

Kinetic Study of FeCoNi Ternary Alloy Deposition

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Introduction

Fe-rich FeCoNi alloys are of interest for their low thermal expansion property.¹ The iron-group system exhibits anomalous codeposition behavior² and the ternary system is also of interest to explore interactive effects in the mechanism. Thus, in this paper, the electrodeposition of FeCoNi alloys was characterized and the deposition kinetics were addressed.

Experimental

Table 1 shows the electrolyte composition used for FeCoNi alloy deposition at pH 3.0, to assess the influence of iron and cobalt bulk concentrations on the metal reaction rates. A recessed rotating cylinder electrode was used as the cathode. A two-compartment cell design was used with a glass frit separating the catholyte and anolyte. All electrolytes were de-aerated with nitrogen gas before deposition. The chemical composition of the deposit was analyzed by a Kevex Omicron X-ray fluorescence analyzer.

Results and discussion

Figure 1, 2 and 3 show Fe, Co and Ni partial current densities during FeCoNi alloy deposition. Fe deposition rate does not change in the kinetically controlled region, when its bulk concentration is varied; while Co deposition rate increases as its bulk concentration increases. Furthermore, Fe and Ni deposition rates do not change with Co bulk concentration, while Co and Ni deposition rates decrease as Fe bulk concentration increases. When the alloy deposition is compared with its single metal deposition, Ni is inhibited while Fe and Co depositions are enhanced. These results agree qualitatively to the findings of iron-group binary alloy codeposition in sulfate electrolytes reported in the literature.³⁻⁶

A model is presented to account for the observed behavior. All metal depositions are assumed to occur in a two-step manner. Mixed-metal Fe intermediate species are formed to account for the enhanced Fe deposition rate, as proposed by Zech *et al.* for the binary iron-group alloy codeposition.⁶ Furthermore, preferential adsorption by Fe intermediate species, is considered to be responsible for the apparent decrease of Co and Ni deposition rates as Fe bulk concentration increases.

Conclusion

The study of Fe and Co bulk concentration effects during the FeCoNi ternary alloy deposition establishes the rate-determining feature of the mechanism to be used in a mathematical model. Ni and Co deposition is decreased with increasing Fe bulk concentration, while Fe deposition is unaffected by the bulk concentration of Fe and Co in the electrolyte. These features can be explained by a model which includes a mixed-metal Fe adsorption rate-determining step.

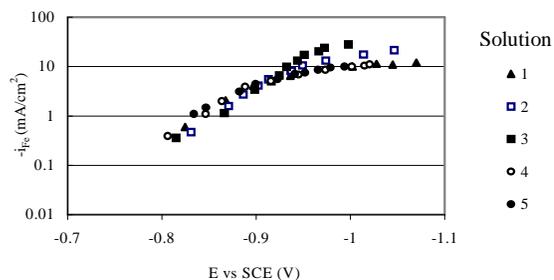


Figure 1. Fe partial current density is not a function of Fe and Co bulk concentrations.

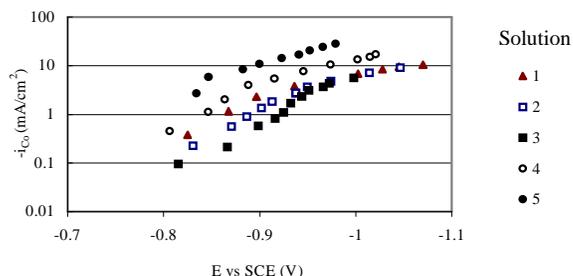


Figure 2. Co partial current density increases with its bulk concentration, but decreases as Fe bulk concentration increases.

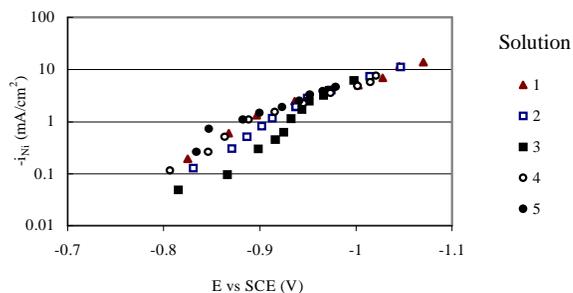


Figure 3. Ni partial current density decreases as Fe bulk concentration increases, and is not a function of Co bulk concentration.

	FeSO ₄	CoSO ₄	NiSO ₄	H ₃ BO ₃	Na ₂ SO ₄
1	0.025	0.025	0.2	0.4	0.5
2	0.05	0.025	0.2	0.4	0.475
3	0.1	0.025	0.2	0.4	0.425
4	0.025	0.05	0.2	0.4	0.475
5	0.025	0.1	0.2	0.4	0.425

Table 1. Composition of solutions for FeCoNi alloy depositions (mol/l).

References

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