The Effect of the Tungsten Content in Electroless Ni-P-B Coatings

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Abstract

In the present work, quaternary electroless Ni-W-P-B coatings were plated on an aluminum alloy substrate from a plating solution of nickel sulphate, sodium hypophosphite, dimethylamine borane, sodium acetate, lactic acid and sodium tungstate. To investigation of tungsten content in multi alloy system, different amount of sodium tungstate is added in acidic Ni-P-B electroless bath. The surface morphologies of multi alloys are observed by using a scanning electron microscope (SEM, JEOL 6060LV) and X-ray diffractometry (XRD).

1. Introduction

Electroless nickel (EN) coating is a surface engineering process involving a chemical reduction between nickel ions (metal source) and reducing agent on metal substrate. Electroless nickel coating is widely used in manufacturing and scientific area. Electroless plating applications are improved chemical and mechanical properties of substrates such as wear resistance, corrosion resistance, hardness etc. [1-2].

The addition of tungstate in electroless nickel deposits improves the deposit characteristics such as wear resistance, corrosion resistance, thermal stability and electrical resistance. Tungsten incorporated electroless nickel coatings have been first studied by Zhang et al and they have approved that 3 wt.% tungsten containing Ni-P coatings containing shows positive effect due to addition of a third passivation element, W, which formed the dense tungsten oxide film on the surface [3]. Aydeniz et al were also studied the structural properties of Ni-W-B alloy. They were obtained that Ni-W-B deposits has higher hardness value than that of Ni-B deposits. Moreover, Ni-W-B deposits showed better wear and corrosion resistance when compared with Ni-B deposits [4].

2. Experimental Procedure

The Ni-W-P-B coating was obtained by the addition of sodium tungstate to the acidic sodium hypophosphite based Ni-P-B bath. The bath composition is presented in Table 1. The temperature of the bath was kept constant at 85°C throughout the deposition process and placed onto magnetic stirrer. Aluminum samples with dimensions of 50mm x 30mm x 2mm were used as substrates. The Al sample was sanding, polished and immersed in an acidic bath for activation etching. Before electroless nickel deposition of Ni-P-B coatings, a zincate pre-treatment of the aluminum substrate was performed by immersion technique. Electroless Ni-P-B deposition processes were carried out using 250 cm³ of the baths. In all cases, electroless deposited samples were heat treated a temperature of 400°C in an inert atmosphere for 2 h to protect from oxidation. The composition and surface morphology of the electroless deposited Ni-W-P-B coatings were examined using Scanning Electron Microscope (SEM). X-ray diffraction (XRD) analyses were used to
determine chemical composition and structure of composite coatings.

Table 1. Bath composition and operating condition for deposition of Ni-W-P-B

<table>
<thead>
<tr>
<th>Bath Components</th>
<th>Sample Code</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
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<tr>
<td>NiSO$_4$·6H$_2$O</td>
<td>33 g/L</td>
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<tr>
<td>NaPO$_2$H$_2$</td>
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<td>C$_2$H$_3$NaO$_2$</td>
<td>16 g/L</td>
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<td>C$_2$H$_3$BrN$_2$</td>
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<td>C$_3$H$_7$O$_2$·Na</td>
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<tr>
<td>C$_3$H$_6$O$_3$</td>
<td>28 mL/L</td>
<td>28 mL/L</td>
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<td>Na$_2$WO$_4$</td>
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</table>

3. Results and Discussion

Surface morphologies of samples prepared with different concentrations of Na$_2$WO$_4$ were examined by scanning electron microscope. Figure 1 shows that grain boundaries become prominently and thin-grained, when Na$_2$WO$_4$ concentration increases in the coating bath. Because tungsten incorporation in Ni-P-B coatings can be lead to increase nucleation rate of deposition [5].

Fig. 1. SEM images of electroless Ni-W-P-B depositions produced with different Na$_2$WO$_4$ concentrations (a) W1, (b) W2, (c) W3 and (d) W4.

It is clearly seen from Fig. 1, W1 and W2 samples has rough structure. However, the structure of deposits from the crystalline structure and nodular with increasing Na2WO4 concentration in the coating bath. The SEM images show that increasing amount of W towards the crystal structure. The crystal lattice formation depends on the less in the atomic radius of Ni (r = 1.62 Å) and P (r = 1.23 Å) and B (r = 1.17 Å). At the same time, the tendency of crystal structures to form is enhanced by the addition of larger size W (r = 2.02 Å). This observation is also confirmed by XRD results [6].

Fig. 2. XRD patterns of Ni-W-P-B electroless depositions with different Na2WO4 concentrations in the bath (a) before heat treatment (b) after heat treatment

Figure 2 shows X-ray diffraction of the Ni-W-B-P coating before and after heat treatment. When we look at Figure 2a, there are large peaks showing the (111) and (200) planes at time $2\theta = 44^\circ$ and $2\theta = 52^\circ$, respectively. At the same time, the tendency of crystal structures to form is enhanced by the addition of larger size W (r = 2.02 Å). This may be due to a decrease in the P ratio in the coating and an increase in the W ratio. The X-ray diffraction results obtained after heat treatment of the Ni-W-B-P coatings in an argon atmosphere at 400 ºC are shown in Fig. 2b. After the heat treatment, there are pointed peaks at 44 º and 52 º and crystalline nickel phases are observed Ni$_2$P, Ni$_3$P, Ni$_2$B and Ni$_3$B phases as well.

4. Conclusion

Quaternary Ni-W-B-P coating was successfully prepared by electroless deposition method. Effects of amount of sodium tungstate on deposit structure were investigated. The result shows that the parameter significantly affects the coating. As the amount of sodium tungstate increases, changes occur in the within of the coating.

Acknowledgment

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References


