



Corrosion resistance of electrodeposited Ni–Al composite coatings on the aluminum substrate

S. Ghanbari ^{a,1}, F. Mahboubi ^{b,*}

^a Department of Materials Engineering, Islamic Azad University Science and Research Branch, Tehran, Iran

^b Department of Mining & Metallurgical Engineering and Advanced Technologies Research Center, Amirkabir University of Technology, Tehran, Iran

ARTICLE INFO

Article history:

Received 19 July 2010

Accepted 7 December 2010

Available online 16 December 2010

Keywords:

C. Coatings

E. Corrosion

I. Adhesion

ABSTRACT

Ni matrix–Al particle composite coating was adopted via sediment co-deposition (SCD) method on the zincate coated aluminum substrate. Surface morphology was investigated by scanning electron microscopy (SEM). The electrochemical behavior of the coatings was studied by polarization potentiodynamic test in 3.5 wt.% sodium chloride using a three electrode open cell. The effect of the electroplating parameters on the Al co-deposition was studied. Maximum of 22 wt.% Al particles were deposited in the coating. It was found that the zincate coating plays an important role in improving the nickel layer adherent. Furthermore, incorporation of aluminum particles in Ni matrix refined the Ni crystal coatings. However, polarization curves shifted to negative potentials and corrosion rate is decreased.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

Surface modifications of aluminum and its alloys can offer a wide variety of mechanical, chemical, electrical properties and decorative finishing. Electroplating has gained commercial applications for components which need to wear and corrosion resistance. Especially, some kinds of plating methods dispersing ceramics particles in metallic matrixes are becoming popular in various wear parts [1].

The electro deposition of metallic coatings containing inert particles can be traced back to studies which produced a graphite–copper composite coating for self-lubricating surfaces in car engines [2]. In the early 1950s and late 1960s, the development of electro deposit composite coatings developed gradually [3,4]. During the 1970s and 1980s, investigations were focused on the necessity of producing coatings with enhanced mechanical and corrosion properties. To this end, irresolvable particles are suspended in a common plating electrolyte and are captured in the growing metal layer. These particles can be hard oxides or carbides such as ZrO₂, WC [5], Al₂O₃ [6] and SiC [7,8]. Foster suggested that the oxidation resistant coatings could be prepared by co-electrodepositing of metal, for example Ni, with micrometer-sized metallic particles such as Cr [8]. Ni–Al composites were prepared by the co-deposition of a Ni matrix and micron sized Al particles by Susan [9,10].

Two common processes involved with incorporation of particles into metallic coatings can be recognized, namely, physical disper-

sion of particles in the electrolyte and electrophoretic migration of particles [11]. Many theories have been suggested including the transport of particles due to electrophoresis. The mechanism proposed by Guglielmi [5,12] had been adopted by several authors. This model enables a quantitative treatment of the influence of particles concentration and current density on the incorporation rate of particles into a metal deposit and excludes hydrodynamic effects and particle characteristics. The common processes involved in the co-deposition of particles into growing metallic layers. Five steps during the co-deposition process can be identified: (1) Formation of ionic clouds on the particles, (2) convection towards the cathode, (3) diffusion through a hydrodynamic boundary layer, (4) diffusion through a concentration boundary layer, and (5) Adsorption at the cathode, where particles are entrapped within the metal deposit [13].

Surface oxide film of aluminum and the extreme reactivity of bare aluminum result in rapid re-formation of the film on exposure to air or aqueous solutions, which cause the difficulty of plating on aluminum substrate [14]. Other problems for Ni coating on aluminum are:

- (1) Influence of electrochemical potential. The electrochemical positions of aluminum and nickel in metal series have a profound influence on deposition reactions and adhesion, making the plating quite difficult [15]. The electrochemical potential of Ni and Al metal are shown in Table 1 [11].
- (2) Effects of the coefficient of thermal expansion on bond strength. The expansion coefficient of aluminum and its alloys are quite different from that of the nickel. In applications, where considerable temperature changes occur, the different expansion of aluminum and the deposited metal

* Corresponding author. Tel.: +98 21 64542967.

E-mail addresses: ghanbari.sivash@gmail.com (S. Ghanbari), mahboubi@aut.ac.ir (F. Mahboubi).

¹ Tel.: +98 21 44220940.