Effect of Magnetic Field on NiCu Alloy Electrodeposition (Invited)

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It is well established that an external magnetic field applied parallel to an electrode surface can alter the rate of mass transport of ions in an electrode reaction [1-3]. Recently, we have demonstrated the effects of a magnetic field on composition, morphology, magnetic properties, crystal structure, stress and surface roughness of NiFe films [4].

In the present work we studied the effect of an external magnetic field on the electrodeposition of nonmagnetic NiCu alloy from a citrate bath containing also NaCl at pH = 2.5 and temperature of 23°C. The electrodeposition of NiCu films on 1000 Å-thick Cu seed layer was carried out in two paddle cells (0.66 cycle/min) of identical geometry. One cell was equipped with a permanent magnet (B = 0.l T) with magnetic field applied parallel to the electrode surface, while the other cell was without an applied magnetic field. The concentration of electrolytes and additives were exactly the same in both cells and NiCu films of different thickness were electrodeposited at constant current density.

The voltammetry at a Pt RDE in the potential range from +0.3 to -0.4 V vs. SCE showed clearly the enhancement of the limiting currents of both waves, corresponding to Cu^{+2} and Cu^{+} reduction steps, in the presence of magnetic field. The enhancement in a magnetic field was attributed to the convection near the electrode surface induced by the Lorentz force.

With an applied field the average copper content in the NiCu deposit increases by 5%, plating rate increases by 17%, and stress decreases by about 40% compared to films obtained without magnetic field. With increasing thickness of the NiCu films, large (Ill) texture grains are more dominant for samples obtained without magnetic field. Magnetic field exhibits an effect by enhancing small (200)-textured grains. The surface roughness of NiCu films obtained without magnetic field increases with thickness, giving the roughness exponent $\beta = 0.86$. However, for the film electrodeposited in magnetic field, the roughness is constant ($\beta \rightarrow 0$) indicating 2D nucleation and growth.

References:

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