Abstract

The effect of milling time on the nanostructure evolution, thermal stability, and the magnetocaloric effect in mechaniocally alloyed $(Ni_xFe_{1-x})_{70.5}B_{17.7}Si_{7.8}Ti_4$ (*at.*%) ($0.3 \leq x \leq 0.5$) has been investigated using x-ray diffraction, differential scanning calorimeter, transmission electron microscope, and vibrating sample magnetometer. The x-ray diffraction analysis reveals the formation of α-Fe in x = 0.3 and γ-Ni phase in x = 0.4 and 0.5 differently milled powders. An enhanced magnetic entropy change of 0.695 J/kgK with a Curie temperature (T_C) of 375 K at 19.9 kOe has been observed for the heat-treated x = 0.4 powders. Therefore, a large number of Fe-Ni- base alloys were surveyed to establish a mathematical relationship between T_C and D/d_{3d} and predict the T_C of γ-Ni phase by estimating its lattice parameter. The effect of milling on soft-magnetic properties of the as-milled powders has been correlated. Furthermore, a model has been developed to predict the T_C of γ-Ni phase from the lattice parameter. The calorimetric studies show the occurrence of ordered α' BCC phase in $Fe_{72}Ni_8Co_8Zr_7B_4Cu_1$ (at. %) upon 72 hours of milling, which transforms into disordered α and $\alpha \rightarrow \gamma$ transformation at 634 K and 909 K, respectively. Furthermore, the thermo-magnetic characterization confirmed the occurrence of $\alpha' \rightarrow \alpha$ transformation in the range of 500 K-600 K in addition to $\alpha \rightarrow \gamma$ transformation at 900 K suggesting the potential high-temperature application of the alloy powder.

The evolution of microstructure, structural transformation, magnetic properties, and magnetocaloric effects in a series of arc melted ingots (AMI) and as-spun ribbons (ASR) of $(Fe_{72-0.9y}Ni_{8-0.1y}Co_8)Zr_7B_4Cu_1Ga_y$ ($0 \leq y \leq 6$) were studied. The thermomagnetic studies revealed that the α-Fe→γ-Fe structural transformation occurred in the range of 691-733 K in AMIs, and 660-723 K in ASRs under the applied magnetic field of 0.01 T. T_C^{γ} lies in the range of 1126-1140 K and 1106-1126 K for AMIs and ASRs respectively. A second-order magnetic transition has been identified in y = 0 ASR using Arrott plot analysis and the magnetic entropy change ($|-\Delta S_M|$) has been estimated to be 0.973 J/kg.K at 0.976 T. The refrigeration capacity of ASR samples corresponding to y = 0, and y = 6 are 12.78 J/kg, and 22.98 J/kg.

Keywords: Nanocrystalline alloy, Mechanical alloying, Microstructure, Characterization, Rapid Solidification, Magnetocaloric effect, Soft-magnetic properties.