Crystallization behavior of mechanically milled nanocomposite Pr-Fe-B alloys

GEORGE HADJIPANAYIS, MELANIA MARINESCU, YONG ZHANG, ALEXANDER GABAY, Department of Physics, University of Delaware, Newark, DE 19716 — In the past few years, research studies have proposed the high energy mechanical milling as an alternative route to the melt spinning for the development of nanocomposite two-phase 2:14:1 / bcc Fe magnets. The current work presents our results on Pr$_9$Fe$_{85}$B$_6$ and Pr$_9$Dy$_1$Fe$_{76}$Co$_8$Si$_1$B$_5$ mechanically milled powders with emphasis on the microstructure peculiarities, phase transformations upon annealing and their relation with the magnetic properties. Calorimetric investigations in as-milled powders show a main exothermic peak occurring at relatively low temperatures (350°C) that has been associated with a stress-relief effect. HRTEM micrographs for as-milled powders give evidence of coexistence of bcc Fe or (Fe,Co) phase ($d_g \approx 10$-15 nm), and an amorphous phase. The amorphous phase is still observed in powders annealed at 400°C and coexists with slightly enlarged bcc Fe or (Fe,Co) grains ($d_g \approx 15$-20 nm) and with a newly precipitated 1:7-type phase. A high degree of strain is present in the nanograin. The microstructure becomes free of internal stresses and completely crystallizes at 650°C. The extrinsic magnetic properties are strongly related to the powder microstructure.

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