Development of Sm-Fe-N bulk magnets showing high maximum energy products

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Introduction

$Sm_2Fe_{17}N_3$ compound shows high J_s, high H_A and high T_C, therefore the $Sm_2Fe_{17}N_3$ based bulk magnet is expected to show high thermal stability with high $(BH)_{max}$. However, it is well known that preparation of bulk $Sm_2Fe_{17}N_3$ based magnets cannot be obtained by conventional sintering process because of decomposition of this compound above around 600 °C. For obtaining bulk Sm-Fe-N magnets, applying metal binder having low melting temperature and/or applying Spark-Plasma-Sintering (SPS) have been reported by many researchers. Recently, our group and AIST group have reported that decreasing oxygen content in $Sm_2Fe_{17}N_x$ based magnets is effective for suppressing deterioration of coercivity after heat treatment [1-4)]. In our previous study, we applied Arc plasma deposition (APD) and SPS for preparing Zn-bonded Sm-Fe-N bulk magnets, and we reported $(BH)_{max}$ of 153 kJm^{-3} with H_{cJ} of 1.1 MAm^{-1} for Zn-bonded Sm-Fe-N magnet and $(BH)_{max}$ of 179 kJm^{-3} with H_{cJ} of 0.8 MAm^{-1} for binder-less Sm-Fe-N magnet [4)]. We also reported that the Hydrogen-Plasma-Metal-Reaction (HPMR) method is useful for preparation of fine Zn particles with low oxygen content [2)]. Thus, in this study, we applied HPMR method and SPS process for preparing Zn-bonded Sm-Fe-N magnets, and we obtained high $(BH)_{max}$ Sm-Fe-N bulk magnets.

Experimental Procedure

Sm_2Fe_{17} coarse powder was pulverized by ball milling. The fine Sm-Fe powder was nitrided under N_2 gas at 450 °C. Zn fine powder was prepared by the HPMR method. After mixing Sm-Fe-N and Zn powder, the Sm-Fe-N/Zn mixed powder was pressed under magnetic field, and it was sintered by SPS with conditions of 750 MPa at 380-440 °C.

Results and Discussion

Oxygen content of the Sm-Fe-N powder was 0.22 wt%, and remanence and coercivity of the powder was 151 Am^2kg^{-1} and 0.72 MAm^{-1}, respectively. Magnetic properties of the Zn-free Sm-Fe-N magnet were H_{cJ} of 0.86 MAm^{-1} and $(BH)_{max}$ of 188 kJm^{-3}, respectively. It is shown that coercivity of the magnet did not decrease after sintering because of low oxygen content. The 10 wt%-Zn Sm-Fe-N/Zn bonded magnets showed excellent magnetic properties of $(BH)_{max}$ = 200 kJm^{-3} with H_{cJ} = 1.28 MAm^{-1}. Compared with previous studies, this $(BH)_{max}$ is highest level of Sm-Fe-N bulk magnets showing high H_{cJ}, simultaneously. The $(BH)_{max}$ of the Zn-bonded magnet was higher than that of Zn-free magnet in this study because of higher relative density. Therefore, Zn binder is effective for not only increasing coercivity but also increasing density of the magnets. Temperature coefficient of coercivity of the magnets were evaluated, and -0.38 %/K and -0.35 %/K for Zn-free and Zn-bonded magnets were obtained, respectively. Consequently, it is successfully obtained high performance Sm-Fe-N bulk magnets.

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Reference

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