Rare-earth Information Center Insight

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

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Giant Magnetostriction in an Itinerant-electron Metamagnet

There are two definitions of metamagnetic transitions. The older definition goes back about fifty years and refers to the transitions that occur when an antiferromagnet or a ferrimagnet is subjected to a large magnetic field. For sufficiently large fields, the field overcomes the exchange energy between the sublattices, and they become ferromagnetically aligned. A more recent definition is for an itinerant-electron metamagnet (IEM). In this case, in the absence of the field, there is not only no net magnetic moment, but there is no magnetic moment at all. The field induces a shift of the Fermi surface so that the spin up and spin down bands are no longer equally populated, and a moment is induced. Obviously, this type of metamagnetic transition occurs in transition metal compounds and not in compounds that include magnetic rare earth ions. Such a transition occurs in $La(Fe_xSi_{1-x})_{13}$. For x=0.88, a first order phase transition occurs at the Curie temperature T_C=195. Slightly above T_C, 200K, an IEM transition can be induced by applying a magnetic field. This transition is accompanied by a large volume magnetostriction of 1.5%. While the transition can be induced at higher temperatures, the field required becomes excessively large for temperatures far from the T_C. From an applications standpoint, it would be quite interesting to have this large volume magnetostriction at room temperature. The T_C of the material can be increased by substituting Co for Si; however, this appears to change the band structure degrading the IEM. Recently, S. Fujieda et al. {*Appl. Phys. Lett.*, 79, [5], 653-5 (2001)} have succeeded in raising T_C by the addition of H. In $La(Fe_{0.88}Si_{0.12})_{13}H_x$, a maximum value of x=1.6 is achieved. This material is ferromagnetic at room temperature. The authors have extensively investigated the composition for x=0.10, which has T_C= 278K. The transition is accompanied by a volume change of over 1%. Applying a field, as much as 10K above T_C results in a 0.30% linear magnetostriction.

Light-induced Metal-insulator Transition

In the May 1996 *Insight*, the results of Huiberts et al. {*Nature*, **380**, 231-234 (1996)} for the loading of thin films of Y or La with H to induce a metal-insulator transition was reported. Due to the reactive nature of Y or La, a thin (5-20 nm) Pd film was deposited over the Y. This layer protects the RE hydride from oxidation but allows H to diffuse readily. The optical properties of YH_2 –YH_3 and LaH_2-LaH_3 thin films were shown to change from metallic mirror like films at the low H end to transparent semiconducting films at the high H end. P. van der Sluis et al. {*Appl. Phys. Lett.*, **70**, 3356-8 (1997)} extended this work to magnesium lanthanide alloys. The motivation for the substitution was that while transparent pure REH films are colored, an optically neutral material is desirable for an optical switch. Since Mg has a large enough band gap to be fully transparent, and the heat of formation of its hydride is similar to that of the transition between lanthanide-dihydride and lanthanide-trihydride, it was chosen as an alloying material. Pure Mg films cannot be loaded with enough H to become transparent due to slow H diffusion. Alloys of Gd, Sm, Lu, and Y were found to reversibly absorb and desorb H with achieved transmission ratios of more than 1000. The metal-insulator transition responsible for the change in optical properties is unusual in that it is continuous and is not

accompanied by a structural phase transition. Recently, A. F. Th. Hoekstra el. al. {*Phys. Rev. Lett.*, **86**, [23], 5349-52 (2001)} have performed a series of measurements on YH_x films at low temperature, which demonstrate that it is possible to move through the T=0 metal-insulator transition by inducing persistent photoconductivity with ultraviolet radiation. The transition has a number of interesting features. Perhaps the most intriguing is that, while it is not possible to generate photoconductivity except at very low temperatures, once generated the carriers persist up to temperatures approaching room temperature. The authors speculate that there is a subtle rearrangement of the hydrogen bonding, which is responsible for the change.

Short Notes

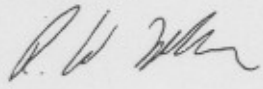
Lynas Corporation Ltd. has announced changes in its board of directors, which will focus the company on its Mt Weld Rare Earth project. Mt. Weld, near Laverton in Western Australia, contains a high grade deposit of rare earth ores, which preliminary estimates indicate could supply 10 percent of the world demand in 2010, and last at least thirty years. Concurrent with the change, Lynas has relocated its office to Lynas Corporation Ltd, Level 8, 17 Bridge Street, Sydney NSM 2000 (www.lynascorp.com).

GE Lighting, a major business unit of the General Electric Company, is introducing a light bulb with a Nd doped glass envelope. The bulb, which has the form of a typical incandescent bulb, appears powder blue when unlit due to the presence of Nd oxide in the glass. The Nd oxide absorbs yellow light, which is much more prevalent in the emission spectrum of the tungsten filament than in sunlight. Thus, the bulb produces a more natural light so that interior colors are seen more clearly (http://www.gereveal.com/reveal/press.html).

An important step in the application of automobile primers is the cationic electrodeposition of a layer of metal ions to the base metal. An adherent, corrosion resistant interface between the metal and the polymeric binder of the paint coating is created by the metal ions. Traditionally, this has been done using Pb ions. Even though Pb pigments have been banned for years, an exemption exists for soluble lead pigments up to 1,000 PPM in electrodeposition coatings, as there has been no satisfactory substitute. PPG Industries is now supplying a water-based yttrium coating to several automakers. The yttrium coating provides corrosion resistance that is equal to or better than that of Pb while maintaining surface quality. YOH is deposited from a Y salt solution during electrocoating and converted to Y_2O_3 during heat curing. PPG will introduce Y in all of its electrocoat products over the next decade.

The magnesium alloys used in casting contain approximately two weight percent Nd; however, the cost of the Nd is a disproportionate 40 percent. On the other hand, the magnet industry generates a tremendous amount of Nd-Fe-B scrap every year that is about 30 wt % Nd. Interestingly, there is very little solubility of Fe in Mg and no intermetallic compounds. The case for B in Mg is not quite so clean, as there are a number of intermetallic compounds, but for small amounts of B, one expects only MgB_2, (recently discovered to be superconducting at 39 K, see March 2001 *Insight*), which is used as a dispersion hardening agent. Noting these facts, L. S. Chumbley et al. at Ames {*JOM*, **53**, [7], 4 (2001)} have developed a potential use for Nd-Fe-B scrap. After solvent is used to remove machining lubricant from the scrap, it is ground and dissolved in liquid Mg at 800°C. The Nd is leached out of the scrap leaving Fe-B particles. The process appears to tolerate oxidation of the scrap, as the oxides appear to float to the surface of the melt. Of course, the degree of oxidation will effect the Nd recovery rate.

Sincerely,



R. W. McCallum
Director of RIC