Gd Eu Tb Sm Dy Pm Ho RARVS Nd Er Pr Tm ® Ce Yb La Sc Y Lu

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Hard Magnet to Become a Magnetic Storage Alloy!

For the past forty years the areal density in magnetic recording has grown at the rate of one order of magnitude per decade. Currently, hard disks with a density of about 150 Mb/in^2 (megabits per square inch) have come on the market, while in the laboratory memories of ~1 Gb/in^2 (where Gb stands for gigabits) have been demonstrated. These advances continue the pace developed earlier and it appears that by the year 2010 magnetic memory products with a density of 10 Gb/in^2 will be available.

One of the leading candidates for these Gb/in^2 hard magnetic disks is none other than Sm-Co, which is our first rare earth permanent magnet alloy. E.M.T. Velu and D. N. Lambeth [**IEEE Trans. Magn. 28**, 3249 (1992)] have shown that Sm-Co thin films, of the approximate $SmCo_4$ composition, deposited on a Cr underlayer (~100 nm thick) had recording characteristics (coercivity, signal to noise ratio, overwritability, etc.) which were far superior to any existing recording medium. The authors found that the epitaxial growth of the SmCo film on a (110) textured Cr film, contained nanocrystallites of SmCo in an amorphous matrix, which were well separated by void space. This microstructure leads to a large reduction of the interparticle exchange interaction and thus reduces the noise level in the recording medium. The nanocrystallites also develop a large coercivity of ~ 3000 Oe, which is about twice as large as that of the CoNiCr or CoCrTa materials used in the current hard disks, which also have the disadvantage of a large noise level. The authors found that the SmCo/Cr based disks had a signal to noise ratio of 44 dB, and an overwritability of more than 45 dB.

Yttria Coatings

Yttria (Y_2O_3) coatings, because of their favorable thermal and mechanical properties, have been used to protect materials, primarily metals and alloys, subject to high temperature and/or severe stress. These uses include thermal barriers in aircraft jet engines, and oxidation and corrosion protection of the underlying substrates. Yttria coatings are normally obtained by plasma spraying. But these coatings usually contain a few percent of the monoclinic B phase, and this tends to weaken the mechanical properties of the coating which is predominately made up of the cubic C form of Y_2O_3. This deleterious effect is caused by a volume expansion when the B form transforms to the C form during high temperature operations. V. Gourlaouen and co-workers from C.E.A. Saclay and the Laboratoire de Chimie Appliquée de l'Etat Solide, Paris, have studied the plasma spray and processing conditions for producing yttria coatings to see if the presence of the B phase in the C phase matrix can be reduced or eliminated. They found that by using an argon/hydrogen atmosphere, the coating contained only 2% B form, while in the coatings

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prepared by plasma spraying in air, the yttria was composed of 5% of the B form and 95% of the C form. The argonne/hydrogen atmosphere yields a black powder (substoichiometric Y_2O_{3-x}), while processing in air gives a white powder (stoichiometric Y_2O_3). They also found that the B content varied with the plasma spray distance. The maximum amount of the B form was found at a plasma spray distance of 10 to 14 cm, while significantly smaller amounts (by a factor of 2 to 3) were found when the distance was about 22 ± 2 cm. They also found that the B form will transform to the C form by suitable heat treatment: either by isothermal annealing between 700 and 1000°C, or by dynamic heating.

The authors concluded that the deleterious effects of the B phase on the plasma sprayed coatings can be eliminated by appropriate heat treatment, but the best solution would be to prevent the B phase from forming in the first place. They hope to do this by adding appropriate dopants which will act as B-phase inhibitors. The results of their investigation have been published in **Mater. Res. Bull. 28**, 415 (1993).

New Developments in Rare Earth Plastic Magnets

Recent information received by RIC indicates that two Japanese companies have made some important significant advances in plastic rare earth permanent magnets. The first concerns an announcement that Daido Steel Company, Ltd. has begun the production of Nd-Fe-B plastic magnets which are usable at temperatures of 180°C. Prior to this development the maximum temperature was around 120°C. According to Daido Steel, they are the first to go into production for making the 180°C plastic magnets on a commercial basis. There are two versions of the plastic magnets — one for use with compression molding and the second for injection molding. Currently they are producing two metric tons per month, and plan to increase their production to ten tons per month in 1996. A special resin coating, which is applied over the entire surface, is used to prevent oxidation at the higher temperatures.

The second announcement comes from Seiko-Epson Corporation, who claim to have developed the world's first extrusion process for forming Nd-Fe-B plastic permanent magnets. Previously, these plastic magnets have been produced by compression and injection molding processes. The extrusion process allows them to make thin plastic magnets with a minimum wall thickness of 0.5 mm, about one half of the thickness attainable by previous methods. The extrusion process is capable of producing tubular and arc-shaped magnets up to one meter long. The magnetic properties of the extrusion processed magnets are said to have magnetic properties superior to the injected molded magnets, and about the same as the compression molded materials.

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