Rare-earth Information Center

# Insight

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## 16th International Workshop on Rare-Earth Magnets and Their Applications

The *16th International Workshop on Rare-Earth Magnets and Their Applications* was held in Sendai, Japan, during the third week of September, 2000. One hundred fifty-five papers were presented in oral or poster form, and the proceedings, which were handed out at the conference, contain a large number of papers of interest to the rare earth community.

### Chinese Rare Earths

As the proceedings were published prior to the conference, they contain a number of papers that the authors were unable to present. Among these is a paper from the China Rare Earth Information Center entitled "The Role of China's Rare Earth in the Globe." The China Rare Earth Information Center, unlike the RIC, collects economic data relative to rare earth materials. The article points out that in 1960 the annual global consumption of REO was 2,000 tons. In 1999, the consumption of REO reached 75,000 tons representing an annual growth rate of 9% over four decades. The article notes that even 75,000 tons represents a rather small industry. (Out of curiosity, I looked up the tonnage for a mid sized bulk carrier and found a number of 25,000 tons, so three ships a year will carry the world's annual consumption of REO.) The paper contains a number of tables including market share data. A sobering thought to those that would compete with China as a rare earth supplier is the statement that between 400,000 and 500,000 tons of REO are mined from a mineral deposit at Baiyunebo in Baotou, Inner Mongolia every year in conjunction with mining iron ore. {Proceedings of the *Sixteenth International Workshop on Rare-Earth Magnets and Their Applications,* H. Kaneko, M. Homma, M. Okada (eds.) p. 25-30 (2000)}

### China's Magnet Industry

Yang Luo, {*ibid.*, p. 31-8} reported on the development of NdFeB production in China. This production is growing at 30% per year and was ~ 5,400 tons in 1999. A major development in the quality of Chinese magnets is that of strip casting capability for the Nd-Fe-B alloy. Due to the peritectic nature of $Nd_2Fe_{14}B$, traditional ingot casting of the alloy leads to phase segregation in the ingot that is impossible to eliminate through annealing. As a consequence, the powders made from cast ingot are less homogeneous than those made from strip cast alloy where the amount of phase segregation is limited by the much faster cooling rate inherent to the process. Pricing information shows that the cost of sintered NdFeB in the Chinese market is approximately one-third that in the Japanese market. The paper includes tables of output, sales value and average sales price for a variety of magnet materials made in China for each of the last four years.

### Sm-TM High Temperature Magnets

A number of papers (Walmer, {*ibid.*, pp. 41-55}; Goll, {*ibid.*, pp. 61-70}; Liu, {*ibid.*,, pp. 71-9) dealt with the new high temperature magnets based on Sm-Co. The magnets have the general form $Sm(Co_wFe_vCu_xZr_y)_z$. The demagnetization curve for these magnets remains linear in the second quadrant for temperature up to 550°C. As should be readily apparent, the determination of v, w, x, y and z is non-trivial and, in fact, should be optimized for each value of the maximum operating temperature as high temperature performance comes at an appreciable cost in BH product. Sm-Co magnets are rather interesting from a fundamental metallurgy viewpoint in that they are produced from a

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high temperature solid solution that is unstable at lower temperatures. When heat-treated below the solid solution temperature stability range, cells develop within the original metallographic grains. The walls of these cells pin the magnetic domain walls giving the material its hard magnetic properties. The cell size and cell wall composition are dependent on both starting composition and heat treatment protocol. The papers in the conference proceedings discuss these factors in detail. Also discussed is the stability of the magnets under high temperature operating conditions. Needless to say, the prevention of oxidation is of considerable interest.

### *Nd-Fe-B*

A number of papers, {*ibid.*, pp. 83-97} discussed aspects of achieving higher energy products in $Nd_2Fe_{14}B$ magnets. Sumitomo Special Metals reported values of 444kJ/m3 (55.8 MGOe) as a result of using strip casting for ingot preparation, and improved powder producing and alignment procedures. They also reported the start of mass production of 400 kJ/m3 with high temperature stability of 200°C. Powder alignment was obtained in cold isostatically pressed magnets by using pulsed fields, and significant increases in the $BH_{max}$ were obtained by alternating the direction of the field pulses. Presumably, this results in differing torques on the misaligned powders, which allows them to move into better alignment. The universal problem in achieving higher energy products appears to be that as the degree of alignment increases, and the amount of second phase decreases, the coercivity of the magnet is reduced. Thus, there is currently a trade-off between increasing the remnant magnetization and decreasing the coercivity.

### *"Cheap" (Pr-Nd-Ce)FeB Magnets for MRI Medical Imaging Applications*

A permanent magnet structure for MRI medical imaging applications contains several metric tons of magnet material. The cost of the magnet material is, therefore a major factor, however, the very best material is not required. If the material has a coercivity ~ 10kOe and an energy product in the 40-45 MGOe range, it is adequate for the job. As a result, M. G. Benz et al., {*ibid.*, pp. 99-108} have investigated using mixed rare earth materials for their magnets. The idea is fairly simple in that one wishes to use a larger percentage of the REO found in the ore while simultaneously reducing the cost of separation by removing the requirement for separating two neighboring rare earth elements. In historic terms, didynium is separated from low Ce mischmetal oxides. The paper reports the range of composition for which the desired properties can be obtained. Pilot scale production of magnets based on 71%Pr, 27% Nd and 2% Ce were produced using 51 metric tons of "Ce free" rare earth chloride. The Pr-Nd-Ce oxide was reduced electrolytically to the mixed rare earth alloy. Jet milled powders produce magnets with a $BH_{max}$ of 45.12 MGOe.

### Science in Vietnam

This year I made my second trip to Hanoi, Vietnam as part of an NSF sponsored research collaboration. There exists in Vietnam a critical shortage of scientific research literature. I have offered to use the publications of the RIC to solicit donations of scientific literature. The shortage is so acute that even old conference proceedings are welcome. If you will send me a list of books or proceedings you no longer need, I will try and arrange for the shipment of selected items to a central library in Hanoi. As there are no funds to support this activity, I will have to be a bit selective in what we send. Please send list to R. W. McCallum, Ames Laboratory, ISU, 116 Wilhelm Hall, Ames, IA 50011-3020 or email me at crem_ric@ameslab.gov.

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