Coercivity enhancement of bulk hot-deformed Nd-Fe-B magnets by the eutectic grain boundary diffusion process using $Nd_{60}Dy_{10}Cu_{30}$ alloy

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Hot-deformed Nd-Fe-B magnets have high anisotropic microstructure composed of ultrafine grains that is comparable with single domain size of $Nd_2Fe_{14}B$ phase[1]. Coercivity, as extrinsic property, can be improved via modifications of grain boundary structure or its chemistry[2,3]. $(Nd,Dy)_2Fe_{14}B$ shell structure that forms after grain boundary diffusion has been considered as the reason of coercivity enhancement[4]. In this work, we applied low-temperature grain boundary diffusion to bulk hot-deformed Nd-Fe-B magnets using $Nd_{60}Dy_{10}Cu_{30}$ alloy powder to modify grain boundary composition and to enhance anisotropy field by localizing Dy at surface of $Nd_2Fe_{14}B$ grains.

Hot-deformed magnets with the composition of $Nd_{12.9}(Fe,Co)_{bal}B_{5.5}Ga_{0.5}$ (at.%) in 7×7×5.6 mm^3 size were used as the starting materials. The eutectic grain boundary diffusion was carried out by annealing at 650°C with sample coated with $Nd_{60}Dy_{10}Cu_{30}$ powder. The microstructures of the samples were studied using SEM/FIB (Carl ZEISS 1540EsB), TEM (Titan G2 80-200).

Demagnetization curves of the hot-deformed and diffusion-processed magnets of different heights are shown in Figure 1. The coercivity (μ_0H_c) of 5.6 mm, 5.8 mm, 6.0 mm high samples were enhanced from 1.4 T to 1.91 T, 2.15 T, and 2.26 T after diffusion process, respectively. The large slope of the demagnetization curves of diffusion-processed samples indicated coercivity distribution from surface to center. We find the formation of thicker intergranular phase with higher Dy segregation close to surface than that of the center region. STEM-EDS elemental maps showed micro-scale phase segregation of Nd and Nd-Dy-Cu (Fig.2). Formation of Nd-rich phase and $(Nd,Dy)_2Fe_{14}B$ shell at surface of $Nd_2Fe_{14}B$ grains are the main reasons for coercivity enhancement of diffusion-processed samples. Based on SEM and detailed TEM results, the mechanism of coercivity enhancement of bulk hot-deformed Nd-Fe-B magnets by grain boundary diffusion process will be discussed.

Reference
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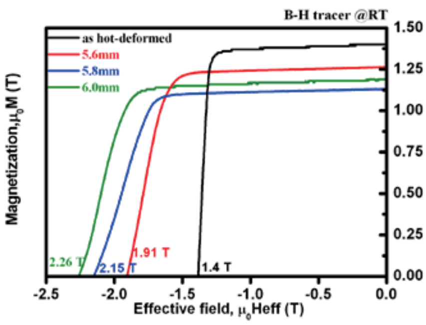

Fig.1 Demagnetization curves of hot-deformed and diffusion-processed magnets

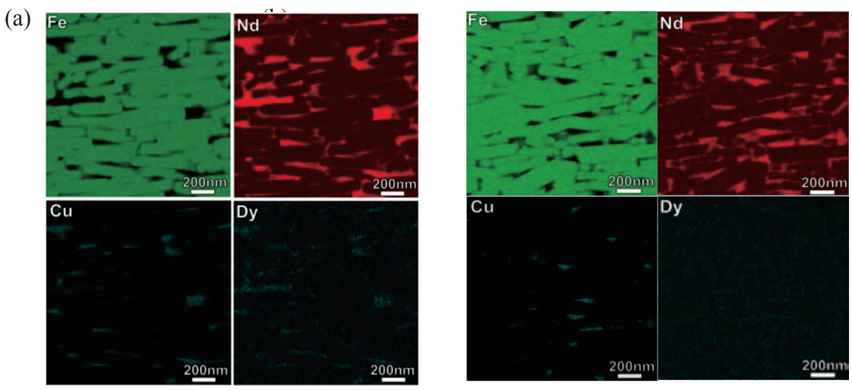

Fig.2 STEM-EDS mapping of surface region (a) and center region (b) of 6.0 mm high Nd-Dy-Cu diffusion-processed sample