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Co-Ni-Fe 과 Co-Ni-Fe-N 박막의 두께변화에 따른 고주파 특성의 변화에 대한 연구

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The Study of High Frequency Characteristics of Co-Ni-Fe and Co-Ni-Fe-N Thin Films with Film Thickness

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1. Introduction

Recent developments in electronic devices have led to demands for higher frequencies operation of magnetic devices such as magnetic heads and magnetic sensors. For these high frequency magnetic devices, the development of soft magnetic thin films with excellent high frequency characteristics is the very important issue. We recently have reported as-deposited Co-Ni-Fe and Co-Ni-Fe-N soft magnetic thin films with high saturation magnetization (B_s). In order to apply these films for high frequency magnetic devices, it is needed to understand the high frequency behavior of these soft magnetic thin films. So, we have studied the thickness effects on the high frequency characteristics of these films.

2. Experimental

As-sputtered Co-Ni-Fe and Co-Ni-Fe-N soft magnetic thin films, which composition ranges are Co22-25Ni29-34Fe42-48 and Co21-24Ni27-30Fe43-49N2-5, respectively, were deposited on Si(100) substrate using rf reactive magnetron sputtering method. The sputtering chamber was first pumped down to ~ 7.0×10^{-7} Torr. The high frequency characteristics and magnetic properties of these films were investigated as a function of film thickness with the range of 0.01 – 1.0 μm. The microstructure was analyzed by x-ray diffraction (XRD) and transmission electron microscopy (TEM). The film composition was determined by electron probe analysis (EPMA). $4\pi M_s$ and Coercivity (H_c), and magnetic anisotropy field (H_k) were

measured by an vibrating sample magnetometer (VSM). The permeability and the electrical resistivity were measured by a permeability measurement system using s-parameter and network analyzer and four-point probe method.

3. Results and Discussion

As for Co-Ni-Fe thin films, the H_c is increased from 1.5 Oe to 8.9 Oe with thw decrease of the film thickness. The electrical resistivity also is increased from 25 μΩcm to 88 μΩcm with the decrease of the film thickness. The initial permeability of these films is about 1100, which is maintained up to 200 MHz at 0.5 μm thickness, and above 700 MHz below 0.05 μm thickness. The changes in coercivity and electrical resistivity of Co-Ni-Fe-N thin films with the film thickness showed similar trend with those of Co-Ni-Fe thin films. In case of Co-Ni-Fe-N films H_c and electrical resistivity are increased from 1.1 Oe and 53 μΩcm to 5.5 Oe and 188 μΩcm, respectively, with the decrease of the film thickness. The initial permeability of Co-Ni-Fe-N films is about 850, which is maintained up to 400 MHz at 0.5 μm thickness, above 700 MHz below 0.1 μm thickness. Therefore Co-Ni-Fe-N thin films show the excellent high frequency characteristics, which is interpreted to be due to the high electrical resistivity and anisotropy field.

We also investigated the microstructure of these films through XRD patterns and TEM observation. For Co-Ni-Fe thin films, the α-FeCo(110) peaks are clearly observed in films above 0.3 μm thickness, and for Co-Ni-Fe-N thin films, the NiFe(200) peaks are clearly observed in films above 0.1 μm thickness. Whereas, both films below 0.1 μm thickness are constituted of amorphous phase, which gradually are changed to crystalline structure as the film thickness increase. It is considered that high electrical resistivity below 0.1 μm thickness is partly due to the amorphous phase.

4. Conclusions

As-sputtered Co-Ni-Fe and Co-Ni-Fe-N soft magnetic thin films have showed the excellent high frequency characteristics below 0.3 μm film thickness. Therefore, these films are the good candidates for high frequency magnetic devices.