vacuum (~10^{-6} Torr) with a high power electric field. This caused electrothermal self-heating of the GNR to hundreds of degrees which removed *p*-doping sources. The researchers, then, functionalized GNRs by introducing electron-rich nitrogen species by e-annealing the GNR devices in a ~1-Torr NH_3/Ar environment. The GNR devices functionalized in this way showed Dirac point positions shifted by ~-20 V before and after e-annealing in NH_3, that stayed stable and constant in vacuum, signifying *n*-type electronic doping without degradation of their carrier mobility. The researchers demonstrated by x-ray photoelectron spectroscopy and nanometer-scale secondary ion mass spectroscopy that the thermal annealing with NH_3 generated carbon-nitrogen species mostly at the edges of the graphene where chemical reactivity is high. Theoretical calculations performed by the researchers showed that GNRs functionalized by oxygen and nitrogen species on their edges were *p*- and *n*-doped, respectively, which agreed with the experimental results the researchers obtained.

Using the e-annealing approach in NH_3, the researchers fabricated *n*-type sub-10 nm GNRFETs with Ti contact metals and a 5 nm Pd buffer layer that operated at room temperature with a subthreshold slope similar to that of the as-made *p*-type GNRFETs. The researchers said that the ability to control graphene chemistry through edge doping at the nanoscale is an important step toward controlled graphene electronics.

JOAN J. CARVAJAL

Light-Assisted Writing of Bits Achieved on Low-Doped (Ga,Mn)As Ferromagnetic Semiconductors

Energy-assisted switching mechanisms for magnetic bits will be needed in future magnetic recording technology. These mechanisms use a second source of energy to reduce the material's coercivity, the applied magnetic field needed to reverse the orientation of the magnetization of a ferromagnet. Mechanisms under consideration include heating a magnetic material with a laser or stimulating it with a transverse microwave field. Ideally, such a method should be local and reversible: It should reduce the coercivity of a bit only where it is applied and only for so long as it is applied, after which it should recover fully. G.V. Astakhov and coworkers of the University of Würzburg, Germany and V.L. Korenev of the Russian Academy of Sciences have recently found just such a mechanism in low-doped (Ga,Mn)As thin films at low temperatures using the photocoercivity effect. By removing the need for heating, this could provide a low power alternative to other energy-assisted recording technologies.

The researchers demonstrated light-assisted writing in the May 8 issue of *Physical Review Letters* (DOI: 10.1103/PhysRevLett.102.187401; #187401). They used low-temperature molecular beam epitaxy to deposit a 360 nm layer of $(Ga_{1-x}Mn_x)As$ ferromagnetic semiconductors, with $x \approx 0.005$. These samples were measured at 2 K with the magneto-optical Kerr effect at two different laser powers, the "dark" condition at 10 μW and the "light" condition at 1 mW. Finding the coercivity to be 525 Oe and 285 Oe, respectively, the researchers returned to 10 μW and found the coercivity recovered to its original value—showing that the effect is reversible. They then wrote patterns on the substrate in an intermediate field of 470 Oe, evidencing both the locality of the transition and its potential to write bits.

The mechanism the researchers propose for this behavior is the mobility of holes. The magnetic behavior of the (Ga,Mn)As is mediated by the holes, and in low-doped samples, the mobility is low. This means that the holes are not free to relocate to their most favored state when a field is applied, and therefore some extra field is required to move domain walls. In comparison, the photocoercivity effect was not seen in more highly doped samples with $x \approx 0.05$, in which holes move readily. This mechanism provides a clue for materials engineers on how to extend this effect to low-power light-assisted magnetic recording in consumer products.

JIM RANTSCHLER

LaSrCoFeO Offers Alternate Cathode Material to Pt for Micro-Fuel Cells

With the proliferation of portable electronic devices, there is a critical need for reliable power sources for these devices. One solution to meet this increasing demand is the use of fuel cells. In particular, solid oxide fuel cells (SOFCs) are relatively very efficient and are flexible in the type of fuel they can use. However, SOFCs typically operate above 700°C. It would be advantageous for them to operate at lower temperatures in the 200–600°C range, allowing for greater material flexibility and efficient operation as well as reduced corrosion than for current systems. SOFCs typically use yttria-stabilized zirconia (YSZ) electrolyte. Researchers have demonstrated Pt cathodes for operation of YSZ-based SOFCs at intermediate temperatures. However, the Pt may degrade at the higher temperatures in this range, and materials such as $La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (LCSF) have been proposed and tested as alternatives to Pt for intermediate temperature SOFC cathodes. In a recently reported study, A.C. Johnson, B.-K. Lai, H. Xiong, and S. Ramanathan of Harvard University describe the fabrication of micro-SOFCs using dense ultrathin-film LSCF cathodes, formed using RF-sputtering, and YSZ electrolyte films. The results of their study were published in the January issue of the *Journal of Power Sources* (DOI: 10.1016/j.jpowsour.2008.10.021; p. 252).

The thin-film SOFCs were fabricated with both Pt and mixed conducting oxide cathodes using sputtering, lithography, and etching. Each device is comprised of 75–150-nm thick YSZ electrolyte, a 40–80-nm porous Pt anode, and a cathode made of 15–150-nm dense LSCF or 130-nm porous Pt. Several devices were fabricated to systematically investigate the electrical properties of the individual components of these fuel cells. For fuel cell measurements, five fuel cells were developed including three LSCF/YSZ/Pt cells (LCSF cathode) and two Pt/YSZ/Pt cells (Pt cathode). While the Pt-cathode cells produced the greatest power at most temperatures, the LCSF-cathode cells were not far behind. For instance, at 500°C, power densities of 90 mW cm^{-2} and 60 mW cm^{-2} were observed for the Pt and LSCF cathodes, respectively. The latter is comparable to previous reports using ultrathin-film oxides.

The major advantage of the present approach is that the thin-film cathode processing is compatible with current photolithography and patterning. It is relatively simple to synthesize a multicomponent, highly dense complex oxide thin film from a single target. The results suggest that the

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