Coercivity enhancement of hot-deformed Nd-Fe-B magnets by the eutectic grain boundary diffusion process

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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], indicating that they have the potential for higher coercivity. Coercivity, as extrinsic property, can be improved via modifications of grain boundary structure or its chemistry [2,3]. Nd has eutectic reactions with various types of Nd_xM_y compounds, where M includes Al, Cu, Ga, Zn, Mn, Co, Ni, and Fe. However, only a few eutectic systems, Nd-Cu and Pr-Cu, were explored for the eutectic grain boundary diffusion process [4]. In this work, we applied the low-melting-point eutectic alloy grain boundary diffusion process to 2 mm thick hot-deformed Nd-Fe-B magnets to adjust intergranular phase composition to achieve complete magnetic isolation.

Hot-deformed magnets with the composition of $Nd_{13.2}(Fe,Co)_{bal}B_{4.7}Ga_{0.5}$ (at.%) in 4×4×2 mm^3 size were used as the starting materials. The eutectic grain boundary diffusion was carried out by coating the magnets with melted eutectic alloy ribbons, followed by heat treatment at proper temperature for 1 hour. 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. After the heat treatment at 700°C for 1 h by $Nd_{90}Al_{10}$ diffusion process, coercivity can be increased from 1.26 T to around 2.45 T; by $Nd_{70}Cu_{30}$ diffusion process satisfactory magnetic property for the diffusion-processed sample can also be obtained, with coercivity of 2.26 T (Fig.1a). However, NdAl-diffused magnets exhibited a poorer temperature dependence of coercivity than that of NdCu-diffused magnets. We find the good isolation between $Nd_2Fe_{14}B$ grains provided by the intergranular Nd-rich phase compared with hot-deformed magnets (Fig.2) Based on SEM and detailed TEM results, the mechanism of coercivity enhancement as well as the thermal stability of the hot-deformed Nd-Fe-B magnets by grain boundary diffusion process will be discussed.

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Reference

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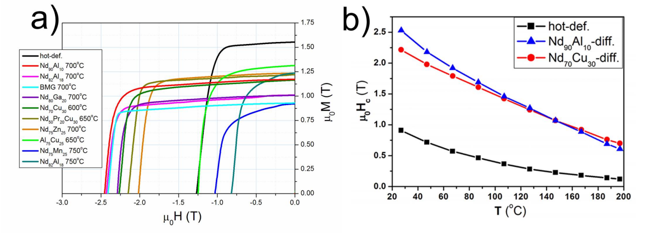

Fig.1 Demagnetization curves of the hot-deformed and diffusion-processed magnets a); temperature dependence of hot-deformed, NdAl-diffused and NdCu-diffused magnets b).

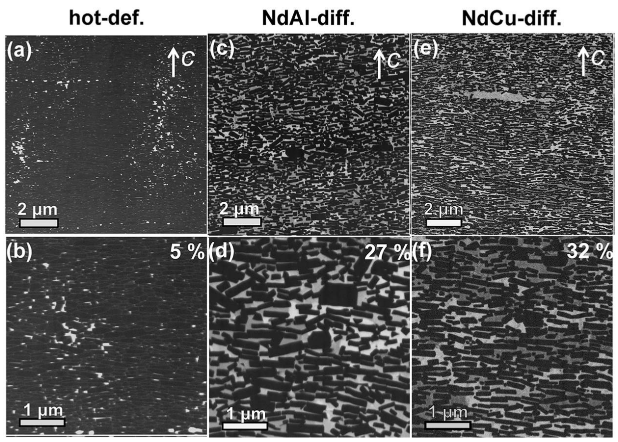

Fig.2 BSE-SEM images of the hot-deformed (a,b), NdAl-diffused(c,d) and NdCu-diffused magnets (e,f) with c-axis in-plane.