A Study of Anions Effects in FeCoNi Electrodeposition

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FeCoNi alloys with high saturation magnetization are essential components of write heads in high density magnetic recording systems and are becoming increasingly important in the fabrication of miniaturized sensors and actuators.

In the production practice, plating solutions containing both sulfates and chlorides of the metals are utilized. Chloride ions are necessary to avoid anode passivation, contribute to grain size refinement and improve the throwing power of the bath. The sulfate ions tend to minimize film internal stresses. In the electrodeposition of NiFe it is found that the limiting current for proton reduction is lower in chloride solutions, which results in a higher current efficiency. In this work, we studied the effect of the anion used in the electrodeposition of FeCoNi alloys on the current efficiency of the process and on film composition, structure, and magnetic properties.

Electrodeposition was carried out from pure chloride, pure sulfate, and 1:1 chloride:sulfate electrolytes. The concentration of the metals and boric acid was kept constant at $[Fe^{2+}]$ = 0.025M, $[Co^{2+}]$ = 0.05M, $[Ni^{2+}]$ = 0.2M, $[H_3BO_3]$ = 0.4M, with pH 2.8. A comparison of the *i* –E curves obtained from the three solutions is given in fig.1. It can be seen that the overpotential for FeCoNi alloy deposition in chloride solutions is lower than in mixed or pure sulfate solutions. This result is similar to that obtained in the electrodeposition of NiFe, where it is hypothesized that chloride ions promote the deposition of metal ions by Cl^- bridges formed between the metal ion and the electrode surface.

Fig. 2 shows the relation between current efficiency and current density for the various solutions. The current efficiency increases with increasing current densities, and this dependence is more pronounced at the lower current densities. The current efficiency is lower in sulfate solutions than in the mixed and all-chloride solutions.

Film composition is almost the same at corresponding current densities for the different solutions except at 5 mA/cm^2, at which a higher Fe content is observed for films obtained from chloride solution. Consequently, this film shows a single bcc phase. All the other films fabricated at 5 and 10 mA/cm^2, show mixed bcc+fcc phases. The variation of coercivity and saturation magnetization of 850 nm thick FeCoNi films with current density is illustrated in Fig. 3. At lower current densities, the coercivity is much higher for films obtained from the chloride solution, which may be due to the higher internal stress. Best magnetic properties are associated with the coexistence of bcc and fcc phases.

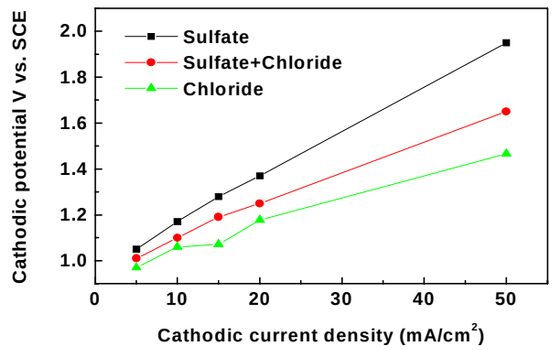

Fig.1 Relationship between cathodic current density and cathodic potential for FeCoNi electrodeposition from Sulfate-based, Chloride-based and mixed sulfate and chloride solutions.

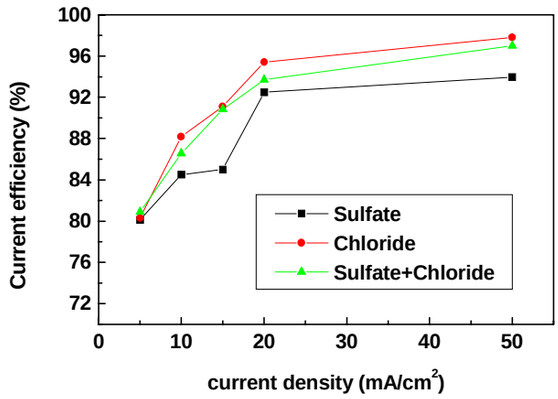

Fig.2 Cathodic current efficiency for electrodeposition of FeCoNi films from Sulfate-based, Chloride-based and mixed sulfate and chloride solutions.

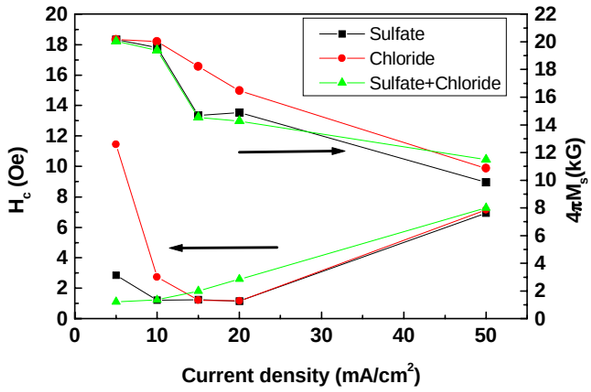

Fig.3 Coercivity and saturation magnetization of FeCoNi films electrodeposited from Sulfate-based, Chloride-based and mixed sulfate and chloride solutions.