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Insight

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Ferromagnetism in the Hexaborides

As reported in the May 99 *Insight*, $Ca_{1-x}La_xB_6$ has no partially filled d- or f- bands, and yet for a narrow range of doping ($0 \leq x \leq 0.01$), there is a moment of $\leq 0.07\ \mu_B$/La, and the material is ferromagnetic with a Curie temperature of ~600 K. A more detailed theoretical explanation has now been proposed by M. E. Zhitomirsky et al. {*Nature*, **402**, 251-3 (1999)}. They show that a ferromagnet with a small magnetic moment, but with a high Curie temperature, may result when an excitionic insulator is doped. An excitionic insulator contains a condensate of a spin-triplet state of electron hole pairs. CaB_6 is a poor conductor that is reported to have a small overlap of the conduction and valence bands at certain points in the Brillion zone. In such a system, electrons and holes created from the overlap act like a gas of oppositely charged particles that form bound pairs. In the undoped system, the spins balance however when extra electrons are doped in, is distributed asymmetrically between the two spin projections. While the original state has spins paired antiferomagnetically, the extra spins pair ferromagnetically, resulting in a net moment.

Transparent Conducting CeO_2-SiO_2 Thin Films

Transparent electrochromic devices are one in which an electrical potential applied across the device results in a change in the optical properties, resulting in tinting or decreasing the transparency of the material. Such materials are envisioned as smart windows that would allow the control of light and heat entering a room or automobile. A requirement for such a device is a transparent material for use as a counter electrode. A limited number of suitable materials have been identified, and the majority of them are solid solutions based on doping CeO_2. An interesting alternative has been identified by B. Zhu et al. {*Mater. Res. Bull.*, **34**, [10/11] 1507-12 (1999)}. Their material consists of crystalline CeO_2 in an amorphous SiO_2 matrix. The films were prepared on indium-tin-oxide coated glass via a sol-gel process. A xerogel layer was coated onto the substrates, using conventional spin coating techniques. After heat treating the film, the film consisted of a two-phase glass-crystalline composite whose electrochemical and optical properties are comparable with, or better, than conventionally ion-doped CeO_2 films.

Magnetoresistive Memory Element

Core memory was the original random access memory for computers. Tiny ferromagnetic toroids where threaded with wires, which allowed the direction of magnetization to be sensed and changed. The memory was non-volatile, but a typical computer may have had 16k of this hand-assembled memory. Magnetic memory elements had a second incarnation in bubble memory, where the position of small circular magnetic domains could be used as a storage device. This technology looked very attractive, but never quite caught up with semiconductor memory. F. J. Cadieu et al. {*Appl. Phys. Lett.*, **75**, [21], 339-71 (1999)} have now demonstrated another type of magnetic random access memory based on the room temperature magnetoresistivity of $La_{0.7}Sr_{0.3}MnO_3$, which is used to sense the direction of magnetization of a small bias magnet. While bulk $La_{0.7}Sr_{0.3}MnO_3$ exhibits a Curie temperature of 364 K, its narrow transition as a function of temperature and the fact that multi-Tesla fields are required to produce significant changes in the magnetoresistance preclude it use in devices. Polycrystalline thin films of $La_{0.7}Sr_{0.3}MnO_3$ exhibit considerably lower Curie temperatures and an enhanced low field magnetoresistivity. Using pulsed laser deposition (PLD), the authors produced a stable memory element by placing a small interacting bias magnet strip parallel to the magnetoresistive-sensing strip. Two distinct voltage states were observed following positive versus negative applied field excursions. Presumably, such devices could be made using conventional deposition techniques. Since current is only required for reading and writing, the memory is non volatile and the energy consumption should be very low.

Dendrimers

Another report in *Chemical and Engineering News* focuses on dendrimers. Dendrimers are typically well-defined globular macromolecules constructed around a core unit. The name is derived from two Greek words meaning tree and part. (Dendron, tree, is also the sources of dendrite for those of us who prefer metals.) The dendrimers are built up by successive reaction steps with each step adding a layer of branches. In theory, all the molecules can be exactly the same in terms of structure, composition and molecular weight, but often the dendrimers contain defects. For medical use, dendrimers may be designed so that the outside consists of functional groups that bind to specific target organs, allowing targeted delivery of drugs. In the case of a dendrimer called Gadomer-17, a highly branched macromolecule complexed with Gd^{3+}, the dendimer delivers a contrast agent for magnetic resonance imaging. Gd^{3+} chelates have been used clinically for over ten years, but the new dendrimer is designed for angiography and tumor differentiation. An advantage of dendrimers appears to be that they can be designed so that they are completely eliminated from the body after performing their function.

Diyttrium Potassium

A recent theoretical paper in *Science* on the energy levels of the diyttrium potassium molecule has generated a reasonable amount of interest in the more popular scientific press with an analysis of the paper as long as the original published in the December issue of Chemical and Engineering news [C&EN]. As this molecule has not been successfully produced, the results are strictly theoretical and compare the energy levels for linear and T-shaped isomers. The calculations were unable to determine which isomer was, indeed, the ground state. As experiments have been unsuccessful and the theory is ambiguous, it appears that the Y_2K problem is not of long term interest. The authors suggest that YOY or YNOT may be more interesting molecules in the future.

Blowing Our Own Horn

During the past week, a small overlapping group of about seven researchers at Iowa State University and Ames Laboratory has made the front page of the of *Wall Street Journal* in the January 27, 2000 issue for a new superhard material; the front page of the Department of Energy (DOE) web site (www.doe.gov) for our new high temperature furnace for x-ray diffraction using synchrotron radiation, and top billing (but, unfortunately, not top dollar) on a DOE press release (www.doe.gov/news/releases00/janpr/pr0021.htm) for new funding for work on functionally graded permanent magnets.

Conferences of Interest

- ***Polymer Bonded Magnets 2000***, March 27-29, 2000, Nashville, Tennessee, info@intertechusa.com
- ***IEEE Intermag Conference***, April 9-12, 2000, Toronto, Canada, http://www.intermagconference.com
- ***17th. Technology Short Course and Workshop on Permanent Magnet Design***, May 1-3, 2000, info@magnetweb.com
- ***Symposium on Magnetic Materials for Magnetoelectronic Devices***, May 17-18, 2000, Iowa State University, Ames, Iowa, xljrgard@exnet.iastate.edu
- ***19th Annual Conference on Properties and Applications of Magnetic Materials*** May 22-24, 2000, Illinois Institute of Technology, Chicago, Illinois, bonnie@ece.iit.edu

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