Effect of Fe on the Magnetic Properties for Co-based Amorphous alloys

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1. Introduction

Metallic glasses composed of transition metals (such as Fe, Co, and Ni) and of metalloids (such as B and Si) have good soft magnetic properties. Especially, the synthesis of iron- and cobalt-based magnetic amorphous alloys has attracted attention due to their enormous potential in magnetic applications [1]. Amorphous ferromagnetic alloys are being developed for motor, electrical transformers, switching power supplies, sensors, and other electrical energy conversion devices [2, 3].

Fe-Co system exhibits the high saturation magnetization and the permeability in comparison to Fe-only and Co-only cases. Furthermore, the substitution of Co for Fe enhances glass-forming ability (GFA) [4]. Fe-Co-B-Si alloys were reported to exhibit good soft magnetic properties in 1974 [5]. The melt-spun (Fe, Co)-B-Si amorphous alloys have been used as soft magnetic materials in pole and switching transformers named by METGLAS [6]. However, these amorphous alloys do not have high GFA. Cr is a key to solving this problem. It is well known that small additions of Cr lead to an increase in GFA together with an enhancement of their soft magnetic properties of Fe-Si-B ternary amorphous alloys [7].

In this study, we research $(Co_{1-x}Fe_x)_{72}B_{19.2}Si_{4.8}Cr_4$ ($0 \leq x \leq 1$) in order to investigate the effect of Fe on the magnetic properties for Co-based amorphous alloys.

2. Experiment

Alloy of the composition $(Co_{1-x}Fe_x)_{72}B_{19.2}Si_{4.8}Cr_4$ ($0 \leq x \leq 1$) were prepared by melting high purity constituent elements in arc-melting under a Ti-gettered argon atmosphere. Each ingot was re-melted at least four times to maximize compositional homogeneity. Amorphous ribbons were produced by melt spinning using a wheel speed of 39.27 m/s in an argon atmosphere. The ribbons were typically 2 mm in wide and 30 μm in thick. The composition and structure of ribbons identified by X-ray diffraction (XRD) with Cu-Kα radiation. Thermal stability associate with the crystallization temperature (T_x) was measured using a differential scanning calorimeter (DSC). About 20 mg of the sample was placed in a crucible and heated from room temperature to 1100 K (826.85 ℃) in an argon atmosphere at a rate of 0.34 K/s. The saturation magnetization (M_s) at room temperature was measured in a maximum applied field of 800 kA/m with a vibrating sample magnetometer (VSM).

3. Result and discussion

The effect of variable Fe and Co content on the thermal and magnetic properties for $(Co_{1-x}Fe_x)_{72}B_{19.2}Si_{4.8}Cr_4$ ($0 \leq x \leq 1$) amorphous ribbons has been established. The Co-Fe-B-Si-Cr glassy ribbons exhibited soft magnetic properties with a high saturation magnetization. Also, these amorphous materials had no crystal anisotropy. It was found that the crystallization temperature of the alloy with 50.4 at.% Fe ($x = 0.7$) has a maximum value. It was also found that the saturation magnetization of the alloy with 64.8 at.% F ($x = 0.9$) was superior compared with

the others.

4. References

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