

Chemical and electrochemical deposition of NiFe thin films

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Hard magnetic thin films obtained by electrodeposition have been extensively investigated, for instance for perpendicular magnetic recording. Comparatively, very little is known about magnetically soft ultra-thin films deposited from aqueous solutions. In this paper we report the results obtained by investigating the magnetic behaviour of NiFe thin films, deposited by chemical or electrochemical methods. In particular, the properties of NiFe thin films deposited at constant potential or by chemical deposition were compared. Surface roughness strongly affects the magnetic properties of thin films. In order to avoid substrate roughening, electroless deposition was activated by means of a potentiostatic pulse instead of utilizing a Pd solution. Therefore, it was possible to compare and evaluate nucleation, growth, structure, composition and magnetic properties of electrodeposited and electroless plated films on identical substrates. Both potentiostatic and electroless deposition were carried out at room temperature. NiFe alloys were deposited on Si/SiO₂/TiN/Cu wafers. Sulphur-bearing Nickel was used as counter-electrode and Ag/AgCl/KCl sat. as reference electrode.

The thickness of NiFe alloys was in the range 4÷100 nm and Fe content in the range 15÷45 at.%. Two electrolytic solutions were used (1), whose composition is reported in Table 1.

Table 1. Electrolyte composition.

Chemicals	Electrolyte A (mol.dm ⁻³)	Electrolyte B (mol.dm ⁻³)
NiCl ₂ .6H ₂ O	0.059	0.059
NaH ₂ PO ₂ .H ₂ O	0.105	-
NaKC ₄ H ₄ O ₆ .4H ₂ O	0.120	0.120
NH ₄ OH	0.060	0.060
FeNH ₄ (SO ₄) ₂ .12H ₂ O	0.012	0.012
(CH ₃) ₂ NHBBH ₃	-	0.100

Surface roughness was determined by Atomic Force Microscopy and profilometry. Composition and morphology were studied by Energy Dispersive Spectroscopy and Scanning Electron Microscopy, respectively. Crystallographic structure was determined by thin-film X-Ray Diffraction. Magnetic properties were measured by Vibrating-Sample Magnetometer and Magneto-Optic Kerr Effect magnetometer.

Coercivity (in plane H// and perpendicular to the substrate H_⊥) and saturation induction (Bs) were measured as function of thickness and composition. The log-log graph of in-plane coercivity vs film thickness (Figure 1) shows that H// decreases with increasing thickness (curve c) or is

constant (curves b and a), depending on electrolyte composition and plating parameters.

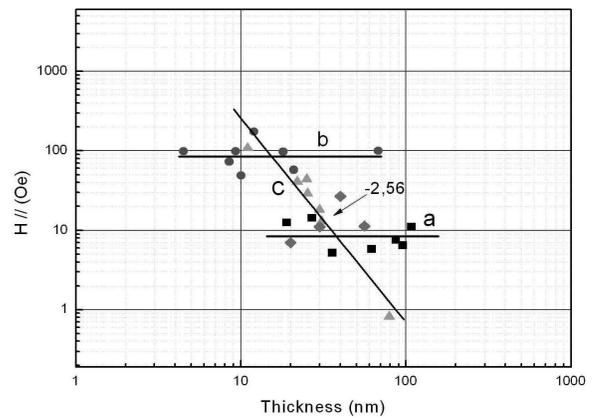


Figure 1. In-plane coercivity (H//) of NiFe thin films as a function of thickness (potentiostatic: ■ -1,1 V, bath A; ● -1.1 V, bath B; ▲: -1.5 V, bath B; pot. trig. electroless: ◆ -1.1 V, bath A).

Saturation induction Bs increases with decreasing film thickness below 100 nm. Moreover, Bs increases from about 1000 to 8000 Gauss with increasing Fe content in the range 15÷50 at.%. Non-magnetic phases containing Fe, Ni and P or B are possible, and they can be responsible for the saturation induction decrease.

(1) D.W. Hall, J.A. Lindholm, L.T. Romankiw and A.F.Schmeckenbecher, "Process for electrolessly plating magnetic thin films", U.S. Patent 3, 702,263 to IBM Corp., 1972.