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고 포화 자화 및 우수한 고주파 특성을 가진 나노결정 FeCoTaN 박막의 제조

한양대학교 신재민*, 김종렬

한국과학기술연구원 김윤명, 한석희, 김희중

Fabrication of Nanocrystalline FeCoTaN Magnetic Films Having High Saturation Magnetization and Excellent High Frequency Characteristics

Hanyang University J. M. Shin*, J. Kim

Korea Institute Science and Technology Y. M. Kim, S. H. Han, and H. J. Kim

1. Introduction

High saturation magnetization (B_s) and excellent high frequency characteristics of magnetic thin films has been recognized as the most important requirement for further miniaturization and higher frequency operation in magnetic devices, such as magnetic heads and magnetic sensors . Up to now, Fe-X-N (X =Ti, Hf, and Al etc.) films with B_s of 15 ~ 19 kG and coercivity (H_c) of 0.5 ~ 5.0 Oe have been successfully fabricated and proven to satisfy various requirements as a potential candidate for thin film head materials. In these films, the effective permeability rapidly deteriorate above 100 MHz owing to relatively low electrical resistivity (, ~50 μΩ·cm) and small anisotropy magnetic field (H_k, ~ 5 Oe). For the further improvement of high frequency characteristics, the needs of new magnetic films with high B_s and H_k increase.

In general, adding Co on Fe-based films is expected to increase the B_s and H_k. Previously, we investigated the magnetic properties of as-deposited Co-Ni-Fe and Co-Ni-Fe-N soft magnetic thin films. It was shown that both films did not increase the B_s and H_k simultaneously [1-2]. In this experiment, we, therefore, aim to develop a new soft magnetic thin film with high B_s and excellent high frequency characteristics.

2. Experimental method

As-deposited Fe-Co-Ta-N soft magnetic thin films were fabricated by rf magnetron sputtering using a composite target. The deposition was carried out under an (Ar + N_2) atmosphere with a total gas pressure of 1 m Torr. The rf input power was fixed at 450 W, and the nitrogen partial pressure (P_{N2}) varied in the range of 0 ~ 10 % of the total pressure. The film with a thickness of 250 nm was deposited on Si (100) substrate. The microstructures of the films were analyzed by X-ray diffraction (XRD) and transmission electron microscopy (TEM), and the chemical composition analyzed by Auger electron spectroscopy (AES). B_s, H_c, and H_k of these films were measured by a vibrating sample magnetometer (VSM). The permeability and ρ were measured by a high permeability measurement system and a four-point probe method, respectively. The corrosion resistance of Fe-Co-Ta-N thin films was investigated using an EG & G Par 273A electrochemical test system and 352 Softcorr corrosion software. The measurement were carried out at room temperature in an EG & G flat cell with a circular area of pH = 6.0.

3. Results and Discussion

Fig. 1 shows the frequency dependence of $Fe_{78}Co_8Ta_9N_5$ films fabricated at 4 % P_{N2} in which is B_s 21 kG, H_c 3 Oe, ρ ~100 $\mu\Omega$·cm, and H_k 20 Oe. As shown, the effective permeability of these films is about 2000, and maintained up to 700 MHz. This result proves that the FeCoTaN films have excellent higher frequency characteristics, partly due to the high ρ and to the high H_k both of which reduce the eddy current losses. In addition, the structural analysis of these films by XRD and TEM showed that the reduction of grain size from 50 to 7 nm with the increment of P_{N2} played an important role in the reduction of coercivity.

To ensure reliability in the process of magnetic devices, magnetic films must possess good corrosion resistance. The corrosion resistance of FeCoTaN films was investigated by electrochemicalcorrosion test under the condition with the 0.5 M NaCl electrolyte. As shown in Fig.2, the corrosion resistance of these films was improved with the increment of N concentration and higher than that of CoNiFe and FeHfN films.

4. Conclusion

The effects of nitrogen partial pressure, magnetic properties were investigated in Fe-Co-Ta-N thin films. An excellent soft magnetic film ($Fe_{78}Co_8Ta_9N_5$) with B_s of 21 kG, $H_{c\text{-}hard}$ of 3 Oe was obtained at the nitrogen partial pressure of 4%. Since the film had ρ of 100 $\mu\Omega$·cm, and H_k of about 20 Oe, the effective permeability is about 2000, which is maintained up to 700MHz. Furthermore, this film has better corrosion resistance than Co-Ni-Fe and Fe-Hf-N thin films. Due to these excellent properties, these films are promising for applications as a core material of writing heads and high frequency magnetic devices.

5. References

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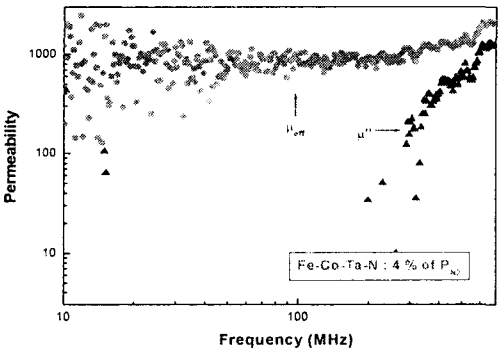

Fig1. Frequency dependency of permeability for $Fe_{78}Co_8Ta_9N_5$ films fabricated at 4 % of P_{N2}

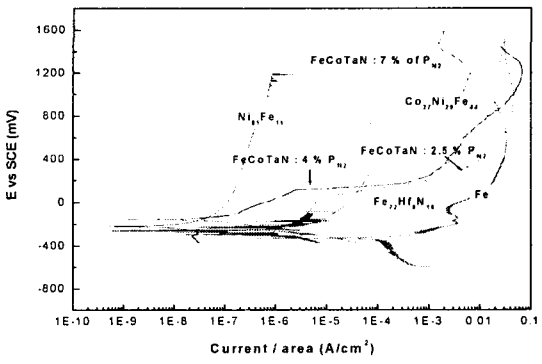

Fig. 2. Comparison of the Anodic polarization curves for Fe-Co-Ta-N films with Fe-Hf-N, Co-Ni-Fe.