ABSTRACT

Electroless plating is a well known surface engineering process, which involves autocatalytic reduction of metallic ions from aqueous solution and subsequent deposition of the metal without the use of external electrical energy. Although a variety of metals can be deposited by electroless method, electroless nickel coating is most widely used in engineering applications owing to its unique characteristics like excellent wear resistance, abrasion resistance, corrosion resistance, electrical properties, magnetic properties, ductility and solderability. Numerous modifications of electroless nickel plating processes have been made through the years, among which the development of electroless nickel poly-alloy coatings is considered to be the most valuable as they extend the potential utility of electroless nickel coatings for innumerable applications in a variety of areas.

The present work aims to produce nickel-boron ternary alloy coatings (Ni-B-P and Ni-B-Zn) through electroless route and evaluate their characteristic properties. The electroless Ni-B-P alloy coatings are prepared using alkaline plating bath with nickel chloride as the source of nickel ions, sodium borohydride and sodium hypophosphite as reducing agents as well as the source of boron and phosphorous ions, respectively. The effect of variations in concentrations of the reducing agents in the plating bath on various characteristics like plating rate, chemical composition, surface

morphology, structural characteristics, phase transformation behaviour, surface roughness, hardness, wear and corrosion behaviour of the electroless Ni-B-P alloy coatings is evaluated. The effect of heat treatment on the structural changes, hardness and wear behaviour of the Ni-B-P alloy coatings is also evaluated.

The plating rate of the electroless Ni-B-P alloy coatings increases with increasing concentration of reducing agents in the electroless plating bath. The boron and phosphorous content of the electroless Ni-B-P alloy coatings increase with increasing sodium borohydride and sodium hypophosphite concentrations in the plating bath respectively. The electroless Ni-B-P alloy coatings prepared from the plating bath containing the lowest sodium borohydride concentration (0.2 g/l) produces a corn-cob like surface morphology, whereas the coating produced from the bath containing the highest sodium borohydride concentration (0.8 g/l) produces a cauliflower-like surface morphology.

The increase in boron content of the coatings results in the formation of partly nanocrystalline structure, which is confirmed by the peak broadening in the XRD pattern and the discontinuous ring pattern in the selected area diffraction pattern obtained from transmission electron microscope. Heat treatment of electroless Ni-B-P alloy coatings leads to the formation of nickel boride precipitates in the nickel matrix which is confirmed by the appearance of sharp Ni_3B peaks in the XRD pattern. The

electroless Ni-B-P alloy coating containing the highest boron content shows a maximum hardness value of 750 and 1186 HV in as-plated and heat treated condition respectively. The electroless Ni-B-P alloy coating with the highest hardness shows the lowest specific wear rate (i.e., more resistance to wear) in both as-plated and heat treated condition. The coating with low boron and high phosphorous content shows a smooth surface and better corrosion resistance in 3.5% NaCl solution.

The electroless Ni-B-Zn alloy coatings are prepared using an alkaline plating bath with nickel chloride as the source of nickel ions, zinc acetate as the source of zinc ions and sodium borohydride as the reducing agent as well as the source of boron ions. The effect of variation in concentrations of sodium borohydride and zinc acetate in the plating bath on the plating rate, chemical composition, surface morphology, structural characteristics, surface roughness, hardness, wear and corrosion behaviour of the electroless Ni-B-Zn alloy coatings is evaluated. The plating rate of the electroless Ni-B-Zn alloy coatings increases with increasing sodium borohydride concentration in the plating bath. Zinc acetate inhibits the reducing action of sodium borohydride and decreases the plating rate and also boron content of the coatings.

Maximum hardness value of 738 HV and minimum specific wear rate of 1.96×10^{-10} kg/Nm are observed for as-plated electroless Ni-B-Zn alloy coatings prepared from plating bath containing the highest sodium

borohydride concentration (0.8 g/l) and the lowest zinc acetate concentration (1 g/l). The as-plated electroless Ni-B-Zn alloy coating prepared from electroless plating bath containing 0.2 g/l sodium borohydride and 1 g/l zinc acetate shows the lowest surface roughness value (0.22 μm) and better corrosion resistance. The influence of changes in the plating bath concentration on the various characteristic properties of the electroless Ni-B-P and Ni-B-Zn alloy coatings is studied in detail.