Influence of microchemistry and interface structure of cell boundary phase on the coercivity of $Sm(Co_{0.78}Fe_{0.10}Cu_{0.09}Zr_{0.03})_{7.19}$ sintered magnets

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Excellent hard magnetic properties of Sm_2Co_{17}-type sintered magnets at elevated temperature make them the only choice for the applications above 300℃. However, the coercivity of Sm_2Co_{17}-type permanents magnets strongly depends on the cooling rate from aging temperature of ~850℃; No coercivity for rapidly quenched sample while the coercivity is enhanced to ~2.0 T after slow cooling [1]. This has been correlated to the Cu content and its distribution in the cell boundary phase [2]. Questions raise here; does just small increase of Cu in the cell boundary phase substantially enhances coercivity or are there other microstructural features influencing the coercivity of Sm_2Co_{17}-type permanent magnets? In this work, we have revisited the microstructure of Sm_2Co_{17}-type sintered magnets with different coercivity levels and discussed the coercivity mechanism by employing finite element micromagnetic simulations to answer to these open questions.

Commercial $Sm(Co_{0.784}Fe_{0.100}Cu_{0.088}Zr_{0.028})_{7.19}$ sintered magnets with two different heat treatment conditions, one quenched rapidly and the other slowly cooled from 850℃ were studied. The magnetic properties of the samples were measured using a SQUID-VSM. Microstructure of the samples were analyzed using SEM/FIB (Carl Zeiss 1540EsB), TEM (Titan G2 80-200)) and 3DAP. Influence of the microchemistry of the cell boundary phase to its pinning strength was studied using micromagnetic simulations.

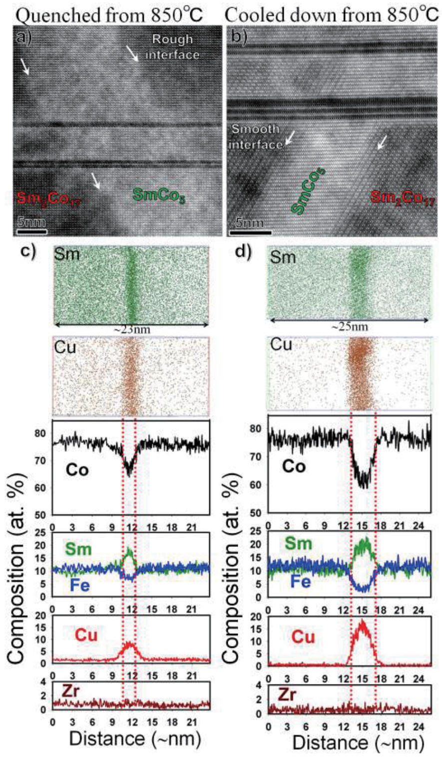

Fig. 1. (a) and (b) STEM-HAADF image and (c) and (d) 3DAP atom maps of Sm and Cu and calculated composition profile obtained from the Sm_2Co_{17}-type magnets quenched and slowly cooled down from aging temperature of 850℃.

The sample slowly cooled down from 850℃ showed the high coercivity of 2.6 T, while coercivity of the quenched sample was only 0.14 T. Figure 1 (a) and (b) show high resolution STEM-HAADF images obtained from the quenched and slowly cooled samples respectively. Sm_2Co_{17} matrix phase, $SmCo_5$ cell boundary phase, and Z-phase are observed in the microstructure. Unlike the quenched sample, $SmCo_5/Sm_2Co_{17}$ interface is sharp and smooth in the slowly cooled sample. Figure 1 (c) and (d) show 3D atom maps of Sm and Cu and their composition profiles obtained from the two different cell boundaries of the quenched and slowly cooled samples. Enrichment of 8.6 at. % of Cu and 7.7 at. % Fe was found in the cell boundary of the quenched sample while the $SmCo_5$ cell boundary phase of slowly cooled down sample contains 15.4 at. % of Cu and 3.0 at. % Fe. In addition, the distribution of Cu broader than that of Sm was found in the cell boundary of the quenched sample. Micromagnetic simulations showed that the enrichment of Fe in the cell boundary and the broad distribution of Cu results in a smaller gradient of K_1 through the 2:17/1:5 interface, which decreases the pinning strength of the cell boundary phase. This explains the low coercivity in the quenched sample.

[1] D. Goll, *et al.* Appl. Phys. Letters 76 (2000) 1054-1056. [2] X. Y. Xiong, *et al.* Acta Mater. 52 (2004) 737-748.