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SOFT MAGNETIC PROPERTIES OF Fe/CoNbZr MULTILAYERS BY HEAT TREATMENT

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1. Introduction

In recent years, the operating frequency of soft magnetic materials has increased. To obtain high performance magnetic heads, it has been suggested the magnetic materials should possess high saturation magnetic flux density and high permeability at high frequency. In general, magnetic materials such as Fe-based films have attracted attention due to saturation magnetic flux density. Fe-based nanocrystalline or multilayered films, prepared by inserting intermediate layers, are being studied in an attempt to obtain the high relative permeability[1,2]. The good soft magnetic properties of Fe-based multilayers were explained by small grain size of Fe below the domain wall width. In order to improve the soft magnetic properties of Fe/CoNbZr multilayers, the effect of magnetic layer thickness, deposition and annealing conditions were studied.

2. Experimental

500 nm thick Fe (x nm)/CoNbZr (10 nm) multilayered films were deposited on Si (100) by using rf magnetron sputtering apparatus. The base pressure in the process chamber was less than 9×10^{-7} Torr. Deposition gas pressure was kept constant at 2 mTorr. Sputtering rf powers for Fe and CoNbZr are 200 W and 130 W, respectively. Heat treatment was performed at 250 ~400 ℃ for 10~50 min in a vacuum, under applied in-plane magnetic field of 1.2 kOe. The saturation magnetization $4\pi M_s$ and coercivity H_c were measured by a vibrating sample magnetometer. The permeability μ was measured from 0.5 to 100 MHz at 2.12 Oe ac field by using 8-figure coil method. Microstructures were characterized by X-ray diffraction (XRD) with Cu K-α radiation

3. Results and discussion

In as-deposited films, we observed the minimum coercivity (1.1 Oe) at the thinnest Fe layer thickness (5 nm). Coercivity increased with increasing Fe layer thickness. This is related with the grain size of Fe. However, maximum 2300 of μ was obtained at 15 nm thick Fe layer. Degradation of μ at thinner Fe layer region is due to the interdiffusion layer or defects, such as Fe-Co alloy that has high magnetostriction at the interfaces. Furthermore, the high saturation magnetic flux density of 1550 emu/cc was obtained when Fe layer thickness is 15 nm. Heat treatment effects for these multilayers were studied at 250~400 ℃. Coercivity has minimum value at various temperature when the multilayer has annealed for 30~40 min. At 250~300 ℃, permeability increased until 40 min, then decreased after 40 min. On the contrary, at 350~400 ℃, permeability decreased gradually with annealing time. These results may closely be related with total magnetic anisotropy energy by lattice deformation. Maximum permeability of 2500 was obtained through the annealing for 40 min at 300 ℃. At the same time, we obtained minimum coercivity of 0.35 Oe.

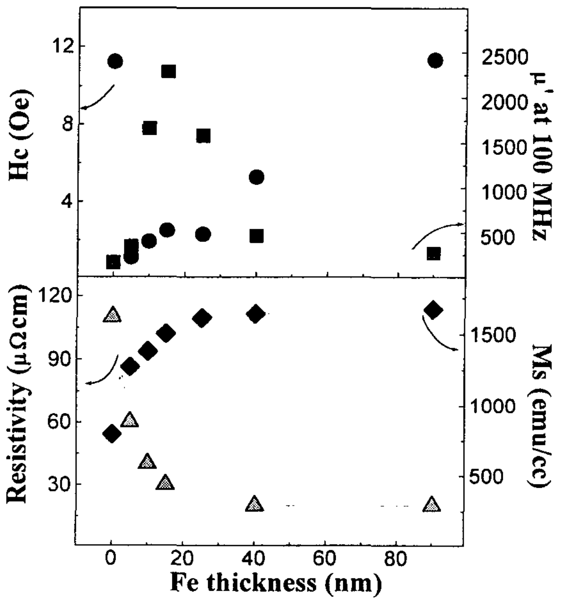

Fig. 1. Variation of H_c, μ (100 MHz), M_s and resistivity of Fe/CoNbZr multilayer as a function of Fe layer thickness.

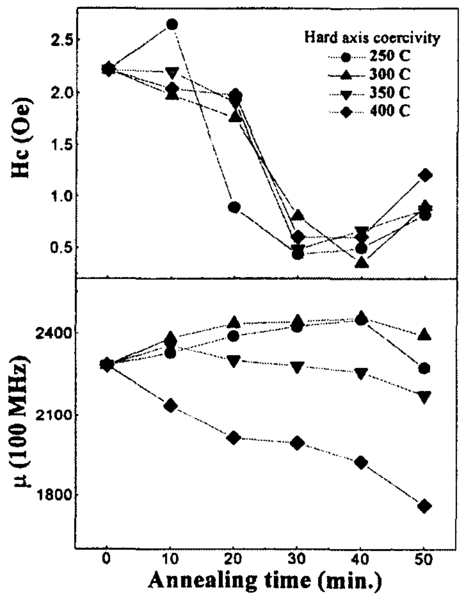

Fig. 2. Hc and μ (100 MHz) with annealing condition of $[Fe\ 15\ nm/\ CoNbZr\ 10\ nm]_{20}$ multilayer

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References

[1] F. W. A. Dirne, F. J. A. den Broeder, J. A. M. Tolboom, H. J. de Wit, and C. H. M. Witmer, Appl. Phys. Lett. 53, 2386 (1988)

[2] M. Takahashi and T. Shimatsu, IEEE Trans. Magn. 1485 (1990)