SURFACE MORPHOLOGY AND MAGNETIC PROPERTIES OF Co-Ni-P FILMS PREPARED BY MAGNETIC ELECTROPLATING

V. Georgescu[1], M. Georgescu[2, 1], A. Mandreci[1], N. Apetroaei[1]

[1] Faculty of Physics, Al. I. Cuza University, Blvd. Carol I No 11, Ro-6600 Iasi, Romania

[2] Materials Research Dept., Gesellschaft für Schwerionenforschung, Planckstr. 1, D-64291 Darmstadt, Germany

When a magnetic field is externally imposed on an electrolytic cell system (magnetic electroplating), an electromagnetic force is induced to move the ions and thus promotes a mass-transport process that influences the film growth. At the same time, an induced magnetic anisotropy appears in the magnetic film prepared by this procedure. The present investigation was undertaken to determine the effect of the direction (referring to the cathode plane) of the magnetic field applied during electrodeposition, on the magnetic properties and the morphology of Co-Ni-P plane films. Thin electrolytic Co-Ni-P films (400 nm) were plated on Cu plane substrates in a cell of about 200 cm^3 containing a solution of $CoSO_4.7H_2O$, $NiSO_4.7H_2O$, NH_4Cl, $NaHPO_2.H_2O$ with additives, in double distilled water. The work electrolysis parameters (temperature, pH and current density) were maintained constant for all experiments. A nickel plane electrode (in the shape of a 2.3 cm diameter disk) was used as anode. The cathode was a disk of Cu mounted parallel to the anode plane. Magnetic field was applied so that the magnetic flux lines run horizontally parallel (or perpendicular) to the cathode surface. The electrochemical cell was inserted between the pole pieces of a Weiss electromagnet. The magnetic field applied during the experiments was of 120 kA/m for a 7.0cm gap. The composition of the films was of about 85 % Co, 14 % Ni and 1% P. Morphology of the samples was investigated by atomic force microscopy (AFM) in tapping mode.

Magnetic measurements were performed by an induction method in a magnetic field (parallel to the film plane) up to 60 kA/m, at room temperature, using a digital scope interfaced to computer. The curves representing the derivative of magnetization with respect to time (dM/dt) versus the a.c. magnetic field intensity (H) with sinusoidal-field excitations (at a frequency of 50 Hz) were investigated.

Magnetic field applied during preparation influences the precipitation mode and the film morphology. As an example, AFM measurements of three typical samples deposited without an external imposed magnetic field (figure 1a) and with magnetic field parallel to the plane of the films (figure 1b) or with magnetic film perpendicular to the film plane (figure 1c) are shown in figure 1. It is found that magnetic electroplating changes the surface morphology of the films. Magnetic susceptibility curves and hysteresis loops of various Co-Ni-P films prepared by magnetic electroplating were investigated at room temperature. It was found that the shape of such curves is a very sensitive function of the type of induced anisotropy.

Atomic force microscopy (AFM) studies showed that the surface topography and the phase images of the film surface changed in films with different field-induced anisotropy. Therefore, the film growth process modifies as an effect of applying a magnetic field on cathode/electrolyte interface.

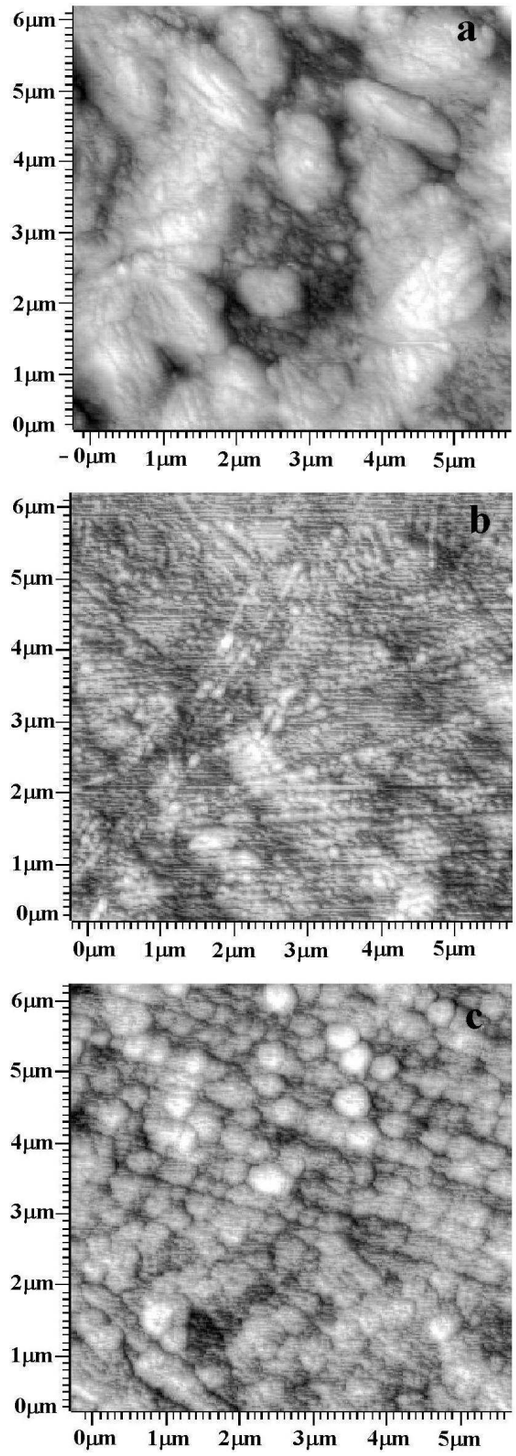

Figure 1 – Topographical AFM images of the Co-Ni-P samples plated in the case of: a) H=0, b) H parallel and c) H perpendicular to the film plane.

The induced anisotropy appears due to a preferential orientation of the easy axis of magnetization in the magnetic field direction. The modification of the growth morphology of the films (grain shape, textures, phase composition, etc), could also have an influence on the magnetic properties. The modification of the growth morphology with the magnetic field could arise from many processes, such as: a specific convective flow of the ions, changes both in electrical charges of the double layer and in the thickness of diffusion layer.