KMS-1-Q2

MAGNETIC AND MICROSTRUCTURAL STUDY OF $Nd_2Fe_{14}B$ + $Nd_2Fe_{14}B$ /Fe HYBRID MAGNET

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Introduction

Nanocomposite magnets exploiting the exchange-coupling through a grain boundary between the magnetically hard and soft nanosize grains are attracting a great interest in the permanent magnetic field due to their enhanced remanence. Most of the today's nanocomposite materials are isotropic in nature. Recently, a hybridization technique, in which the $R_2Fe_{14}B/\alpha$-Fe (R = Nd, Pr) nanocomposite material is hybridized with an $Nd_2Fe_{14}B$ single phase material, has been proposed, and this hybrid magnet is anisotropic. The aim of the present study is to provide knowledge on the effect of the host and added alloy composition on the magnetic properties of the hybrid magnet.

Experimentals

In the present study two types of rare-earth-rich $Nd_xFe_{93.5-x}Ga_{0.5}B_6$ (x = 13.5 and 11.8) alloys were used as a $Nd_2Fe_{14}B$ single phase host alloy. The $Nd_{11.8}Fe_{81.7}Ga_{0.5}B_6$ alloy is near $Nd_2Fe_{14}B$ stoichiometric and the $Nd_{13.5}Fe_{80}Ga_{0.5}B_6$ alloy has an excessive Nd. Two types of rare-earth-lean $Nd_xFe_{93-x}Nb_1B_6$ (x = 6 and 9) alloys were used as a $Nd_2Fe_{14}B$/Fe nanocomposite phase added alloy. The $Nd_6Fe_{87}Nb_1B_6$ alloy may have more amount of α-Fe in the nanocomposite form compared to the $Nd_9Fe_{84}Nb_1B_6$ alloy. The alloys were prepared by an arc-melting using the high purity component elements, and were melt-spun using Cu wheel with 30 m/sec speed. The melt-spun alloy ribbons were crushed into powders, and powders were mixed thoroughly with the desired ratio. The mixed powder was then compacted in vacuum at 750 °C with a pressure up to 410 MPa and subsequently die-upset with height reduction of 80 %. Magnetic characterization of the compacted and die-upset magnets was performed at 300 K along the direction parallel to the pressing direction in the compacting and die-upsetting. The cubic shape specimens (1 x 1 x 1 mm^3) were pre-magnetized with dc field of 50 kOe in a SQUID and the room temperature demagnetization curve was measured using a combination of the SQUID and VSM.

Results and discussion

The magnetic properties of the hybrid magnet were influenced significantly by the composition of the host and added alloys (Fig. 1). The effect of added nanocomposite alloy composition on the magnetic properties of the hybrid magnet was examined using the hybrid magnet consisting of $Nd_{13.5}Fe_{80}Ga_{0.5}B_6$ host alloy and $Nd_xFe_{93-x}Nb_1B_6$ (x = 6 and 9) added alloys. The hybrid magnet with added alloy of $Nd_6Fe_{87}Nb_1B_6$ had a better magnetic performance (higher *Mr, iHc,* and *(BH)max*) with respect to the hybrid magnet with added alloy of $Nd_9Fe_{84}Nb_1B_6$ in both the compacted and die-upset states. The effect of $Nd_2Fe_{14}B$ single phase host alloy composition was examined using the hybrid magnet consisting of $Nd_xFe_{93.5-x}Ga_{0.5}B_6$ (x = 13.5 and 11.8) host alloy and $Nd_9Fe_{84}Nb_1B_6$ added alloy. The effect of host alloy composition on the magnetic performance showed a different trend in the compacted and die-upset states. In the compacted hybrid magnet, a higher *Mr* and *(BH)max* was obtained in the hybrid magnet with host $Nd_{11.8}Fe_{81.7}Ga_{0.5}B_6$ alloy. The compacted hybrid magnet with $Nd_{11.8}Fe_{81.7}Ga_{0.5}B_6$ host alloy, however, exhibited much lower coercivity with respect to the hybrid magnet with $Nd_{13.5}Fe_{80}Ga_{0.5}B_6$ host alloy. Meanwhile, in the die-upset hybrid magnet, the hybrid magnet with $Nd_{13.5}Fe_{80}Ga_{0.5}B_6$ host alloy showed a significantly higher overall magnetic performance (*Mr, iHc,* and *(BH)max*) compared to the hybrid magnet with $Nd_{11.8}Fe_{81.7}Ga_{0.5}B_6$ host alloy.

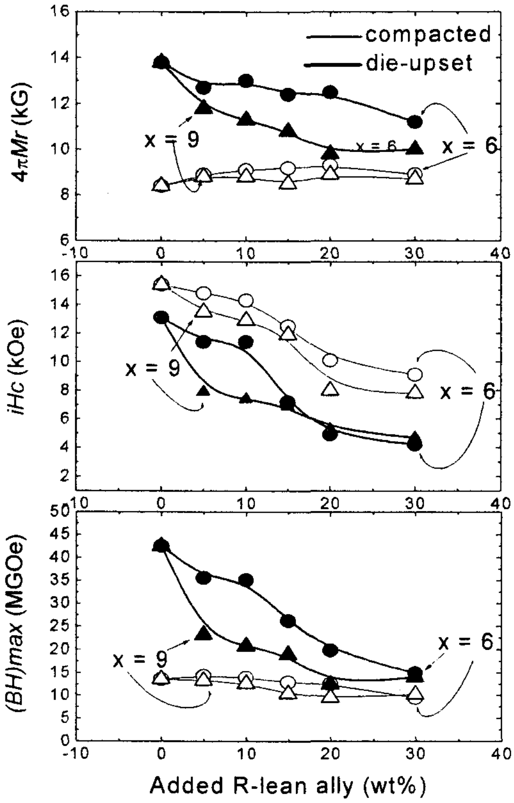

Fig. 1: Magnetic property variations of the compacted and die-upset hybrid magnets consisting of $Nd_{13.5}Fe_{80}Ga_{0.5}B_6$ and $Nd_xFe_{93-x}Nb_1B_6$ (x = 6 and 9) melt-spun ribbons as a function of wt% of the added R-lean nanocomposite alloy.