Ni-Fe CODEPOSITION ONTO A MHD MONITORED ELECTRODE

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Magnetic materials as Fe-Ni or Fe-Co alloys are of a great interest in electronic applications and new attempts have been made to improve their properties by applying a magnetic field during their crystallization [1]. In this study, various physical techniques such as SEM, EDX, line profile and X-ray mapping, as well as polarization curves and (EIS) measurements have been used to show the magneto-induced modifications on their morphology, composition and electrodeposition kinetics.

Electrochemical studies

The potentiostatic curves for the electrodeposition of permalloy show a strong decrease of the current as a magnetic field B is superimposed on the electrochemical cell (Fig.1). This effect can be explained by the MHD convective effect of B on Fe(II) ions, which are under mass-transport control and have revealed to be inhibiting species for Ni electrodeposition [2-3]. Through dynamic investigations, the MHD effect can be investigated more deeply. B superimposition increases the inductive loop of the impedance in Nyquist diagram for the alloy electrodeposition because of the Fe species enrichment at the cathodic interface (Fig.2). The phenomenon is similar to that obtained for Ni electrodeposition in the presence of an inhibitor such as butyne-diol [4].

Physical investigations

The chemical composition and morphology of the electrodeposits were characterized by a SEM Philips 505, coupled with a PGT-EDX microprobe. The chemical analyses of the alloys were performed qualitatively by line profile and X-ray mapping and quantitatively by EDX carried out in a model for ZAF matrix corrections.

The B superimposition significantly modifies the Fe-Ni surface morphology. As depicted in Fig.4, pits are entirely eliminated, so that a quite compact surface is obtained, as compared to that without magnetic field (Fig.3). The results reveal a strong homogeneity of the distribution of nickel and iron atoms throughout the line profiles. For B = 0.9 T, a dramatic effect of the magnetic field on Fe-Ni codeposition tends to increase the Fe K_α intensity of X-ray, witnessing that the Fe-Ni alloy becomes richer in iron atoms.

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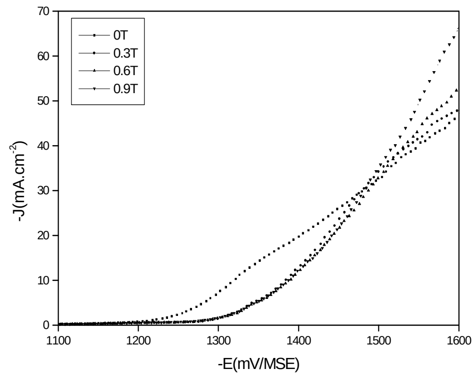

Fig. 1 - Current density-potential curves for nickel-iron alloy electrodeposition under various magnetic field values. $NiSO_4$ 0.5 M, $FeSO_4$ 0.1 M. pH = 3.

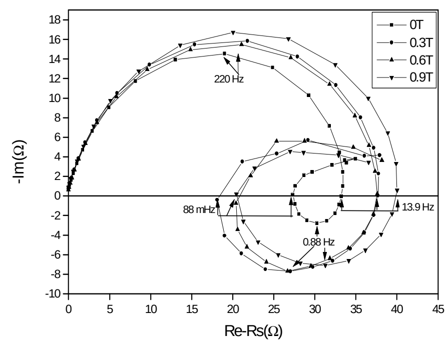

Fig. 2 – EIS data in the Nyquist plan for various magnetic field same solution as Fig.1, E_p = -1.4 V. R_S: solution resistance.

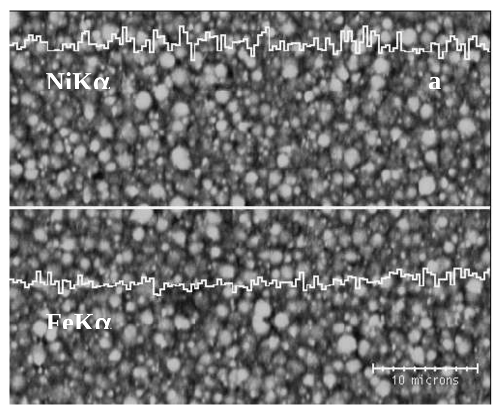

Fig.3 - SEM images and corresponding line profiles of Ni and Fe in alloys deposited at Ep = - 1.5 V/SSE. Same solution that Fig. 1. No magnetic field. Plating time = 30 mn.

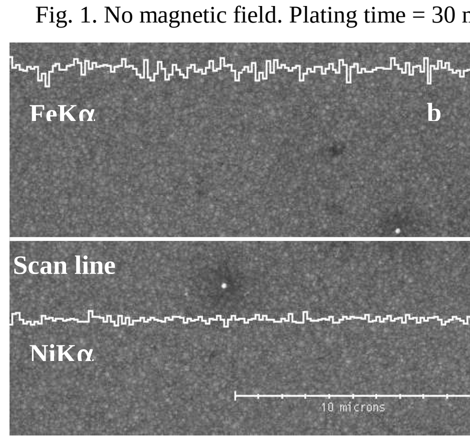

Fig.4 – Same as Fig.3 except B = 0.9 T.