Q-20

Annealing Temperature Dependence of Magnetic Anisotropy in $Co_{66}Fe_4Si_{15}B_{15}$ Amorphous Ribbon

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1. Introduction

It has been reported that the effective anisotropy field plays a significant role in magnetoimpedance (MI) [1]. However, it hasn't been explained about contribution of nanocrystalline to induced anisotropy in detail. In this work, we will discuss magnetic anisotropy from GMI profiles in terms of nanocrystalline distribution change under different annealing temperature.

2. Experiment

The *amorphous ribbons*, $Co_{66}Fe_4Si_{15}B_{15}$, were annealed at temperatures from 200 ℃ to 500 ℃ *in vacuum* applying a field amplitude of 3 Oe for 8 hours. The *ribbons*, 20 μm thickness, 2 mm width, 3 cm length, were used to measure magnetoimpedance (MI) profiles using a HP4192A impedance analyzer at *room* temperature. The microstructures of the annealed *ribbons were also examined* by transmission electron microscope (TEM).

3. Result and Discussion

The microstructures of the $Co_{66}Fe_4Si_{15}B_{15}$ ribbons annealed at *each* temperature were examined by TEM. It was observed that *almost no* crystallines could be seen when T_a is less than 400 ℃, however, many nanocrystallines could be observed when T_a was higher than 450 ℃, It can be seen that grain size ranges from a few nanometer at T_a=450 ℃ to 12-13 nm at T_a=500 ℃. It reveals that the number and average size of the crystallites increase with increasing annealing temperature.

Figure 1 (a) and (b) show the GMI profile of *ribbon annealed* at T_a=200 ℃ and 400 ℃ for the frequency of 10 MHz, respectively. It appears double-peak GMI profile, and GMI ratio maximum ($GMIR_m$) is about 28 % in Fig. 1 (a), however Fig. 2 (b) shows single peak profile, and $GMIR_m$ is about two times than that at 200 ℃. $GMIR_m$ dependence of annealing temperature was plotted in Fig.2. It can be seen that $GMIR_m$ value shows sensitive reflection to annealing temperature, that is, $GMIR_m$ depends on the formation of nanocrystallines in the matrix of amorphous phase. $GMIR_m$ value increases with annealing temperature, and shows maximum value

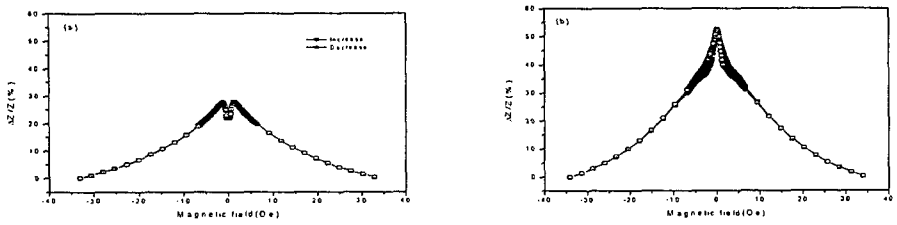

Fig.1 GMI profile of ribbon annealed at 200 ℃ and 400 ℃, respectively.

56.8 % at T_a=300 ℃, little decrease at T_a=400 ℃, then decreases linearity with longer annealing temperature for the frequency of 10 MHz. Moreover, anisotropy field H_k as a function of annealing temperature was also shown in Fig.3. Anisotropy field decreases when the temperature is raised to 400 ℃, however, when the annealing temperature continues to increasing, anisotropy field trends to increase sharply. It reveals that $GMIR_m$ value increases when the temperature is less than about 400 ℃ due to the reduction of anisotropy field originating from fabrication stress, then decreases when T_a is higher than about 400 ℃ because of many crystallines impede in the amorphous matrix during the annealing.

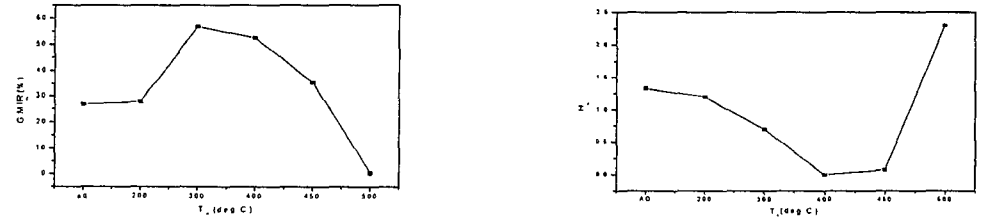

Fig.2 $GMIR_m$ versus annealing temperature. Fig.3 H_k as a function of annealing temperature T_a.

4. Conclusion

Co-based amorphous ribbons were annealed in vacuum at different annealing temperature during 8 hours applying a field of 3 Oe. In this work, both microstructure change and GMI effect were investigated. The ribbons annealed below 400 ℃ exhibit ultra softness, however, the ribbons annealed at higher temperature above 450 ℃ show low $GMIR_m$ due to formation of majority of nanocrystalline phase in amorphous matrix which leads to large increment of anisotropy field.

5. Reference

[1] C.G.Kim et al. Journal of Magnetics 3(4), 123-126 (1998).