Studies of the coercivity mechanism in the bulk nanocomposite Pr-Fe-B-type magnets

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Nanocomposite $Pr_9Fe_{50+x}Co_{13}Zr_1Nb_4B_{23-x}$ (x = 0, 5, 8) bulk magnets in the form of rods were produced by two-step process: the suction-casting rapid quenching technique and subsequent devitrification annealing. The rapid solidification resulted in obtaining the fully or partially amorphous structure of the rods depending on the B content in the alloy composition. Subsequent annealing at 983 K for 5 min caused formation of three crystalline phases: the hard magnetic $Pr_2Fe_{11.2}Co_{2.8}B$, the soft magnetic α-Fe and the paramagnetic $Pr_{1+x}Fe_4B_4$. Due to the initial composition of the alloys as well as diversity in the crystal growth dynamics of constituent phases some differences in the grain sizes were revealed. Particularly, the soft magnetic α-Fe phase had the finest grains of the average diameter of about 10 nm while for the $Pr_2Fe_{11.2}Co_{2.8}B$ phase the crystallites were much bigger with the average diameters ranging from 35 to 95 nm depending on the chemical composition of the alloy. Furthermore, all the annealed rods have shown the remanence enhancement. Moreover, the x=0 alloy rod exhibited the highest coercivity (of 950 kA/m) among all annealed rods of investigated alloys. In order to analyze the coercivity mechanisms in the annealed rods, the Kronmüller method was used [1]. Based on the hysteresis loops measured at the temperatures ranging from 25 K to 400 K, the temperature dependencies of coercivity ${}_J\mathrm{H}_C$, remanence polarization J_r and saturation polarization J_s, were determined. Furthermore, based on the $\mu_0\mathrm{H}_c/\mathrm{J}_s$ vs. $\mu_0\mathrm{H}_N/\mathrm{J}_s$ plots constructed using hysteresis loops measured at various temperatures, the microstructural parameter α and the effective demagnetization factor N_{eff} of the Kronmüller coercivity relation [2] were calculated. It also allowed to assess the magnetization reversal in the investigated specimens.

References:

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