Electrodeposition of Co-Ni and Co-Ni-P films with modulated magnetic behavior

P. Cojocaru and L. Magagnin
Politecnico di Milano, Dipartimento di Chimica, Materiali e Ingegneria Chimica "Giulio Natta". 20131 Milano. Italy

E. Gomez and E. Valles
Universitat de Barcelona, Departament de Quı´mica Fısica. 08028 Barcelona. Spain

Magnetic materials have received considerable attention due to their importance in the electronic industries. Specifically, ferromagnetic films are widely used in the microelectronics industry, magnetic media and computer science. In order to prepare these films, the electrodeposition is a useful technique due to the simplicity of the required equipment.

Cobalt-nickel alloy forms a solid solution over the whole concentration range, which enables to modulate the magnetic properties according to the cobalt percentage. Then, this alloy is especially interesting to be incorporated in multiple applications. Moreover, Co-Ni films are expected to show a great resistance to corrosion. From these premises, the aim of the work is the preparation of CoNi micrometric films of modulate magnetic properties as a function of structure and composition. The influence of the electrodeposition conditions in these parameters will be studied.

CoNi electrodeposition is performed using an optimized sulphamate solution containing boric acid and additives. Taking into account that Co-Ni belongs to the anomalous electrodeposition type, in which the less noble metal is preferentially reduced, solutions in which nickel is the main metallic ion are selected. The influence of P incorporation in the alloy has been also tested adding hypophosphite to the bath.

Anomalous CoNi deposition was observed for all conditions tested. CoNi deposits obtained are fine-grained, coherent and uniform. At fixed current density (10 mA cm^{-2}) a low decrease of the Co percentage was observed when temperature was increased. An increase of the current density favoured the decrease of the Co percentage. CoNi deposits showed mainly diffraction peaks corresponding to a fcc structure. The position of these peaks was slightly shifted to lower θ values than those corresponding to pure Ni as a consequence of the cobalt incorporation in the fcc crystalline lattice. The intermediate position of the peaks between those of Co fcc and Ni fcc confirms the formation of solid solution. They were soft magnetic with very low coercivity. The magnetisation of saturation was lower for CoNi deposit prepared at the higher deposition rate (50mA cm^{-2} and 50°C) because lower Co percentage was detected in this case.

The presence of hypophosphite in the bath induced P incorporation in the deposits. In all cases, ternary (CoNiP) deposition took place, although low incorporation of P in the deposits was observed. In the most conditions, deposits were richer in Co revealing anomalous codeposition although at the lower reaction rates normal deposition was observed. The dependence of Co percentage with temperature was similar than for the binary CoNi deposits. The decrease of the additive concentration in the bath led to an increase of the P percentage in the deposits. Then, the adsorption of additive on the electrodeposit seems to difficult the P incorporation.

The CoNiP deposits prepared at low current densities (10 mA cm^{-2}) presented diffraction peaks assigned to CoNi fcc structure, independently of the Co percentage in the deposits. However, deposits prepared at high deposition rate (50 mA cm^{-2}) showed an hcp structure. Magnetic curves of CoNiP reflected the change in the crystalline structure observed from XRD characterization. The CoNiP deposits with hexagonal phase showed higher values of both coercivity and magnetic susceptibility.

Corresponding author e-mail: paula.cojocaru@polimi.it