



Rare-earth Information Center

Insight

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SmFe₇

Non-cubic rare earth iron compounds are of considerable interest for technological applications, since they often exhibit either large magnetocrystalline anisotropy or giant magnetostriction. Since many of these intermetallics form through peritectic reactions, even equilibrium phases may not necessarily form under standard process conditions. The intermetallic phases may also be stabilized or suppressed by small amounts of impurity elements. As a result, our knowledge of the phase diagrams is incomplete. A recent report by Samata et al. {*Jpn. J. Appl. Phys.*, **36**, L476-8 (1997)} suggests that this is the case in the Sm-Fe system, where they have reported the growth of single crystals of SmFe₇. The crystal structure is reported to belong to the space group P4₂/mnm, which is the same space group as the RE₂Fe₁₄B materials; in fact, the structure is reported to be remarkably similar to the 2-14-1 structure, since the only reported difference is the lack of B in sites occupied in the 2-14-1 structure. The magnetic properties also are very close to Sm₂Fe₁₄B. These facts raise the possibility that the 2-14-1 structure has been stabilized by a small amount of impurity, as the crystals were grown in alumina crucibles coated with BN. The authors used auger microscopy in an attempt to detect B and N and found none. Clearly, this interesting result bears further investigation.

PrFe_{10.5}V_{1.5}N_x Hard Magnets

Over the past several years, a considerable amount of effort has been devoted to stabilizing the ThMn₁₂ structure for RFe_{12-x}M_x where M = Ti, V, Cr, Mn, W, Si, or Al. The stabilized material is then nitrided, which enhances the magnetization and Curie temperature. This work has primarily focused on RE = Nd. W. Mao et al. {*Appl. Phys. Lett.*, **70**, 3044-6 (1997)} reported the successful fabrication of PrFe_{12-y}V_yN_x material with properties comparable to Nd₂Fe₁₄B. Milled powders in an anisotropic bonded magnet produced a coercive force of 3.3 kOe, remanence of 10.9 kG and a maximum energy product of 16MGOe at room temperature.

X-ray Laser at 7 Nanometers

Most of the lasers reported in *Insight* are small, solid state devices that are aimed at communication or data storage applications. J. Zhang et al. {*Science*, **276**, 1097-100 (1997)} reported on a x-ray laser, which would have applications for holography and microscopy of biological specimens, and for analysis of dense plasmas for inertial confinement fusion. Do not expect these devices to turn up in the biology labs at your local school any time soon, as the laser, which has an output energy of 0.3 millijoule in 50-picosecond pulses, is driven by the VULCAN Nd:glass laser. The article assumes you are familiar with this installation, which implies that it is on the large size. The concept employed is rather interesting in that an initial pulse from the drive laser is used to form a plasma from a Sm target. A second pulse then causes lasing in the plasma. The energy efficiency on this application seems a little bit low.

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Yellow to Violet Upconversion

Upconversion, the process by which two photons raise an atom to an excited energy state, which then decays with the emission of a single higher energy photon, has been discussed a number of times in the *Insight* in the past year. S. R. Bullock et al. {*J. Non-Cryst. Solids.*, **212**, 85-8 (1997)} discussed another interesting aspect of this process. While many rare earth elements have energy levels suitable for upconversion, the problem is to provide a host, which does not allow non-radiative decay from the excited states. While fluoride glasses are satisfactory with regard to non-radiative decay, the fibers are fragile. Silica glasses have desirable mechanical properties but have large phonon frequencies, which enable non-radiative decay. Bullock and co-workers have developed a glass composition, which meets all the requirements: La_2O_3 (7.1 mol%), PbO (13.9 mol%), TeO_2 (29.5 mol%), and $\text{Ba}_3\text{Y}_3\text{WO}_9$ (1.7 mol%). The glass is doped with $\text{Nd}_2(\text{SO}_4)_3$ and B_2O_3 and was added to reduce viscosity. The authors reported that they observed yellow to violet upconversion at room temperature. The violet wavelength is of particular interest for data storage purposes.

Low Temperature Oxygen sensor

Many of us are familiar with Y_2O_3 -stabilized ZrO_2 (YSZ) oxygen sensors. These sensors provide a high degree of sensitivity over a remarkable range of oxygen partial pressure (PO_2). A drawback to sensors, using YSZ as the electrolyte, is that the sensor must be operated at an elevated temperature of approximately 900K. A lower operating temperature would increase the sensor lifetime, reduce warm up time and save energy. T. Ishihara et al. {*J. Electrochem. Soc.*, **144**, L122-5 (1997)} have reported an oxygen sensor based on the perovskite LaGaO_3 . Using $\text{La}_{1-x}\text{Sr}_x\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_3$ with $x = 0.1$ and 0.2 , an operating temperature as low as 600K was observed. The results for this material were lower than theoretical values. Doping with Nd to produce $(\text{La}_{0.9}\text{Nd}_{0.1})_{0.8}\text{Sr}_{0.2}\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_3$ resulted in a good agreement with the Nernst value. This sensor operated down to 673K and 90% of the response was obtained within 15 s.

Ferroelectric FET

Using the remnant polarization of a ferroelectric thin film, it is possible to construct nonvolatile memory elements. When incorporated in a ferroelectric field effect transistor (FET), it is possible to read the memory device nondestructively. This idea has been around since the 1950's, but satisfactory performance has not been obtained due largely to problems of materials compatibility between the perovskite ferroelectric and silicon. S. Mathews et al. {*Science*, **276**, 238-40 (1997)} have overcome this problem by replacing Si with $\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ and using $\text{PbZr}_{0.2}\text{Ti}_{0.8}\text{O}_3$ as the ferroelectric. $\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ has recently received considerable attention as a giant magnetoresistive material, but in this application the material is magnate stoichiometry controlled to tune the carrier concentration in the semiconductor. The device exhibited a retention loss of 3 percent after 45 minutes without power.

R&D 100 Awards

This year's R&D 100 Awards have just been announced and one in particular is of interest to the RIC. A collaboration between Idaho National Engineering and Environmental Laboratory and Ames Laboratory received an award for developing alloys of Nd-Fe-B, which are suitable for gas atomization. The INEEL group consists of Dan Branagan, T. A. Hyde, and Charlie Sellers. The Ames group is made-up of Bill McCallum, Matt Kramer and Kevin Dennis. The collaboration was conducted under the auspices of the Center for Excellence in Synthesis and Processing of the Office of Energy Research, U.S. Department of Energy.



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