obtained in the pure Co film. A carbon-containing phase identified as C_{60} filled the grain boundaries. Similarly, the $Fe_{73}C_{60}$ film had a finer diameter (5 nm) than the pure Fe film (15 nm). The grains in the $Fe_{73}C_{60}$ film were approximately 50 nm long, and were oriented perpendicularly to the substrate. In contrast, the grains in the pure Fe film were randomly oriented.

The investigators attribute the controlled microstructure to a self-assembly grain growth model involving migration of C_{60} to the edges of metallic nuclei, formation of an interconnected C_{60} structure that confines the metal atoms and a subsequent build-up of layers of metal atoms surrounded by C_{60} after the thickness of the previous layer is exceeded.

Possible applications of this research include magnetic memory devices, magnetic switches, spin valves, and magnetic springs.

TIM PALUCKA

Surface Conductivity in Hydrogenated Diamond Requires Exposure to Air

In their study of the origin of surface conductivity in hydrogenated diamond, researchers at the Institut für Technische Physik, Universität Erlangen, Germany, have asserted that chemisorbed hydrogen is a necessary but not sufficient condition to create a hole accumulation layer that causes surface conductivity. Their experiments demonstrate that an additional adsorbate from the atmosphere is needed to induce the surface hole accumulation 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} Ω^{-1}.

In the first experiment, the homoepitaxial (100) diamond layer in a high conductance state was annealed in ultrahigh vacuum UHV at 410 ± 20°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} Ω^{-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 CH_2 characteristic stretching modes using multiple internal reflection infrared spectroscopy (MIRIRS). After the sample had been annealed at 190°C, they found that the hydrocarbon adsorbates CH_2 characteristic modes disappeared, while the sample still exhibited RT conductance of about 10^{-6} Ω^{-1}. After annealing at 230°C the CH mode of the hydrogen termination also disappeared, and the RT conductance dropped to 10^{-11} Ω^{-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—$2H_3O^+ + 2e^- \leftrightarrow H_2 + 2H_2O$—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

$BaZrO_3$ and $BaCeO_3$ Solid Solutions May Allow the Applicability of Doped Perovskites in Low-Temperature Fuel Cell Applications

In oxides doped with M^{3+} ions and exposed to water vapor, 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 $O^=$ 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 $BaZrO_3$ and Gd-doped $BaCeO_3$. 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 $BaCeO_3$ in the conditions of a fuel cell environment is that exposure to CO_2 results in the formation of $BaCO_3$. To reduce the reactivity of $BaCeO_3$, this group of researchers introduced small additions of $BaZrO_3$. 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 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 CdO, Cd_2SnO_4, and Zn_2SnO_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.