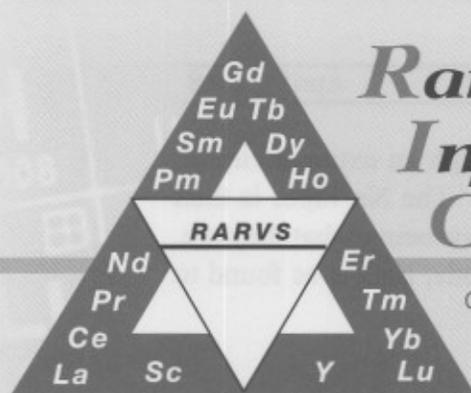


Rare-earth Information Center

Insight



Center for Rare Earths and Magnetics
Ames Laboratory
Institute for Physical Research and Technology
Iowa State University, Ames, Iowa 50011-3020 U.S.A.

Volume 11

April 1, 1998

No. 4

Gschneidner Update

A little over two years ago, Karl A. Gschneidner Jr. stepped down as director of the RIC in order to devote full time to research. As has been previously reported, that research has focused on magnetic refrigeration. As part of that research, Gschneidner and Vitalij K. Perchinsky discovered a new class of materials based on gadolinium-silicon-germanium. Late last year, that discovery earned the inventors the Department of Energy's 1997 Materials Sciences Award for "Significant Implication for Department of Energy Related Technologies" in materials science. Karl has yet to make ice cream on central campus, but the developments are very encouraging.

Manganese-doped Yttrium Orthoaluminate

From the number of papers on optical properties of rare earth-doped materials reviews in this newsletter, it is clear that this is a rather active field. What we do not see much of is rare earth-based materials doped by transition metal ions. Such a doping is reported by G. B. Loutts et al. {*Phys. Rev.B*, **57**, 3706-9 (1998)}. When a material is doped with a rare earth ion, it is the optical transitions of the doping ion, which are of interest. When a transition element is doped in, it is frequently the case that the optical properties are being changed by changing the electronic states. In the case reported by Loutts et al., yttrium orthoaluminate ($YAlO_3$) is doped by manganese (Mn). When a spot on this material is exposed to a laser beam of suitable intensity, photoelectrons are produced, which are free to migrate to other parts of the sample, where they are trapped. This results in regions of varying charge across the sample. If the laser beam is scanned across the sample, it is possible to scribe a series of charge domains across the material, which produces a refractive-index or holographic grating via the electro-optical effect. Thus, data or images can be stored in the material and readout using an appropriate light source. At the current time, we are not talking long-term storage, as the image fades 10% in one day at room temperature and 50% in a year.

LaB₆ Electrodes for Alkali Metal Thermoelectric Converters

One of the most sought after forms of energy conversion is the direct conversion of thermal energy into electrical energy. A recent paper by K. Tsuchida et al. {*J. Mater. Sci.*, **33**, 755-62 (1998)} drew my attention to a converter that I was previously unaware of. This is the alkali metal thermoelectric converter (AMTEC). This device has a high-temperature region (900-1300 K) containing liquid Na. A β -alumina solid electrolyte separates the liquid from a porous electrode. A pressure difference across the cell causes Na to be ionized at the liquid-electrolyte interface.

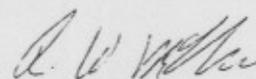
The Na^+ then passes through the electrolyte, while the electron passes through an external circuit. The two are recombined in the porous electrode, and the Na is evaporated. The Na vapor is then condensed and pumped back around for another trip. Liquid Na and Na vapor being what they are, the materials requirements for the cell are nontrivial. For the porous electrode, LaB_6 was found to have both the desired conductivity and a low reactivity with the Na.

Two-powder $\text{Nd}_2\text{Fe}_{14}\text{B}$ Magnets with DyGa Addition

In a Nd-Fe-B sintered magnet, magnetization reversal takes place by the nucleation of a reverse domain. The most likely place for nucleation of reverse domains is at triple points and grain boundaries, where the demagnetization fields are high and the anisotropy is reduced due to surface effects. Thus, if one could increase the anisotropy at these points, the coercivity could be increased. A well-known way of increasing coercivity in 2-14-1 is to replace some of the Nd with Dy. This replacement has been limited by the fact that Dy aligns antiferromagnetically to the Fe spins, and hence, reduces the saturation magnetization. Dy is also expensive. However, if the Dy could be placed selectively, where high anisotropy is required, the reduction in saturation magnetization would be inconsequential. In an attempt to do just that, C. H. de Groot et al. {*J. Appl. Phys.*, **83**, 388-93 (1998)} have added DyGa to $\text{Nd}_{14.2}\text{Fe}_{78.6}\text{B}_{7.2}$ powders. The combined powders were aligned, isostatically pressed and sintered to full density. The samples were then annealed at various temperatures. It was found that the Dy did not diffuse into the center of the 2-14-1 grains. Except for an enhancement at the boundary of the core, the Dy was uniformly distributed in the part of the grain that was precipitated from the melt. Ga was found to diffuse readily into the 2-14-1 grain. There was a sharp decrease in coercivity for samples annealed above 640°C .

Er-doped Polymers

Er-doped planar optical amplifiers have been demonstrated in a number of oxide hosts, such as SiO_2 , Al_2O_3 , and LiNbO_3 . However, there are also polymer waveguides, which are becoming increasingly important; and hence, there is an interest in making polymer amplifiers. Inorganic Er salts are not directly soluble in an organic matrix, so Er^{3+} ions must first be encapsulated by an organic ligand, which can be dispersed in a polymer film. One requirement of the ligand is that it does not provide paths for nonradiative decay of the Er^{3+} excited state. This means that O-H bonds must be avoided since the excited state of the Er^{3+} can couple to the vibrational modes of the O-H bond. L. H. Sloof et al. {*J. Appl. Phys.*, **83**, 497-503 (1998)} have reported on the optical properties of different Er-doped polydentate hemispherand organic cage complexes. They observe the standard $1.54\ \mu\text{m}$ Er luminescence spectrum, but the linewidth is unusually broad at 70nm FWHM. The broad linewidth is said to enable high gain bandwidth for optical amplification. The Er could be excited either directly or by exciting the surrounding ligands with light of a shorter wavelength.



R. W. McCallum
Director CREM/RIC