Structure and Mechanical Properties of Ni-Co and Ni-Fe Alloys Electrodeposits

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ABSTRACT

This study aims at developing the Ni-Co and Ni-Fe alloy electrodeposits based on the knowledge about the pure nickel electrodeposited from basic sulfamate bath. The relationship of the microstructure and mechanical properties of the deposits was systematically investigated to understand the annealing behaviors of the distinct alloy deposits plated at various electrolyte metal cation concentrations, current densities and saccharin contents. The composition of the alloy deposits was measured via EDS. Detailed microstructure of the deposits was characterized using cross-sectional optical microscope (OM) and transmission electron microscopy (TEM). Experimental results show that the codeposition of Ni and Co or Ni and Fe alloys belongs to anomalous deposition. The addition of Co2+ and Fe2+ to the basic sulfamate Ni bath refined the structure of the deposits. Moreover, the addition of saccharin reduced the recrystallization temperature of the deposits. When observed under OM, the Ni-Co deposits made from the baths with 1~3 g/l Co2+ exhibited a fine-grained structure. The alloys deposited from the baths containing 3~17 g/l Co2+ exhibited a lamellar grain structure when observed under OM, whereas TEM further revealed that the deposits displayed a columnar grain structure that contained a high density of defects. Consequently, these alloy had the largest hardness among the various Ni-Co alloys studied. Conversely, when observed using OM or TEM, the deposits made from the bath with Co2+ content exceeding 17 g/l exhibited a well-defined columnar grain structure with less lattice defects. Then, the deposit hardness decreased with increasing Co2+ content. The columnar Ni-Co alloys were shown to have better high-temperature strength than the lamellar Ni-Co alloys. Most of the Ni-Fe deposits investigated in the present study had hardness ranging from 490 to 520 Hv and retained their hardness after 1h of annealing at 400 oC because of their fine-grained structure. Some of the deposits had relatively-large internal stress, i.e., 45 kg/mm2. Increasing the electrolyte Fe2+ content and current densities enhanced the cathode current efficiency. When Fe2+ content exceeded 20 g/l, the deposit Fe content was approximately 75 wt. % regardless of the current density. Like Ni-Co alloy deposits, the addition of saccharin into the electrolyte reduced the recrystallization temperature of the Ni-Fe deposits.

Keywords : Ni-Co electrodeposits, Ni-Fe electrodeposits, sulfamate nickel, anomalous deposition

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