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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New Magnetic Alloy Production Facility

Recently, Neomet Corporation dedicated a new rare earth alloy production facility in Edinburg, Pennsylvania. Neomet, which is a subsidiary of Mitsubishi Materials Corporation, also celebrated the beginning of the production of anisotropic Nd-Fe-B permanent magnet powders by the HDDR process. The HDDR (hydrogenation, decomposition, dehydrogenation, reaction) process, which was invented and developed by Dr. Takuo Takeshita (who is now the General Manager of the Central Research Institute of Mitsubishi Materials Corporation), involves: (1) the hydriding $Nd_2Fe_{14}B$ at low temperature (H), (2) then decomposing it to form $NdH_2 + \alpha Fe + Fe_2B$ by heating the material above 650°C (D), (3) dehydrogenating the NdH_2 at a temperature less than 1000°C and pumping off the hydrogen (D), and (4) finally reacting the neodymium metal with the iron (α-Fe) and Fe_2B at a temperature below 1000°C to form the anisotropic $Nd_2Fe_{14}B$ powder (R). Neomet has the authority to produce, process and commercialize the HDDR product by virtue of a three-way licensing agreement between Magnequench, Mitsubishi Materials Corporation and Sumitomo Special Metals Company {see **RIC Insight 7** [3] (March 1994)}. Neomet, which has been a worldwide supplier of alloys for the magnet industry since 1989, is suppling the HDDR powder for anisotropic resin-bonded magnets, micro motors and unique magnets.

Enhanced Remanence in Nd-Fe-B Magnets

Improved remanences have been recently achieved in hard magnetic materials by exchange coupled nanostructures relative to that in comparable alloys with coarser microstructures. The nanostructure materials consist of a hard magnetic phase matrix with soft magnetic grains distributed within this matrix. This enhancement occurs if the grain size is small enough so that the exchange energy overcomes the anisotropy energy which allows the exchange interactions between neighboring grains. In mixtures of hard and soft materials remanence enhancement is expected to be higher because the magnetic moments of the soft phase aligns parallel to the average direction of the easy axis of the neighboring hard magnetic grain. J. Wecker and co-workers from Siemans AG in Erlangen, Germany and the Technische Universität Graz, Austria reported in **Appl. Phys. Lett., 67**, 563-565 (24 July 1995) that by hot compaction at 600°C of mechanically alloyed Nd-Fe-Co-Si-B powders they obtained materials with a remanence of 1.0T, an energy product of 121 kJ/m^3 (15.2 MGOe) and a coercivity of 4.2 kA/cm (5.2 kOe). The remanence is more than 30% above the expected limit for noninteracting single domain particles. Unfortunately, the coercivity is about half to one-fourth that of normal Nd-Fe-B permanent magnets.

The samples were prepared by milling a mixture of neodymium, iron and boron powders with ~15% excess of iron compared to the $Nd_2Fe_{14}B$ stoichiometry plus silicon and cobalt in a planetary ball mill. After milling for 50 hours the samples were hot compacted at 600°C and 400 MPa for less than two minutes. The compacted powders had a density of 95% of theoretical, and the powders had an average grain size of 20 nm.

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Telephone: (515) 294-2272
Facsimile: (515) 294-3709
Telex: 269266
Internet: RIC@AMESLAB.GOV

Calculations indicate that the coercivities could be improved if the grain size was reduced to 10 nm. As the authors note: "The challenge, therefore, is to optimize the composition and the processing in order to guarantee homogeneous nanocomposites on the scale".

Hydrogen Storage Alloy Production Plant

Japan Metals and Chemicals Company Ltd. announced plans to construct a factory on a 20 acre site in Durham County, North Carolina for producing rare earth-based hydrogen storage alloys. The new facility will be operated by JMC (USA) Inc., which is a wholly owned subsidiary of Japan Metals and Chemicals Company Ltd. and was established in 1993. Construction began a few months ago and will be completed in early 1997. Initial production will be 1000 metric tons per year. Japan Metals and Chemicals Company Ltd. which is affiliated with Nippon Steel, began research on hydrogen storage alloys in 1978 and is the world's largest producer of these materials for use in batteries. The new plant is another step in the company's plan to internationalize its operation and is being built in response to continued growth in demand for these materials. The major output of this facility is to supply the nickel-metal (rare earth) hydride alloy for a battery manufacturing plant owned by a consortium formed by Duracell (USA), Toshiba (Japan) and Varta (Germany).

The nickel-metal hydride market is one of the top growth markets for the rare earths. In 1994 Japan produced over 200 million nickel-metal hydride batteries, which required about 2000 metric tons of alloys. For more information about these battery materials see **RIC Insight 3** [8] (August 1990), **4** [9] (September 1991) and **7** [10] (October 1994).

Where Will It End?

The latest inflationary report is that it has increased from $2.5 \times 10^7\%$ to $1 \times 10^8\%$. The "it" refers to the super GMR (giant magnetoresistance) effect. As reported in the September 1995 issue of **RIC Insight** (**8** [9]), the record GMR effect was more than 10 million, an increase of more than one order of magnitude from the prior record. Since that record has now been surpassed by about another order of magnitude, the authors from Brown University and IBM Research Center in Yorktown Heights now call the super GMR effect the "colossal magnetoresistance (CMR)" effect. If the GMR inflation continues we will soon be running out of adjectives to describe the effect. G.-Q. Gong and co-authors [**Appl. Phys. Lett. 67**, 1783 (18 September 1995)] achieved their record using basically the same material as used in the earlier reports — $La_{1-x}Ca_xMnO_3$. The authors note that for $x = 0.5$ the super GMR effect is $1 \times 10^6\%$ at 125K, but readily increases to $1 \times 10^8\%$ when the temperature is lowered to 57K. Gong *et al.* reported that their material is antiferromagnetic, which changes to ferromagnetic when a field is applied. Most of the other $La_{1-x}Ca_x MnO_3$ materials have ferromagnetic ground states, and this difference may be critical. The main problem is that the GMR effect drops off rapidly with increasing temperature and the effect is not nearly so large at room temperature, which is where one would like to have as large a value as possible for technological applications.

Karl A. Gschneidner, Jr.

K. A. Gschneidner, Jr.
Director, RIC