



Rare-earth Information Center

Insight

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Bulk Amorphous II (or as I was saying)

Over the past several years, a number of multicomponent alloy systems have yielded bulk amorphous alloys. These alloys can be formed into castings with cross-sectional dimensions in mm and still remain amorphous. This is in contrast to conventional amorphous metal alloys, where rapid solidification processing produces materials with cross sections in the 10's of microns. Some of these alloys, Fe-(Al,Ga)-(P, C, B, Si, Ge) and Nd-Fe-(Al,Ga), are ferromagnetic at room temperature. Not surprisingly, the first of these materials has good soft magnetic properties. Quite surprising is that the Nd compound exhibits hard magnetic properties. A recent paper by A. Inoue et al. {*Mater Trans. JIM*, **37**, 1731-40 (1996)} adds Pr-Fe-Al bulk amorphous alloys to the list of amorphous materials, which exhibit hard magnetic properties. In order for a material to exhibit hard magnetic properties, it must have local anisotropy. This may come from the shape of the magnetic particle or grain as a result of the demagnetization factor, or it may come from the environment surrounding an individual magnetic ion. For a bulk amorphous material, one would not expect either of these effects to be operative. If the atomic arrangement is truly random, there should be no net magnetocrystalline anisotropy. An interesting insight to the problem is provided by comparing the bulk amorphous material to amorphous material formed by melt spinning. Inoue et al. found that the melt spun material is, as one would expect, soft. This suggests that there is short range order in the bulk material. The natural assumption is that the bulk material is crystalline on a very fine scale. The problem with this assumption is that when the material is crystallized, it becomes paramagnetic at room temperature. Thus, the short range order in the bulk amorphous material does not correspond to the crystalline order.

Dental Lasers

Henry Higgins would rather have the dentist drilling than some other politically incorrect statement. From numerous press reports, the only thing that stands between the dental drill and the scrap heap is the \$39,000 it costs for an Er-YAG laser. The laser is said to remove decay painlessly so that there is no need for anesthesia. The laser light is feed through fiber optics to a hand piece for precise control. The laser has the capability of drilling smaller holes and, thus, decreasing the size of fillings.

Oxygen Production on Mars

Many of us are familiar with yttria-stabilized zirconia (YSZ) oxygen analyzers, where the difference in oxygen partial pressure across the YSZ oxygen ion conductor results in a voltage. K. R. Sridhar and B. T. Vaniman {*Solid State Ionics*, **93**, 321-8 (1997)} have produced test cells using the same principles in reverse to decompose CO₂ and produce O₂. The motivation for the work is rather simple, significant savings in launch mass for both manned and unmanned Mars missions can be obtained if oxygen for propulsion and life-support can be extracted from Martian resources. Since the Martian atmosphere is predominately CO₂, the use of a solid oxide electrolyser to produce oxygen is attractive. The paper

outlines the theory of operation and describes the operation of several test cells. The cells exhibit ideal behavior as the YSZ has no electronic conduction.

Magnetostrictive SmFe₂/metal composites

Recently, there has been considerable interest in magnetostrictive materials for various sensor applications, where a force applied to the sensor results in a change in magnetization direction. Terfenol-D (TbFe Naval Ordinance Lab with Dy) or (Tb,Dy)Fe₂ exhibits giant magnetostrictive behavior with strains as much as 2000 ppm, but the material is expensive and brittle. More common magnetostrictive materials, including some steels and Ni, have much better mechanical properties and low cost, but the strains are only ~30 ppm. In an attempt to find a middle ground, various groups have looked at composite materials. F. E. Pinkerton et al. {*Appl. Phys. Lett.*, **70**, [19], 2601-3 (1997)} have recently produced composite materials of SmFe₂ and Fe or Al by hot pressing. The SmFe₂ was produced by melt spinning. This resulted in increased mechanical properties and substantial magnetic coercivity. Both of these characteristics may be attributed to the fine grain size of the melt spun materials. The hot pressing temperatures were limited by the onset of exothermic reactions between the SmFe₂ and the matrix material. The temperatures selected were 540°C for the Al matrix and 610°C for Fe. As a result of the low hot pressing temperature, the densities obtained were limited to between 86 and 94% of theoretical. Magnetostrictions, an order of magnitude larger than Fe or maraging steel, were obtained in materials which were easily machinable.

One Gd atom

Superconductivity and magnetism are competing effects. In superconductivity, the conduction electrons form pairs where the electrons in the pair have equal energies, equal but opposite momentum and opposite spins. When such a pair encounters a magnetic moment, the interaction with the moment is opposite for the opposite spins, which means that the two electron energies are no longer equal and the pair is broken destroying superconductivity. The theory for this pair breaking dates back to 1961 and experimental studies go back to the same era. Experimentally, one has always sought to reach the single impurity limit so that interactions between magnetic atoms need not be considered. A. Yazdani et al. {*Science*, **275**, 1767-70 (1997)} have in essence reached the single impurity limit. Starting with a single crystal of Nb, which has a superconducting transition of 9.2K, 0.005 of a monolayer of either Mn or Gd, was deposited on the surface from a calibrated electron beam evaporation source. A scanning tunneling microscope (STM) was then used to study the surface. The Gd ions appeared as 1.8Å bumps on the surface. The local tunneling density of states was determined from the differential conductance of the STM junction as a function of bias voltage. While the Mn atoms on the surface acted in accordance with the theoretical predictions, the Gd did not. It is believed that the interaction with Gd requires a more careful calculation of the electronic structure of the surface.

Web Site

Baotou Steel & Rare Earth Co. (USA), a subsidiary of Baotou Iron & Steel Co. China, has set up a world wide web site at [HTTP://www.baotou.com](http://www.baotou.com). Their e-mail address is Baoutou@aol.com



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