Underlayer Effects on the Magnetic Properties of Electrodeposited, High Moment Fe-Co-Ni Thin Films

Xiaomin Liu and Giovanni Zangari
Department of Metallurgical and Materials Engineering
and Center for Materials for Information Technology
The University of Alabama, Tuscaloosa, AL 35487

Soft, high moment FeCoNi films with thickness in the range 50–1200 nm were electrodeposited at constant current density on non-magnetic (100 nm Cu), ferromagnetic F (100 nm $Fe_{20}Ni_{80}$), antiferromagnetic AF (10 nm FeMn), and composite AF/F (F on top) underlayers from a sulfate-based electrolyte without any organic additives. All underlayers were DC sputtered onto a Si substrate, without stripping its native oxide. The influence of the underlayer on alloy composition, structure and magnetic properties – in particular, dispersion of the easy axis, coercivity and anisotropy field – was investigated.

Film composition (as determined by EDX) was approximately constant at $Fe_{34}Co_{47}Ni_{19}$ (at %) down to a thickness of ~ 100nm. Below this thickness, Ni content decreased slightly and Fe content correspondingly increased. All films exhibited mixed FCC/BCC phases, with the relative amount of FCC phase increasing with thickness (Fig. 1). The BCC content decreases from 73.4% to 27.7% by increasing the film thickness from 130 nm to 1130 nm. Correspondingly, an increase in saturation magnetization Ms with decreasing thickness was observed (shown in fig.2).

Fig. 3 shows hysteresis loops of FeCoNi films with ~300 nm thickness on different underlayers. Films grown on Cu or FeMn exhibit an open hard axis loop, with coercivity H_c ~ 4 Oe. As shown in fig. 3(b), FeCoNi films on $Fe_{20}Ni_{80}$ underlayer exhibit a well-defined uniaxial anisotropy, M_s ~ 21 kG, easy axis H_c =1.5 Oe, anisotropy field H_k~20 Oe, and very small hard axis hysteresis. Films grown on FeMn/$Fe_{20}Ni_{80}$ underlayers show very similar properties. The Permalloy layer can thus improve the uniaxial anisotropy of FeCoNi through exchange coupling, while FeMn does not exchange couple effectively to FeCoNi, perhaps due to oxidation of the underlayer upon exposure to air prior to deposition. The permeability at 10 MHz for all films is in the range 800-1300, showing no definite dependence on the film thickness or underlayer.

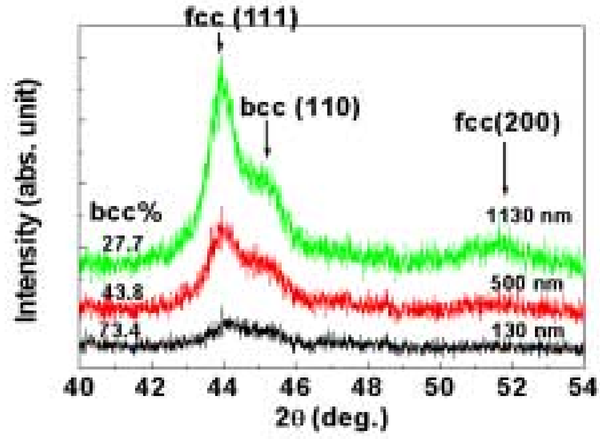

Fig.1 Glancing angle XRD spectra of FeCoNi films of varying thickness on $Fe_{20}Ni_{80}$ underlayers.

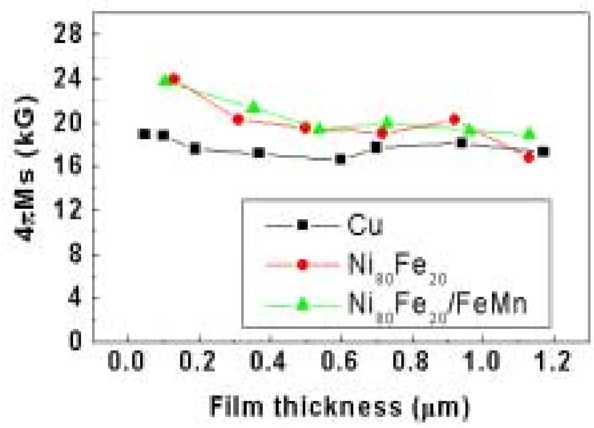

Fig.2 Saturation magnetization as a function of film thickness and underlayer.

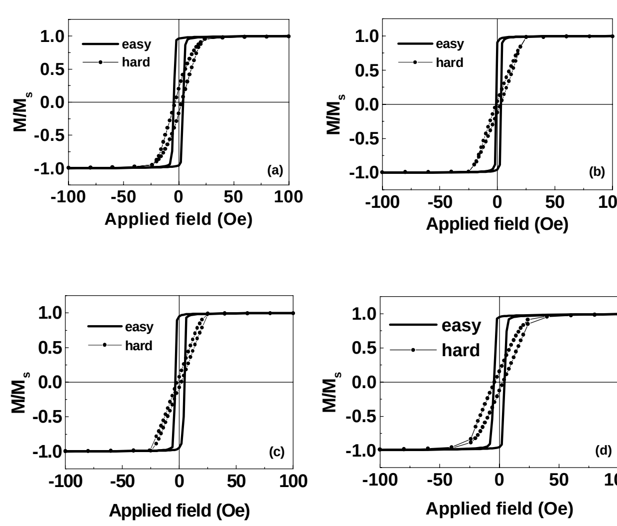

Fig.3 In-plane hysteresis loops along the easy and hard axis of FeCoNi films (~300nm) on different underlayers. (a) Cu; (b) $Fe_{20}Ni_{80}$; (c) FeMn/$Fe_{20}Ni_{80}$; (d) FeMn.