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

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The eutectic grain boundary diffusion process was applied to hot-deformed Nd-Fe-B magnets using various types of Nd_xM_y compounds as the diffusion source, where M includes Al, Cu, Ga, Zn, Mn, Co, Ni, and Fe. Formation of non-ferromagnetic Nd-rich intergranular phase was believed as the main reason for remarkable coercivity enhancement, whereas also leads to large degradation in remanent magnetization [1-3]. T.T. Sasaki et al [4] showed that trace amount of Ga doping to Nd-Fe-B sintered magnets could give rise to coercivity of 1.8 T by post annealing with more homogeneous distribution of Nd-rich grain boundary phase. In this work, we used $Nd_{62}Fe_{14}Ga_{20}Cu_4$ at.% alloy as diffusion source, applying to 4 mm thick hot-deformed Nd-Fe-B magnets aiming for an optimal coercivity with high remanent magnetization.

Hot-deformed magnets with the composition of $Nd_{13.2}(Fe,Co)_{bal}B_{4.7}Ga_{0.5}$ (at.%) in 5×5×4 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 600°C for 3 hour. The microstructures of the samples were studied using SEM/FIB (Carl ZEISS 1540EsB), TEM (Titan G2 80-200).

Hysteresis loops of the hot-deformed and diffusion-processed magnets are shown in Figure 1. After the heat treatment at 600°C for 1 h by $Nd_{62}Fe_{14}Ga_{20}Cu_4$ diffusion process, coercivity can be increased from 1.26 T to around 2.22 T with a remanence of 1.31 T at room temperature (Fig.1a). The diff. proc. sample can retain the coercivity of around 0.80 T at 160°C. We find the NdFeGaCu diff. proc. sample shows relatively better texture compared with that diff. proc. with Nd-Al compound (Fig.2). Detailed TEM characterization was carried out to figure out the microstructure of grain boundary phase formed after the diffusion process, as well as the interface feature that may contribute to the texture evolution when the diffusion happened.

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Reference

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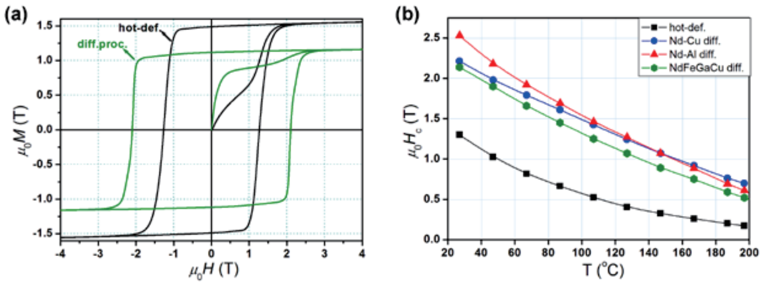

Fig. 1 Hysteresis loops of hot-deformed and NdFeGaCu diff. proc. samples a); temperature dependence of hot-deformed, Nd-Al, Nd-Cu, and NdFeGaCu diff. proc. samples b).

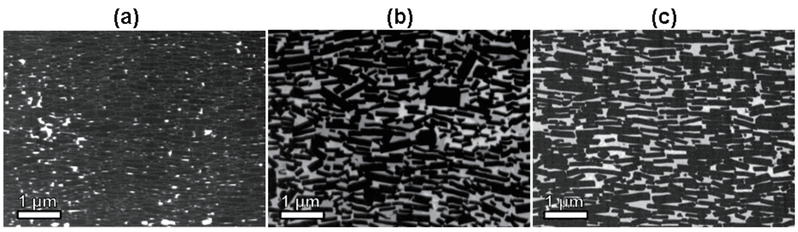

Fig. 2 BSE-SEM images of hot-deformed a), Nd-Al diff. proc. b) and NdFeGaCu diff. proc. samples c).