Coercivity enhancement in hot deformed Nd-Fe-B magnets processed from amorphous precursors

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The hot-deformed magnets have attracted considerable interests since Lee reported their highly-anisotropic and ultrafine-grained microstructure features in 1985.[1)] Given the small grain size (~400 nm) in hot-deformed magnets, the coercivity is expected to be as high as ~2.5 T. However, experimental values are much lower.[2)] The coercivity is extremely sensitive to microstructure, such as the chemical composition of intergranular phase and the aspect ratio (ratio between length along ab plane and length along c plane: L_{ab}/L_c) of grains. These microstructural features change depending on processing conditions. In this paper, we processed hot-deformed magnets from amorphous and nanocrystalline precursors and compared their microstructures and coercivities to explore the optimum processing route to maximize the coercivity.

The crystal and amorphous powders with composition of $Nd_{28.3}Pr_{0.06}Fe_{bal}Co_{3.41}Ga_{0.53}Al_{0.06}B_{0.97}$ (wt.%) were produced by melt-spinning with different cooling rates. These two kinds of powders were compacted by hot pressing at 650°C in vacuum, which were subsequently hot-deformed at 850 °C until 75% height reduction were achieved. The magnetic properties and microstructure were studied by BH tracer and SEM/FIB (Carl ZEISS 1540EsB), respectively.

Fig. 1 shows the demagnetization curves of hot deformed magnets processed from nanocrystalline and amorphous powders. By processing magnets from amorphous powders, the coercivity can be increased from ~1.28 T to ~1.4 T, while keeping the remanence at 1.42 T, which is resulted from optimized microstructure in this sample as indicated in Fig. 2. In Fig.2, the aspect ratio of $Nd_2Fe_{14}B$ grains in hot-deformed magnets processed from amorphous precursors is calculated to be ~0.43, which is reduced to ~0.32 in the counterpart processed from amorphous precursors. Consequently, grains in the sample produced from nanocrystalline precursors present more feature of elongated shape, suggesting bigger effective demagnetized factor and lower coercivity. STEM/EDS studies of the intergranular phase suggested the Nd-concentration in the sample fabricated from the amorphous precursor is higher than that processed from nanocrystalline precursor.

Reference

1) R.W. Lee, Appl. Phys. Lett. **46** (1985) 790.
2) K.Hono, H. Sepehri-Amin, Scri. Mater. **67** (2012) 530.

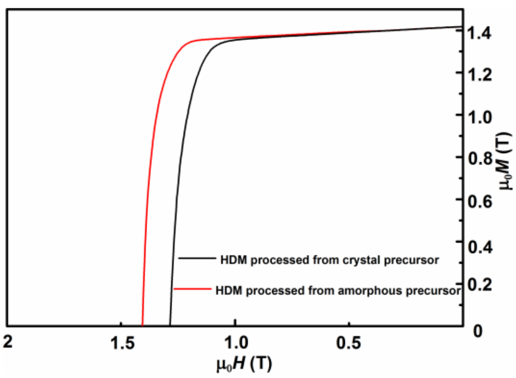

Fig. 1 Demagnetization curves of hot deformed magnet (HDM) processed from nanocrystalline and amorphous precursors.

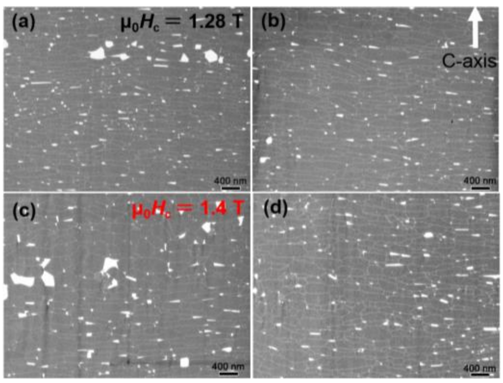

Fig. 2 BSE-SEM images of the hot-deformed magnets processed from nanocrystalline precursor (a,b) and amorphous precursor (c,d).