Abstract

Pure Sn coatings have been prepared from different types of aqueous solutions (alkaline stannate, stannous sulfate, triammonium citrate, methyl sulfonic acid and pyrophosphate baths) by pulse electrodeposition technique. The current efficiency of the triammonium citrate bath is found to be the highest followed by the stannous sulfate bath. The deposits plated from the triammonium citrate bath have pyramidal grain morphology while that of the sulfate bath consists of equiaxed grains, and the deposits plated from other baths have either nodular or dendritic morphology. It is also observed that the propensity for the whisker growth is much lower in the deposits plated from either sulfate or citrate bath compared to the others.

The surface morphology of Sn coatings is found to be strongly dependent on the plating conditions and pulse parameters, i.e., current density, pH, amount of additive (Triton X-100), duty cycle, frequency, bath temperature, and stirring rate. A useful set of pulse parameters for the sulfate bath has been recommended for obtaining the desired morphology of pure Sn coatings.

The lead free Sn/CeO_2 and near eutectic Sn-Ag/CeO_2 nanocomposite films have been pulse co-electrodeposited from triammonium citrate bath containing various concentration of ball milled CeO_2 particles (1, 2, 5, 10, 15, 20, 25 and 30 g/L). The nanocomposites thus obtained consist of embedded CeO_2 nanoparticles (~30 nm) in the matrix. The maximum amount of monodispersed CeO_2 in the composites is realized with dispersing 15 g/L CeO_2 in the electrolytic solution that gives ~6 wt% CeO_2 in the Sn matrix and ~12 wt% CeO_2 in the Sn-Ag matrix. The incorporation of monodispersed CeO_2 in the matrix improves the microhardness, and wear and corrosion resistance of the composites. The density of the composites decreases continously with the CeO_2 incorporation. The melting point shows a decrease of ~2.6 ^{o}C for Sn-Ag/CeO_2 composites while a minor change of ~1 ^{o}C for Sn/CeO_2 is seen when they are prepared from the electrolyte containing 15 g/L CeO_2. There is a rise in the resistivity of the composite matrix compared to the monolithic materials. However, the resistivity of the composites falls within the usable limit as reported for other Sn and Sn-Ag based composites, used for electrical contact applications. An incorporation of CeO_2 nanoparticles in the matrix minimises the compressive stresses developed in the coating and thus lowers the chance of Sn whisker growth in the coatings.

Keywords: lead free; ball milling; wear; conductivity; nanocomposite; microhardness; pulse electrodeposition; wear resistance; corrosion resistance; Sn whisker.