Oral | Material, processing, and characterization

Tue. Jul 29, 2025 9:00 AM - 10:25 AM JST | Tue. Jul 29, 2025 12:00 AM - 1:25 AM UTC Convention Hall(300, 3F)

[O5] RE-Fe-B Magnets III

Session Chair: Prof. Dagmar Goll(Aalen University)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[O5-3] High Coercivity of 2.8 T in HRE-Free Anisotropic Magnets by Microstructure Engineering

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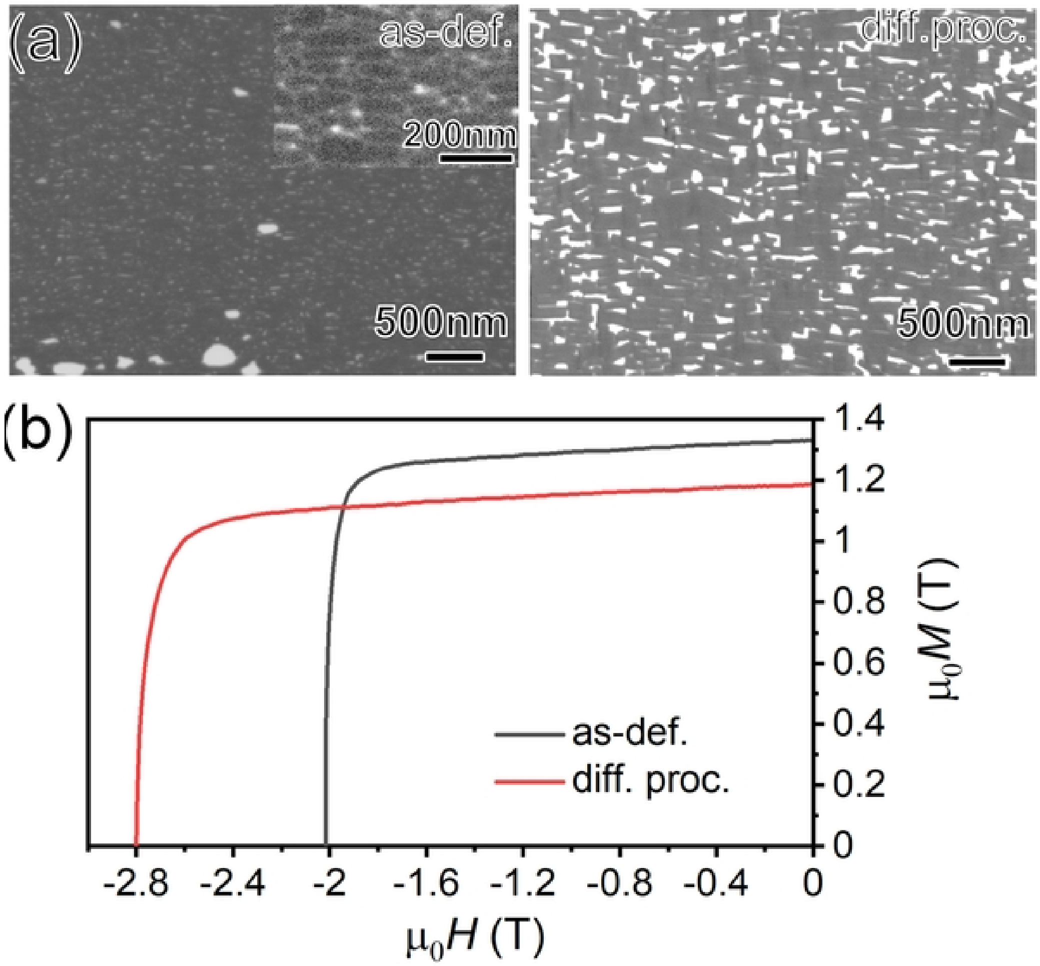
Currently, (Nd,Dy)-Fe-B-based anisotropic magnets used in major applications exhibit coercivity above 2.8 T, typically containing more than 8 wt.% Dy [1]. However, the scarcity of Dy in the earth's crust has driven efforts to develop Dy-free Nd-Fe-B-based magnets with properties comparable to conventional (Nd,Dy)-Fe-B sintered magnets. One approach to enhancing coercivity without reliance on Dy is by reducing grain size [1]. Recent studies on hot-deformed magnets have shown that, despite achieving ultra-fine grain sizes, coercivity remains limited to 2 T due to strong exchange coupling between grains [2]. This suggests that further coercivity enhancement could be achieved by a well-established grain boundary diffusion process [3]. In this study, we applied a heavy rare-earth-free grain boundary diffusion process to ultrafine-grained hot-deformed magnets and demonstrated that an ultra-high coercivity of 2.8 T can be achieved without Dy through microstructure engineering.The starting magnet, with a nominal composition of $Nd_{13.5}Fe_{bal.}Co_{3.5}Ga_{0.57}B_{5.64}$ (at.%), was processed via hot extrusion. Its microstructure, shown in Figure 1(a), reveals a grain size of approximately 80 nm (as seen in the inset). In the as-deformed state, the grain boundary phase exhibits weak contrast, indicative of an Fe-rich intergranular phase, which limits coercivity to 2 T. After the diffusion process, an Fe-lean intergranular phase with bright contrast is formed, significantly enhancing coercivity to 2.8 T as shown in Figure 1(b). Further analysis, benchmarked against 8-9 wt.% Dy-containing sintered magnets, confirms that the Dy-free magnets developed in this study exhibit comparable performance at elevated temperatures. This work demonstrates the potential of ultrafine-grained Dy-free magnets as viable alternatives to commercial 8 wt.% Dy-containing sintered magnets.

References

[1] K. Hono et al, Scr. Mater. 67 (2012) 530.
[2] N. Kulesh et al, Acta Mater. 276 (2024) 120159.
[3] H. Sepehri-Amin et al Scr. Mater. 63, 1124-1127 (2010).


(a)
as-def.
200nm
500nm
diff.proc.
500nm
(b)
as-def.
diff. proc.
$\mu_0 M$ (T)
$\mu_0 H$ (T)
-2.8
-2.4
-2
-1.6
-1.2
-0.8
-0.4
0
1.4
1.2
1
0.8
0.6
0.4
0.2
0