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SPUTTERED CoNi/Pt MULTILAYERS FOR M.O. APPLICATION

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In an earlier paper we have reported about prelimary results of evaporated CoNi/Pt multilayers [1] The main result at that time was a substantially lower Curie temperature for a $Co_{60}Ni_{40}$/Pt multilayer in comparison with the known Co/Pt having the same magnetic parameters. A study of the bulk magnetic phase diagrams shows a lowered T_c for adding Ni into Co. The problem by tailoring the composition for the T_c is that one also have to consider the Kerr rotation because this value scales with the magnetic moment of the multilayer.

Experimental

$Co_{50}Ni_{50}$/Pt multilayers have been sputtered at $P_{ar} = 1.6 \cdot 10^{-2}$ mbar after obtaining an $P_{back} \leq 10^{-8}$ mbar. The target-substrate distance was 100 mm and the substrate temperature was ambient. Deposition rate used were 0.13 nm/s for the CoNi and 0.3 nm/s for the Pt layer. A Pt seedlayer was used on a substrate of glass or Si(100). The MO characterization (polar Kerr rotation and ellipticity) was carried out at wavelenghts of 1.3-4.0 eV at a max field of 0.6 T. With a special stage temperature dependent Kerr measurements from RT to 400°C have been performed. Cross-section and plane view TEM samples have been prepared and studied with a Philips CM30-STEM microscope (see fig 1a). Domain observations were done with this microscope and MFM.

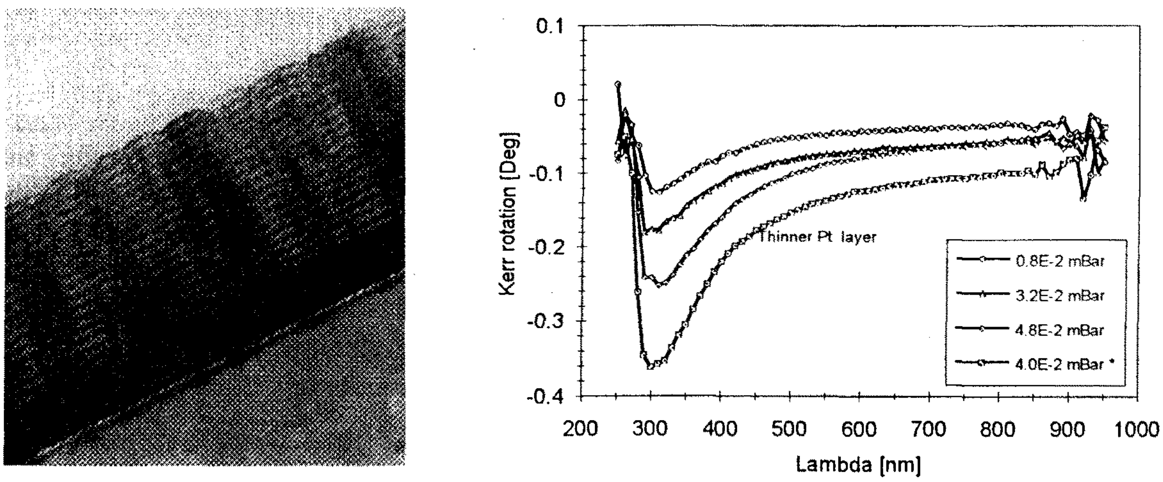

Fig. 1. a) Cross section TEM micrograph of 17 CoNi (3.75 nm)/Pt(1.47nm) bilayers on a 23.5 nm Pt seedlayer on Si. b) Wavelenght dependent Kerr rotation for several samples sputtered with different Ar pressure.

The multilayers clearly grow with a columnar morphology. The columnar size depends on the growing conditions but has an average size of about 22 nm. The crystal size of the Pt seedlayer is about twice as large. The fcc structure shows the [111] as the favourite direction for the film growth. Most of the thick samples have shown a curved multilayer structure probably due to the lattice mismatch. Bias sputtered samples show a smoother structure and a lower H_c. Films with higher H_c's can be explained by the pinning effect of the structure discontinuities to the magnetic domain walls.

In the multilayer composition of 235 Å Pt + 17*(t Å CoNi / 14 Å Pt) t was varied between 4 and 38 Å. The hysteresis squareness is unity up t = 8.8 Å. Wavelenght dependent Kerr measurements for various Argon pressures have shown a max $\theta_k = 0.35°$ around $\lambda = 300$ nm (See fig 1b).
By annealing certain $Co_{50}Ni_{50}$/Pt multilayers we found that the structural and magnetic properties remained stable after annealing at 250°C for 2 hours (Fig 2). Annealing above 250°C caused atomic diffusion and relaxation of stress, which result in changes in interfacial structures and magnetic properties. A remarkable change is that H_c enhanced after 2 hours annealing at 300°C while M_s and K_{eff} decreased slightly (See fig 3). From 300°C to 400°C, M_s, H_c and K_{eff} decrease rapidly to zero.

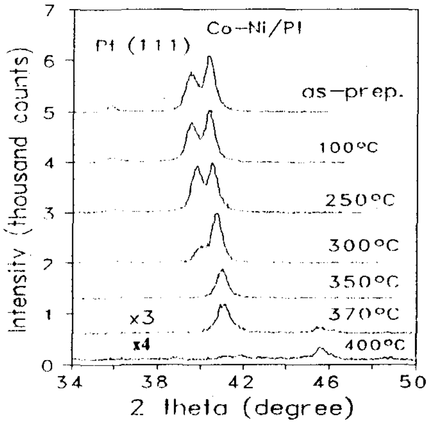

Fig.2 High-angle XRD patterns of a series of annealed samples. The layer thicknesses as sputtered are 235Å Pt+(6.3Å CoNi+14.7Å Pt)×17

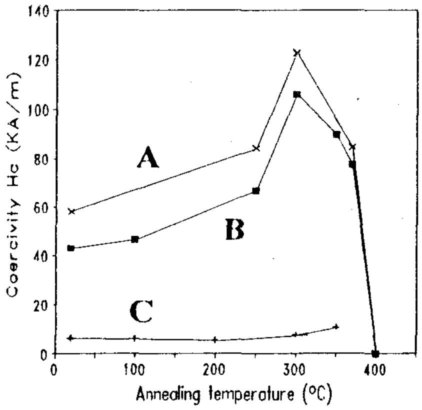

Fig.3 Annealing temperature dependence of Hc
The layer thicknesses as sputtered are
A:235Å Pt+(3.8Å CoNi+5.9Å Pt)×17
B:235Å Pt+(6.3Å CoNi+14.7Å Pt)×17
C:235Å Pt+(18.8Å CoNi+14.7Å Pt)×17

The magnetic microstructure of the multilayers has been observed both with Lorentz microscopy and magnetic force microscopy (MFM). The observed domain width was found to be 60-80 nm (in the low coercivity sample C) which is about 3-4 times the columnar diameter of the multilayer obtained from the TEM measurements. MFM images of the high coercivity samples (Fig 4) reveal rough domain boundaries indicating a strong pinning of walls due to structural dicontinuities.

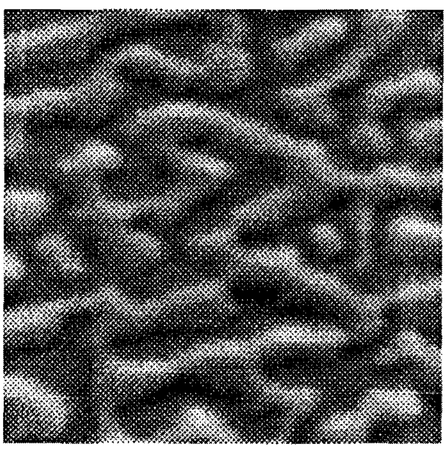

Fig 4. MFM image of a typical domain pattern in the unanealed, high coercivity sample (A: 235Å Pt+(3.8Å CoNi+5.9Å Pt)×17) after demagnetization. The size of the scanned area is 3x3 μm. The rough domain walls indicate the influence of pinning effects during the remagnatization process.

[1] M.Mes, J.C.Lodder, T.Takahata, I. Moritani and N.Imamura, J.Magn.Soc.Jpn., vol 17, Suppl.S1, (1993), 44