

## Electrodeposition of Ni-W, Ag-W and Ag-Ni-W Alloys from Citrate-Thiourea Electrolytes

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### Introduction

Ni-W alloys have been widely studied<sup>1-3</sup> as they are known to possess superior functional properties such as high wear and corrosion resistance, increased micro hardness and good catalytic activity towards hydrogen evolution. Ag-Ni alloys have been investigated as promising alternatives for gold electrical contacts.<sup>4</sup> Electrodeposition of Ag using thiourea as a complexing agent has been widely studied for various applications.<sup>5,6</sup> Electroless deposition of Ag-W has been demonstrated<sup>7</sup> for interest, in part, to minimize the diffusion of Ag into SiO<sub>2</sub> in electronic applications. In the present study, we report on the electrodeposition of Ag-Ni-W alloys. To the best of our knowledge, this is the first demonstration of the influence of Ag during NiW electrodeposition.

### Experimental

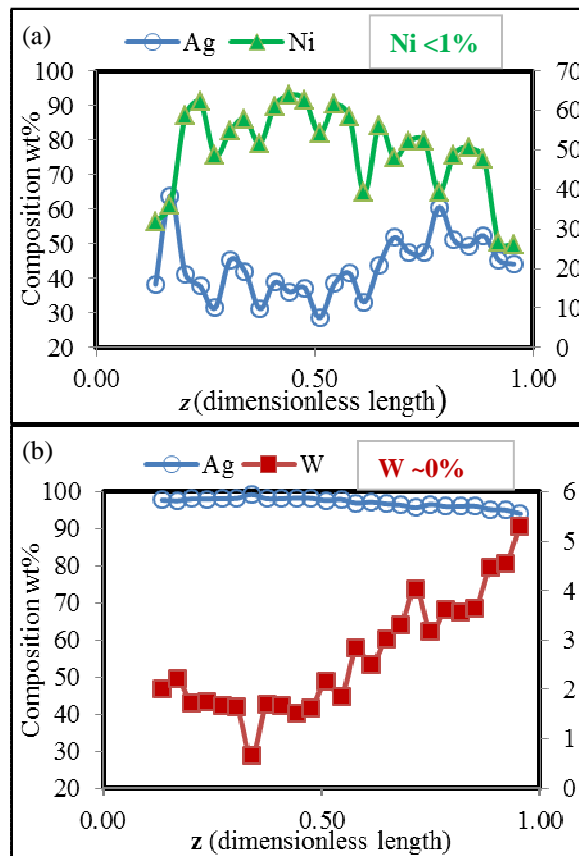
Galvanostatic depositions were performed using a Solartron 1287A potentiostat, with a traditional Hull cell and a rotating Hull cell. The electrolyte contained 50 mM NiSO<sub>4</sub>, 15mM Na<sub>2</sub>WO<sub>4</sub>, 5mM Ag<sub>2</sub>SO<sub>4</sub>, 650mM thiourea and 285mM Na-Citrate at pH 2-8. The deposits were analyzed with XRF and SEM.

### Results and Discussion

Ag-Ni-W thin film alloys fabricated from the electrolyte had an insignificant variation in composition over a wide pH range (2<pH<8), however the morphology changed significantly. Electrolyte agitation affected the composition due to the mass transfer effect on Ag reduction. For example the composition analysis (Figure 1) shows an increase in Ag composition in the deposit with air agitation in a traditional Hull cell. Unexpectedly, an increase in the airflow agitation favored W codeposition and decreased nickel codeposition despite their apparent kinetic control. The presentation will include a comparison of Ag-W, Ni-W and Ag-Ni-W.

### Conclusions

Ag-Ni-W deposits were obtained for a wide pH range with variable electrolyte agitation. Under mass transport conditions for silver, with an increase in agitation the rate of nickel deposition decreased but favored W codeposition.



**Figure 1.** Deposit composition along the length of a Hull cell from an electrolyte containing nickel, tungstate and silver ions at pH 2 under (a) no agitation and (b) with air agitation, 5 L/min.

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