# Role of the solute elements on the microstructure of electrodeposited Ni-Mn alloys

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High-strength and temperature-resistant electrodeposited Ni films for MEMS applications are obtained by incorporation of small amounts of Mn, which raise the recrystallization temperature significantly, contributing to the thermal stability of the alloys. Other elements are also present, such as sulfur, oxygen, and carbon, due to the bath chemistry. Careful examination of these alloys is required to understand the effects of material processing and the microstructural changes involved during thermal aging. Characterization of the compositional structure of these materials is, however, challenging because of both the small spatial scale of the concentration variations and the low solute concentrations (<1 at.%). Due to its inherent high chemical and spatial resolution, atom probe tomography is employed to study the distributions of Mn and other solute atoms in as-deposited and annealed electrodeposited Ni-Mn films.

Pulse-plating conditions are sometimes used with the intent to limit film stresses accumulated during deposition. The resulting material is believed to consist of regions of high-stress Ni-Mn separated by regions of low-stress Ni, therefore forming a material that is compositionally modulated at the nanoscale. The improved thermal stability of electrodeposited Ni-Mn alloys is also not understood and various mechanisms have been suggested to explain the effect of Mn addition on thermal stability: e.g. solute segregation at grain boundaries, solute drag, or texture modifications. To gain insight into the mechanisms operating in these electrodeposited alloys, changes in the distributions of solute elements after annealing at high temperatures (550-700ºC) are studied. They include the formation of Mn-rich precipitates stabilized by the presence of sulfur and/or oxygen. These second phases are otherwise metastable in the binary Ni-Mn system. First-principles simulations are performed to understand the interactions between the different elements. The roles of the solutes on the thermal properties and the strengthening mechanisms operating in these Ni-Mn films are discussed.

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