Effect of Pulse-Reverse Current on the Microstructure and Properties of Electroformed Nickel-Iron Mold Insert

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Abstract

A high-technology approach to the manufacture of microdevices and Ni–Fe films formed by electroforming processes was investigated. The properties of Ni–Fe films were evaluated by stress measurement, transmission electron microscopy (TEM), scanning probe microscopy (SPM) and nanoindentation analysis. Square-wave cathodic current modulation was employed to electrodeposit ultrafine-grained Ni–Fe films from an additive-free Watts bath. The effects of pulse parameters, namely, pulse on-time, pulse off-time and peak-current density on grain size, surface morphology and crystal orientation were determined. Current density significantly influences the microstructure of what. Increasing current density substantially refined the deposited crystals. The crystal size of Ni–Fe films decreased as current density increased. Microstructural modification was accompanied by the corresponding variations in microhardness, current efficiency and hydrogen content. These results are explained by the strong tendency of Ni–Fe to be passivated though the adsorption of foreign species (hydrogen and hydroxide) present during crystallization. However, increasing current density did not affect crystal orientation, indicating that a high pulse-reverse current density inhibits the adsorption of hydrogen species onto Ni–Fe films. Therefore, Ni–Fe films have a low internal stress and a low surface roughness. Current density considerably influences the microstructure of what, revealing that a high pulse-reversed current density inhibits the adsorption of hydrogen species onto Ni–Fe deposits, so that an as-deposited pulse-reversed Ni–Fe alloy has a lower internal stress and a lower surface roughness than a Ni–Fe alloy deposited by direct current density.