V-12

High Frequency Soft Magnetic Properties of $(Co_{1-x}Fe_x)$-Al-O Granular Films with High Electrical Resistivity

Korea University Jaecheon Sohn*, Dongjin Byun
KIST Sang Ho Limb

I. Introduction

There has been a demand for higher frequency operation of magnetic devices. Consideration of the materials that could be applicable to such high frequency applications is the first step when designing magnetic thin films for high-frequency use. Materials suitable for high frequency application should have a larger M_S and an appropriate anisotropy field (H_K), which increase a resonance frequency, and also a larger ρ, which reduces eddy current loss. To satisfy such requests, recent focus has turned to the study of nanogranular structured thin films. The nanogranular thin films consist of nanometer-scale ferromagnetic grains with an insulating amorphous phase covering the nanograins[1]. In this study we report on the fabrication and resulting high frequency soft magnetic properties of (Co-Fe)-Al-O nanogranular magnetic thin films exhibiting large M_S, appropriate H_K and high ρ, with a resulting high resonance frequency.

II. Experiment

(Co-Fe)-Al-O nanogranular magnetic thin films were prepared by radio frequency reactive magnetron sputtering in an O_2+ Ar atmosphere to a background pressure higher than 7×10^{-7} Torr. Co-Fe-Al composite targets composed of a Co-Fe alloy target and Al chips were used. The films were deposited on Si substrates (P-type) in a static field of 1 kOe to induce uniaxial magnetic anisotropy. Oxygen content in films was controlled by varying the ratio of O_2 to Ar in the sputtering atmosphere. Films were annealed for 1 h at 300 °C in a magnetic field of 1 kOe in a vacuum better than 5×10^{-6} Torr. The chemical composition of the films was analysed by EPMA. Film structures were investigated by XRD and HRTEM. Magnetization vs field was measured with VSM. The electrical resistivity was measured using the conventional four-probe method. The ferromagnetic resonance frequency(f_R) and μ_r at f_R were calculated by the following equations. $f_R = \frac{\gamma}{2\pi}\left(4\pi M_S H_K\right)^{1/2}$, $\mu_r = \frac{4\pi M_S}{H_K}$

III. Results and Discussion

With increasing Al content in these films, M_S decreases but H_K and ρ increase[2]. In order to obtain granular films with high M_S, the optimal composition for the films was controlled to be $(Co_{60}Fe_{40})_{84}Al_6O_{10}$.

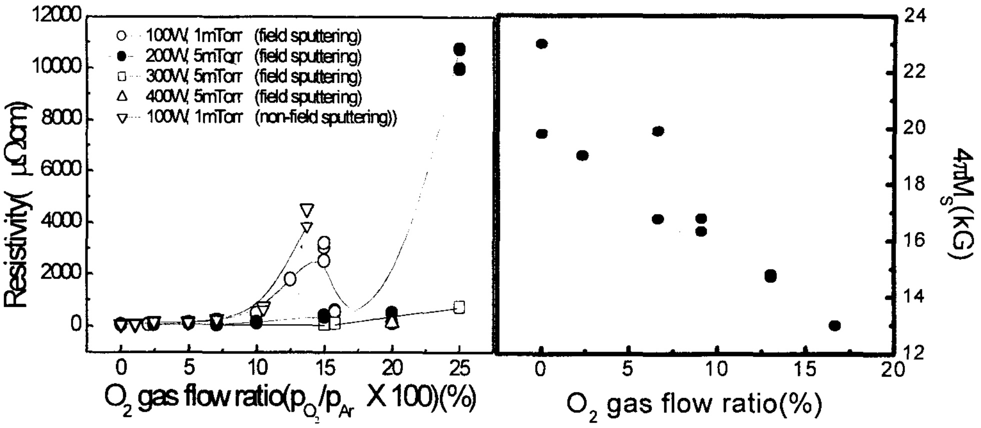
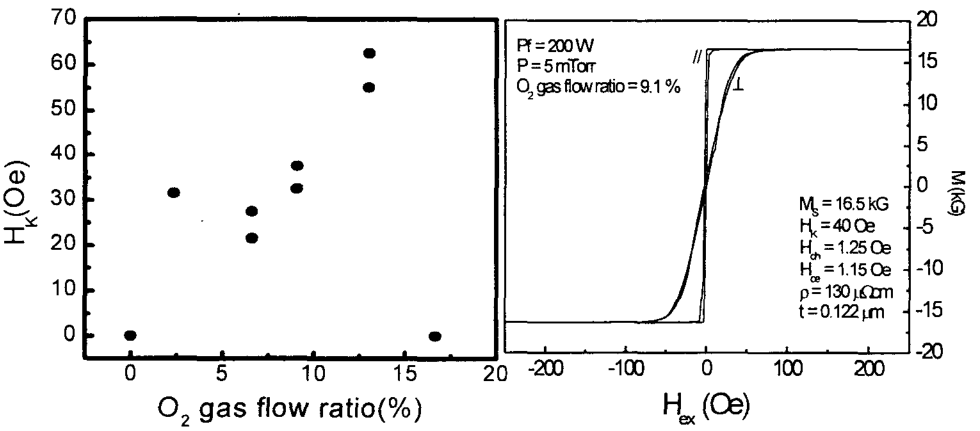


Fig1 shows $(Co_{1-x}Fe_x)$-Al-O granular films. The value of ρ increases with the oxygen gas flow ratio. The value of $4\pi M_S$ decreases with the oxygen gas flow ratio because non-magnetic layer of the amorphouse oxide phase increases in the microstructure. The value of H_K increases up to 13 % of the oxygen gas flow ratio and then decreases



abruptly. The maximum value of H_K is about 65 Oe at 13 % of O_2 gas flow ratio. And the H_K of about 40 Oe was obtained for the films deposited in 5 mTorr of the working pressure and in the input radio frequency power of 200 W, with the O_2 flow ratio of 9.1 %. As we can see the M-H loop, we obtained the very clear anisotropy properties. According to the equations stated above, the f_R and μ_r were calculated as 2.28GHz and 412.5.

IV. References

[1] H. Fujimori, Scr. Metall. Mater., 33 [10/11] 1625-36(1995)
[2] S. Ohnuma et al., J. Magn. Soc. Jpn. 22, 441 (1998)