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MAGNETIC AND STRUCTURAL CHARACTERIZATION OF CoNiCr THIN FILM MEDIA

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Abstract. – Thin $Co_{62.5}Ni_{30}Cr_{7.5}$ films were rf-sputtered onto glass and Cr/glass. Magnetic anisotropy, coercivity and magnetization were compared with inferences from structural characterization. For CoNiCr/glass narrow FMR line widths ΔH, low coercivity H_c and effective anisotropy field H_{keff} values close to $-4\pi M_s$ were observed. For CoNiCr/Cr/glass broader ΔH, larger H_c and H_{keff} deviating from $-4\pi M_s$ were observed. Crystal texture and grain growth depended on the presence/absence of a Cr underlayer.

1. Introduction.

Thin CoNiCr film media have been proposed for longitudinal recording applications both for their desirable magnetic properties [1, 2] and corrosion resistance [3]. It has been reported that the coercivity can be increased by depositing a Cr underlayer [1]. We present in this paper our correlations of the magnetic and structural properties of both CoNiCr/glass and CoNiCr/Cr/glass samples.

2. Sample preparation and characterization

Samples were deposited on 2 in glass wafers by rf diode sputtering in a L-H Z400 system. The argon pressure was set at 10 mT. The alloy target composition is Co-30Ni-7.5Cr(at. %) The CoNiCr was deposited at 5.5 nm/min. The Cr was deposited at 5 nm/min. Specimens were examined with a 33 GHz ferromagnetic resonance (FMR) spectrometer. The dependence of resonant field on sample orientation was consistent with uniaxial magnetic anisotropy [4]. Samples were also examined with a vibrating sample magnetometer (VSM) and a torque magnetometer (TM). Very thin samples ($t < 15$ nm) were measured with a SQUID magnetometer. The crystal structure was studied by transmission electron microscopy (TEM).

3. Results and discussion

For CoNiCr/glass the FMR line width ΔH increases with increasing film thickness, ranging from 200 to 600 Oe. Effective magnetic anisotropy, H_{keff}, values of CoNiCr/glass samples with different CoNiCr layer thicknesses are shown in figure 1. The dotted line denotes the magnetic induction ($-4\pi M_s$) as measured by VSM and SQUID. For all samples, differences between H_{keff} and $-4\pi M_s$ are less then 600 Oe. Hence, for these as-sputtered CoNiCr/glass films demagnetization anisotropy dominates. In-plane coercivity (H_c) values are small and increase with increasing film thickness. Squareness ratio S decreases with increasing CoNiCr thickness. See figure 1.

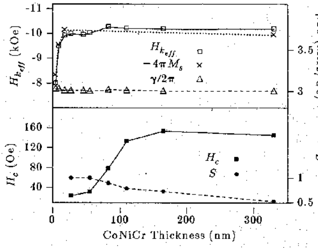

Fig. 1. – CoNiCr/glass: H_{keff}, $4\pi M_s$, γ / 2π, H_c and S *vs.* CoNiCr thickness.

TEM showed that these CoNiCr/glass films are predominantly hcp. Occasionally, the fcc phase has been detected [5]. Initially deposited film layers are amorphous. With increasing thickness, small grains appear and grow in the form of laterally expanding conical columns. Grain sizes found at the upper film surface were 5-12 nm for 28 nm thick film; 20 nm for 78 nm thick film; 80 nm for 165 nm thick film (Fig. 2). The FMR line width ΔH and H_c mimicked this thickness behaviour. Electron diffraction showed that the grains initially are randomly oriented; as film thickness incrases c-axis texture develops. The top of a 78 nm thick film already is significantly c-axis textured. C-axis texture dominates the top of a 156 nm thick film. Since from FMR the change of magnetic anisotropy accompanying this c-axis re-orientation is small, the intrinsic crystal anisotropy presumably is small.

CoNiCr/Cr/glass specimens differed significantly, magnetically, from CoNiCr/glass. The ΔH values are

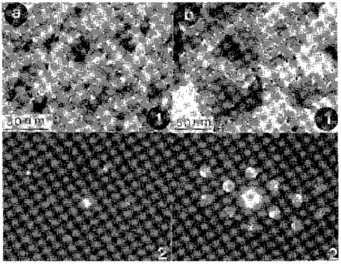

Fig. 2. – Bright field TEM images (1) of CoNiCr/glass films and representative convergent beam electron diffraction (CBED) patterns (2): a) t_{CoNiCr} = 28 nm, b) t_{CoNiCr} = 165 nm.

much larger (> 3 kOe). The H_{keff} values measured for a series of samples with a CoNiCr thickness of 100 nm but with different Cr underlayer thicknesses are shown in figure 3; similar TM-derived data were also obtained. The $4\pi M_s$ value for CoNiCr/glass is the same as that of CoNiCr/glass, about 10 kG. The difference between H_{keff} and $-4\pi M_s$ is about -2 to -3 kOe. We believe that in this case stress affects both H_{keff} and ΔH significantly. The H_c values for CoNiCr/Cr/glass are much larger than those of CoNiCr/glass. The increase of H_c with increasing Cr layer thickness is also shown in figure 3. However, S does not change significantly. Also, at fixed Cr underlayer thicknesses H_c decreases with increasing CoNiCr thickness.

The crystal structure of CoNiCr/Cr/glass also differs from that of CoNiCr/glass. Initially the grains replicate those of the Cr underlayer. Grain size increases with increasing CoNiCr layer thickness. The presence of a Cr underlayer also tends to induce $[\bar{1}011]$ and $[10\bar{1}0]$ texture in the CoNiCr close to the interface. This texture effect is enhanced by a thicker Cr underlayer. As the CoNiCr thickness increases c-axis texture develops, but more slowly than in CoNiCr/glass. At the top of a sample with t_{CoNiCr} = 100 nm and t_{Cr} = 25 nm c-axis texture was dominant; for a sample with t_{CoNiCr} = 100 nm and t_{Cr} = 500 nm, $[\bar{1}011]$ and $[10\bar{1}0]$ texture dominate; (Fig. 4). Large H_c values seem to be associated with the presence of $[\bar{1}011]$ and $[10\bar{1}0]$ texture.

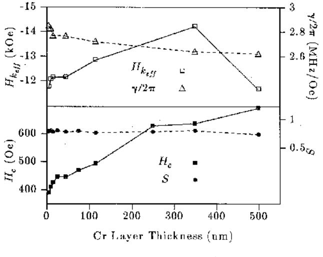

Fig. 3. – CoNiCr/Cr/glass: H_{keff}, $\gamma/2\pi$, H_c and S *vs.* Cr thickness, CoNiCr thickness fixed at 100 nm.

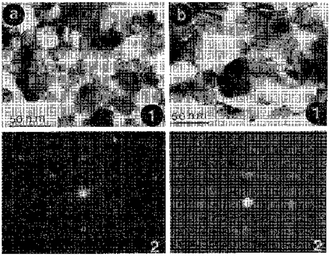

Fig. 4. – Bright field TEM images (1) of CoNiCr/Cr/glass films and representative CBED patterns (2): a) t_{Cr} = 25 nm, t_{CoNiCr} = 100 nm, b) t_{Cr} = 500 nm, t_{CoNiCr} = 100 nm.

4. Conclusions

Significant differences in both the magnetic and structural properties were observed when comparing CoNiCr/glass and CoNiCr/Cr glass films. Demagnetization dominates the anisotropy in CoNiCr/glass. The crystal structure of the CoNiCr layer is modified by the presence of a Cr underlayer. The structural nature of the underlayer at the interface plays a significant role in the determination of the CoNiCr magnetic properties.

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