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)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[O5-5] Investigation on various selected area grain boundary diffusion approaches for Nd-Fe-B magnets

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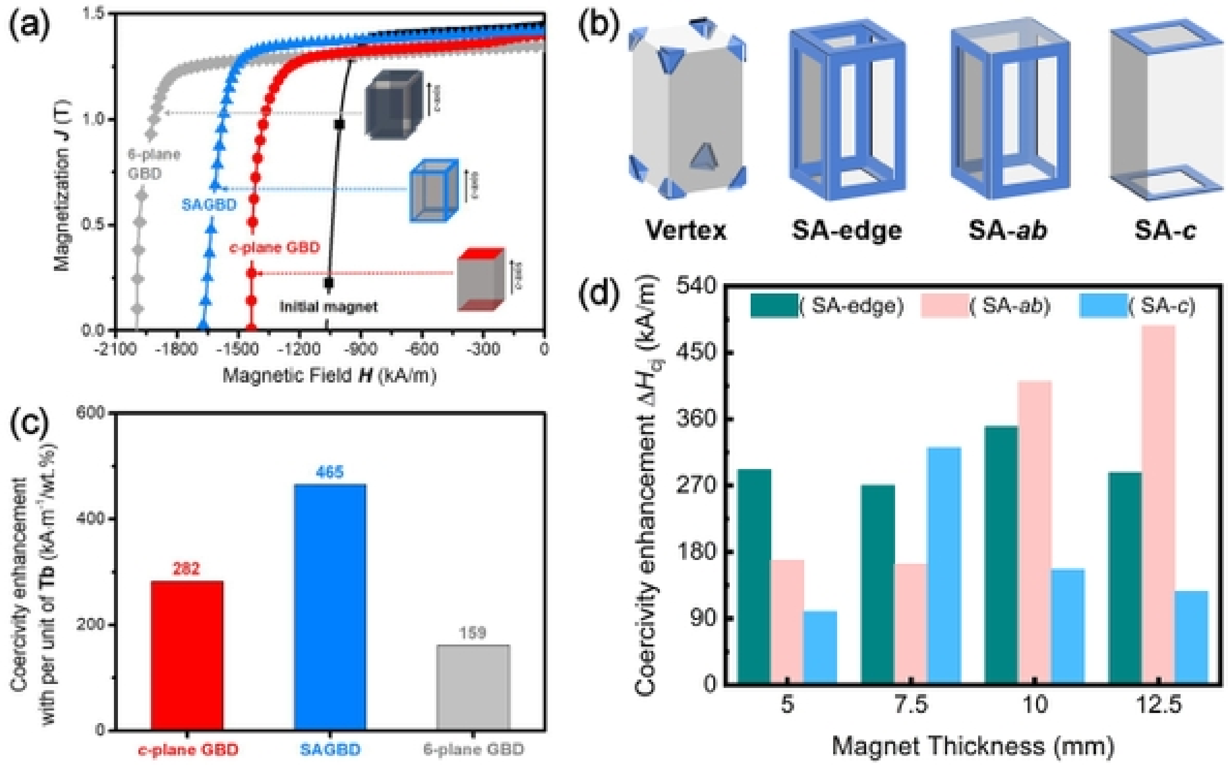
Keywords：Nd-Fe-B magnet、selected area grain boundary diffusion、coercivity、demagnetization behavior

The grain boundary diffusion (GBD) process is a rational approach for enhancing the coercivity of Nd-Fe-B magnets while reducing the consumption of expensive heavy rare earth (HRE). In this process, the diffusion elements are normally covered on the top and bottom sides along the c-axis, and enter into the interior of the magnet along GB, developing magnetically hardened shells around the matrix grains. However, due to the limited diffusion depth and low diffusion efficiency of HREs, the traditional GBD process is generally used to treat only thin magnets less than 10 mm thick, and the diffusion treatment for thick magnets has faced serious challenge. Based on this, we proposed the selected area grain boundary diffusion (SAGBD) to treat large-size magnets in the previous study, focusing on strengthening the weak areas of the magnet. As shown in Fig.1(a) and (b), it can be found that after diffusing Pr-Tb-Al-Cu alloy by SAGBD, the coercivity of a 12-mm thick magnet was increased from 1070 to 1675 kA/m, the coercivity enhancement with 1 wt. % Tb was 465 kA×m^{-1}, 1.6 times as much as that by diffusion from two c-planes. To further understand the mechanism of SAGBD, we further designed various types of SAGBD to treat the Nd-Fe-B magnets with various thicknesses. The diffusions from the twelve edge areas and from eight vertices are named SA-edge and Vertex GBD. Those diffusing from the edge areas of four side planes and two c-planes are named SA-ab and SA-c diffusions, respectively. The GBD from two easy magnetization planes (c-plane) and two parallel planes perpendicular to c-plane are named as c-plane and a-plane diffusions, respectively. Tb-Cu alloy was used as the diffusion source. It is found that the optimal GBD approaches for the magnets with the thicknesses of 5, 7.5, 10, and 12.5 mm are c-plane, c-plane, SA-edge, and SA-ab diffusions, respectively, as shown in Fig.1(d). Specifically, the SA-ab diffusion shows the highest utilization efficiency of Tb in 12.5 mm-thick magnets, reaching a value of 405.5 kA·m^{-1}/wt.%, which is 2.9 and 3.8 times higher than c-plane and SA-c diffusions, respectively. The microstructure observations and micromagnetic simulations suggest that the reversed domains tend to nucleate at the edges and corners of the magnet. The Vertex diffusion can directly hinder the nucleation and propagation of reversed domains at the corners, but the SA-edge diffusion can effectively postpone their rapid propagation over the entire magnet. This study provides the guidelines for the future development of SAGBD for sintered Nd-Fe-B magnets.


(a)
Magnetization J (T)
Magnetic Field H (kA/m)
6-plane GBD
SAGBD
c-plane GBD
Initial magnet
(b)
Vertex
SA-edge
SA-ab
SA-c
(c)
Coercivity enhancement with per unit of Tb (kA.m⁻¹/wt.%)
282
465
159
c-plane GBD
SAGBD
6-plane GBD
(d)
Coercivity enhancement ΔHcj (kA/m)
(SA-edge)
(SA-ab)
(SA-c)
Magnet Thickness (mm)