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MAGNETIC PROPERTIES AND HIGH FREQUENCY RESPONSE FOR Fe-B-N SOFT MAGNETIC THIN FILMS

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Fe-B-N 연자성 박막의 자기적 성질 및 고주파 특성

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1. INTRODUCTION

FeXN (X=Ta, Ti, and Al, etc.) films with high saturation magnetization ($4\pi M_s$) have been proven to satisfy various requirements as a potential candidate for a thin film head material. These films were known to consist of α-Fe phase with slightly expanded lattice parameters. The electrical resistivity of these films is typical about 50 μΩcm around $4\pi M_s \sim 19$ kG. At high operating frequencies, it is known that the eddy current causes a reduction in the permeability, which in turn reduces the efficiency of head. Therefore, materials with high intrinsic resistivity can be used to reduce the eddy current loss. It is also desirable to have high corrosion resistance. [1]

This work showed the magnetic properties and high frequency response for as-deposited Fe-B-N thin films. Also, the electrochemical corrosion tests were performed with comparison to FeXN, Fe and Permalloy films in 0.5 M NaCl electrolyte.

2. EXPERIMENT

As-deposited Fe-B-N films with the variation of the nitrogen partial pressure (PN_2) from 0 to 6.5 % have been prepared by a reactive rf magnetron sputtering method at 450 W input power. And thickness of the film is about 5000 Å. The magnetic properties of the films were measured by vibration sample magnetometer (VSM). The frequency dependence of effective permeability (μ_{eff}) was measured by using an 8-figure coil method. The electrical resistivity of the films was measured by a four-point probe method. The microstructure was investigated by transmission electron microscopy (TEM) and x-ray diffraction (XRD) with CuK_α. Also, electrochemical corrosion data were obtained using an EG&G Par 273A electrochemical test system and 352 Softcorr corrosion software. Potentio - dynamic techniques were used to evaluate the localized corrosion resistance of the films.

3. RESULTS AND DISCUSSION

Fe-B-N films exhibit that the range of $4\pi M_s$ is 17-20 kG and coercivity (H_c) is 0.2 - 3 Oe, respectively. And the frequency dependence of effective permeabilities, μ_{eff} are maintained between 100 MHz and 400 MHz with the values of 1800-5300 (Fig. 1). Especially, $Fe_{85.9}B_{2.6}N_{11.5}$ film fabricated at 6.5% PN_2 exhibits excellent high frequency characteristics up to 400 MHz (μ_{eff}=1800) with high $4\pi M_s$ (~ 18 kG), anisotropy field H_k (~ 15 Oe) and high electrical resistivity (~ 100 μΩcm). It causes that the various meta-stable mixed phase including γ'-Fe_4N and Fe_3B phases exist in grain boundary of α-Fe grains below size of 5 nm, which was confirmed by XRD and TEM. Also, Additional fcc γ'-Fe_4N peaks *dominantly exhibit in the films over* PN_2 *4.5%. And the significant amount of fcc* γ'-Fe_4N *give rise to higher* resistivity and therefore improved high frequency permeability than conventional FeXN films.

By Electrochemical corrosion test under the condition with the 0.5 M NaCl electrolyte, corrosion resistance of these films exhibits excellent than that of FeXN films significantly improved compared to a FeHfN film (Fig. 2)

We successfully fabricated high moment as-deposited Fe-B-N films with soft magnetic properties and excellent pitting corrosion resistance.

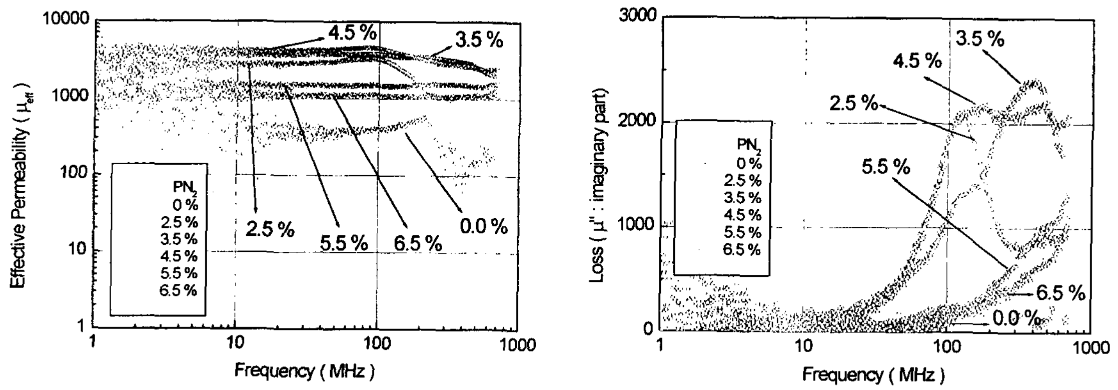

Fig. 1 Frequency dependency of permeability for Fe-B-N thin films (a) effective permeability (b) loss.

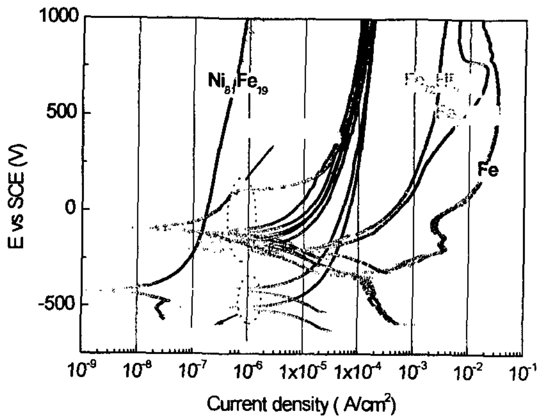

Fig. 2 Anodic polarization curves for FeBN films comparing Permalloy, Fe, FeHfN, and FeTIN films

4. REFERENCES

[1] Yingjian Chen, Chester Qian, Chin-Ya Hung, and Mark Miller, J. Appl. Phys., vol. 87, No.9, pp. 5864-5866, 2000.