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Magnetic properties of FeCoBSiNb BMGs with Cu additions

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Abstract – Ferromagnetic amorphous alloys have shown great industrial value for commercial application. This work is dedicated to $[(Fe,Co)_{0.75}Si_{0.05}B_{0.25}]_{96}Nb_4$ glassy alloys with Cu additions. The basic idea is to study the variation of the glass forming ability of the Cu-containing alloys, as well as the magnetic properties function of nanocrystallization during the heat-treatment processes. The phase evolution will be discussed by analysing the X-ray diffraction patterns taken *in-situ* in transmission configuration, using the synchrotron radiation.

Since Fe-C-P amorphous alloys were produced in 1965, ferromagnetic metallic glasses and the corresponding nano-crystalline alloys such as FINEMET and NANOPERM, produced through crystallization from the corresponding amorphous precursors, were intensively investigated because of their excellent soft magnetic properties including relatively high saturation magnetization (M_s) and permeability (μ), as well as low coercive force (H_c) and core loss (W). Up to now, ferromagnetic amorphous alloys have shown great industrial value for commercial application. Many products consisting of these kinds of metallic glasses have been widely used, for example anti-theft labels and high efficient magnetic transformers in electronic industry. Multi-component ferromagnetic alloys, such as Fe-(Al,Ga)-(P,C,B,Si), Fe-(Zr,Hf,Nb,Ta)-B and Fe–(Cr,Mo)-(C,B,P) systems, allow to decrease the critical cooling rate of glass formation, and enable the formation of bulk metallic glasses (BMGs), which not only ensure the fabrication stability during glass formation, subsequent heat treatment processes and shaping operations, but also give ferromagnetic metallic glasses potential applications as advanced structural materials because of their high fracture strength and high corrosion resistance. Recently, (Fe-Co)-B-Si-Nb BMGs were produced which exhibit high glass-forming ability (GFA) as well as good mechanical and magnetic properties (σ_f: ~4000 MPa; M_s: ~1 T; μ: ~12000; H_c: ~2 A/m) [1]. These alloys are regarded as one of the most attractive candidates for application combining the advantages of functional and structural materials. Thus, enormous efforts have been undertaken for this alloy system, especially for the $[(Fe,Co)_{0.75}Si_{0.05}B_{0.25}]_{96}Nb_4$ glassy alloy, in order to elucidate GFA, thermal stability, mechanical and soft magnetic properties, as well as the effect of minor Cu addition on the physical properties. Studies of crystallization and its effect on the magnetic properties in this system are essential for possible commercial application, similar like in the case of FINEMET-type alloys. However, few works have been devoted to this topic so far. In this paper, $\{[(Fe_{0.5}Co_{0.5})_{0.75}Si_{0.05}B_{0.20}]_{0.96}Nb_{0.04}\}_{100-x}Cu_x$ glassy alloys (x = 1, 2 and 3) were chosen for investigation. The GFA and the thermal stability of these alloys were evaluated. The effects of crystallization during heat-treatement processes on the phase evolution, the kinetics parameter and the magnetic properties, including M_s, H_c and T_c, in these alloys were investigated. The phase analyses were done with the help of the X-ray diffraction patterns recorded *in-situ* by using the synchrotron radiation in transmission configuration.

References

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