Rare-earth Information Center Insight

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Two-Step Two -Color Recording

Sometime in the future, holographic information storage techniques will allow the optical storage of large amounts of information. For this storage to be practical, a method of non-destructive reading is required. (Long ago, we had magnetic memories that had to be rewritten once they were read, but this is no longer acceptable.) The ability to erase the data and start over is also desirable. The process that is used in recording involves using a photon or photons to excite an electron from the photorefractive donor center into the conduction band where it wanders off and is trapped elsewhere in the crystal. The easiest way to read out the data is to scan the material with the same laser and measure the optical absorption that will be lower for the depleted region than it is for the balance of the crystal. The problem with this is that after you are done, everything is fairly uniformly depleted. T. Nikolajsen et al. {*Appl. Phys. Lett.*, 74, [26], 4037-9 (1999)} has recently demonstrated a two-step two-color holographic recording process in a photorefractive praseodymium-doped $La_3Ga_5SiO_{14}$ crystal. The two-step process involves exciting an electron into a local bound state with one photon and then before that state has chance to decay, exciting the electron from there to the conduction band with a second photon. If the energy difference between the ground state and the excited state is different than that between the excited state and the conduction band, the same energy photon can not excite both transitions. Thus, in order to write a spot to lasers of different wave lengths, hence, two colors are required. This is achieved in the case of a hologram by having two writing beams of the same wavelength, which create the interference pattern and a second laser providing a gating signal. Now, once the pattern is written, it may be interrogated using the writing laser. During reading, electrons in the undepleted regions are excited to the local bound state, but they then decay back to their original state rather than going into the conduction band to be trapped elsewhere.

Charge Storage Structures

By now, we are all fairly familiar with the concept of atomic force microscopy (AFM) where the resonant frequency of a tiny cantilever is altered by the proximity of the tip to a surface. If a magnetic film is deposited on the tip, magnetic domains can be imaged as the interaction of the fringe fields of the domains with the film effects the motion of the tip. It is also possible to measure the charge distribution on an insulating surface with an AFM. This is called electrostatic force microscopy. Recently, J. T. Jones et al. {*Appl. Phys. Lett.*, **75**, [9], 1326-8 (1999)} have demonstrated that localized dots of both positive and negative charge can be written in CeO_2/Si/CeO_2/Si(111) multilayers. Not only do the dots have long lifetimes, but also they can be rewritten or replaced with dots of opposite polarity. A double barrier structure was grown with 35 Å CeO_2 barriers and an intermediate 25 Å Si film. The layers were polycrystalline. A commercial AFM with commercial cobalt coated tapping mode AFM tip was used. In order to write a dot, the tip was brought to within 5 nm of the sample surface, and a positive or negative voltage of ten volts was applied for 45 s. In writing, the tip was constrained to a 1 nm^2 area. When the dots are read out, the image is considerably larger with a 115 nm full width a half maximum. The tip bias

for reading is 1 V, and the tip to sample distance is 30 nm. Analysis of the stored charge showed that 20 – 200 electrons were stored in each dot. The dots were stable for more than a day.

Solid State Hydride Optical Switch

In a previous *Insight*, I reported the work of Huiberts et al. on rare earth thin films, which switched from transparent to reflecting when loaded with hydrogen. The films were capped by a thin Pd layer that served both to protect them from oxidation and to catalyze the H_2 absorption. Subsequent work also reported here showed that by making Gd-Mg films the transparent state could be made color neutral. The use of a liquid electrolyte in an electrochemical cell has also been demonstrated as a means of making the transition. Now, R. Armitage et al. {*Appl. Phys. Lett.*, **75**, [13], 1863-5 (1999)} have reported the next step, a completely solid-state device. The concept is fairly simple, a multilayer structure is created in which H may be moved from one layer to another by the application of a voltage across the layers. Starting with a glass substrate, an indium-tin-oxide (ITO) electrode film is deposited. The Gd-Mg film is deposited on top of that and is, as before, capped with Pd. A hydrated Zr-O solid electrolyte layer is then added. The hydrogen storage layer is WO_3 that is then capped by another ITO electrode. When the base electrode is at –3.0V relative to theWO_3, all layers, except the Pd, are fully transparent while at + 3.0V the device view through the glass substrate is reflecting. There is a ways to go before the device is ready for use in high-speed communications. The switching of the prototype took 16 h. The currents used exceed 40 mA. This indicates that much of the current is being carried by shorting paths through the electrolyte. The authors expect that a device with much lower leakage currents would switch in times comparable to those of the liquid electrolyte cells, which is of the order of 5 s, still a long way from high-speed communication. In fact, the diffusion lengths required limit the speed to this time frame.

$Sm_2(Fe_{0.9}Co_{0.1})17N_x$ Bonded Magnets.

$Sm_2Fe_{17}N_{-3}$ has a high saturation magnetization, a high magnetocrystalline anisotropy, a high Curie temperature, and, hence, is a strong candidate for high performance bonded magnets. The fact that it decomposes above 873 K makes a poor candidate for monolithic magnets since the N can not be diffused into a large body below this temperature, and the nitrided material can not be sintered. In order to limit nucleation of reverse domains, the particle size must be 1-3 μm. Since this is a highly reactive material, this introduces a number of problems. It has been shown that the powders can be stabilized by surface coating with Zn. This is achieved by photodecomposition of di-ethylzinc [$Zn(C_2H_5)_2$] with UV light. While these powders had excellent properties, they did not perform well in compression bonded magnets. K. Noguchi et al. {*Appl. Phys. Lett.*, **75**, [11], 1601-3 (1999)} have now optimized the processing conditions, including using a ball milling process incorporating a shaking motion to produce a much tighter distribution of particle sizes. The authors claim to have achieved record energy products for their magnets, which exhibit superior oxidation resistance.

Company Notes:

Santoku Metal Industry, a Japanese producer of rare earth metals and alloys, including strip cast Nd-Fe-B alloys, has opened a U.S. branch, Santoku America in Chicago. The office will handle sales and engineering support for Santoku products. Tel: 847 437-5520, FAX 847 437-5521. Crumax Magnetics, Inc., a U.S. manufacturer of rare earth permanent magnets, has been purchased from YBM Magnex International, Inc. by Morgan Crucible Company, plc., a U.K. based publicly quoted company. For more information, contact crusales@crumaxmagnetics.com.

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