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Electroless deposits of Ni-Mo-P alloy

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A nickel sulphate based formulation has been standardised for the autocatalytic deposition of Ni-Mo-P alloy. Properties of electroless Ni-Mo-P alloy deposits such as hardness, wear resistance and corrosion resistance are discussed in this paper.

Key words: Autocatalytic deposition, electroless deposition, Ni-Mo-P alloy

INTRODUCTION

Electroless deposits of many ternary alloys of nickel display certain desirable functional properties such as high hardness, good wear resistance and appreciable corrosion resistance [1].

Electroless Ni-Mo-P alloy is reported to possess some of the characteristics mentioned above. Extensive studies had been carried out on electrodeposition of Ni-Mo alloys. However, literature on electroless Ni-Mo-P is scanty and hence the experimental work on the electroless deposition of the alloy and its properties has been attempted.

EXPERIMENTAL

Bath formulation

A bath of the following composition gave bright and adherent deposit.

Nickel sulphate	80 g/l
Sodium citrate	20 g/l
Ammonium sulphate	30 g/l
Sodium hypophosphite	65 g/l
1M sodium molybdate solution	100 ml/l
Stabilizer	—
pH	9-10
Temperature	363-365K

Since a lower pH reduces the molybdenum content in the alloy considerably, a higher pH of 9-10 was maintained by the addition of ammonia [2]. Moderate air agitation was used during the electroless deposition. Electroless deposition was carried out on mild steel specimens of different sizes depending on the nature of tests to be carried out.Surface treatment of the mild steel specimens consisted of degreasing by trichloroethylene, cathodic and anodic cleaning in alkali and an activation dip in sulphuric acid.

Composition

Nickel, molybdenum and phosphorus content in the alloy was determined by the EPMA technique. The foil for the studies was prepared by electroless deposition of the alloy on a stainless steel substrate, which was subsequently peeled off.

Hardness

The electroless deposit was heat-treated in vacuum at 673K for two hours and its hardness was compared with the one in the as-plated condition.

Wear resistance

Wear resistance of the deposit was measured using Taber Abrasion Resistance Instrument. The measurement was carried out for 1000 cycles with a load of 500 g.

Corrosion behaviour

The corrosion behaviour of the alloy deposit was assessed in 3% NaCl by means of polarisation studies and AC impedance technique [3]. A three- electrode cell assembly was used for the measurements. Potentiostatic polarisation was carried out from −800mV to −300mV at a rate of $1mV.sec^{-1}$ using saturated calomel electrode as the reference electrode.

Impedance measurements were carried out using PARC's Electrochemical System. The frequency was varied from 10 kHz to 1 kHz at an applied AC signal of 5 mV. Nyquist plots were made.

RESULTS AND DISCUSSION

The EPMA studies using Scanning Electron Microscope (SEM) on the electroless alloy foils revealed the percentage of nickel to be 86.8% and molybdenum 5.6%, the rest being phosphorus.

The hardness of the as-plated deposit was found to be 530 VHN with an indentation load of 50 g. Heat treatment in vacuum at 673K for two hours increased the hardness to 860 VHN. Wear resistance of the as-plated alloy deposit was found to be 4 mg at 500 g load and 1000 cycles.

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Polarisation studies revealed a lesser corrosion rate for the alloy deposit than electroless Ni-P with 10% P content- i_{corr} for alloy deposit being 3.7 $mA.cm^{-2}$ whereas for Ni-P, it was 5 $mA.cm^{-2}$.

The AC impedance analysis shows an increase in Rt values for the alloy deposit (562.5 $\Omega.cm^{-2}$) in comparison to the substrate ($R_t = 40\Omega.cm^{-2}$). These measurements indicate, the alloy deposit has more corrosion resistance than electroless Ni-P.

CONCLUSION

The bath composition was standardised to get electroless deposit of Ni-Mo-P alloy on mild steel substrate. The physical properties of the alloy, such as hardness and wear resistance increased and the alloy was found to be more corrosion resistant than Ni-P coatings.

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