Coercivity Enhancement by RF_3-Doping in Hot-Pressed and Die-Upset Nd-Fe-B-type Magnet

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Nd-Fe-B-type magnets with excellent room temperature properties have been expanding their use in rather harsh condition of high operating temperature (≈ 200 ℃) such as the magnets in the traction motor and generator of the HEV, EV and wind turbine. Due to high temperature coefficients (α, β) of remanence and coercivity the ordinary grade Nd-Fe-B-type magnet cannot function properly at the elevated operating temperature unless it possesses sufficiently high room temperature magnetic properties. In particular, sufficiently high room temperature coercivity is definitely needed in those applications because the magnet can be readily demagnetized by the reverse applied magnetic field during operation. Current technology for enhancing the coercivity in the Nd-Fe-B-type magnet is an alloying technique or grain boundary diffusion (GBD) process by using heavy rare-earth, such as Tb, Dy. In this study, diffusion of rare earths in the Nd-Fe-B-type hot-pressed and die-upset magnets using various RF_3 as a diffusion source of rare-earth, which are chemically more stable and less expensive, was attempted, and its effect on the coercivity were investigated. Commercial melt-spun flakes (MQU-F : $Nd_{13.6}Fe_{73.6}Co_{6.6}Ga_{0.6}B_{5.6}$) were mixed with 1.6 wt% RF_3 (R = La, Ce, Pr, Nd, Dy) and then hot-pressed and die-upset. RF_3 (R = Pr, Nd, Dy)-doping led to an overall coercivity enhancement with respect to the un-doped magnet. In the hot-pressed magnet, the most profound coercivity enhancement (5.0 kOe) was achieved in the DyF_3-doped magnet. NdF_3- and PrF_3-doping was also beneficial for enhancing coercivity (3.5, 3.5 kOe). In the die-upset magnets, RF_3 (R = Pr, Nd, Dy)-doping was still beneficial for enhancing coercivity (4.0 kOe, 2.0 kOe, and 2.0 kOe for RF_3 (R = Pr, Nd, Dy)-doping, respectively). The coercivity enhancement was attributed mostly to the substitution of Nd in $Nd_2Fe_{14}B$ matrix grains and the modification of Nd-rich grain boundary in the flake by the dopant.

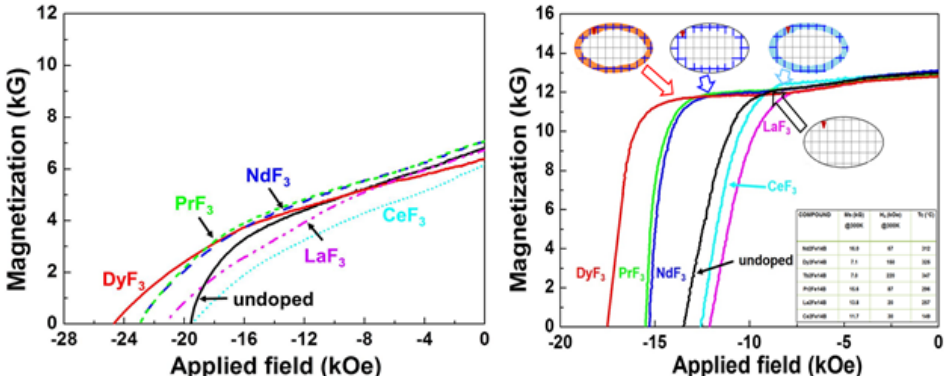

Fig. 1. Demagnetisation curves of the hot-pressed (a) and die-upset (b) Nd-Fe-B-type magnets doped with RF_3.