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Short Communication

Effect of plasma nitriding on electrodeposited Ni–Al composite coating

N. Daemi [a], F. Mahboubi [a,*], H. Alimadadi [b]

[a] Department of Mining and Metallurgical Engineering and New Technologies Research Center, Amirkabir University of Technology, Hafez Ave., P.O. Box 15875, Tehran 4413, Iran
[b] Department of Mechanical Engineering, Technical University of Denmark, Kemitorvet, Building 204, 2800 Kgs. Lyngby, Denmark

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ABSTRACT

In this study plasma nitriding is applied on nickel–aluminum composite coating, deposited on steel substrate. Ni–Al composite layers were fabricated by electro-deposition process in Watt's bath containing Al particles. Electrodeposited specimens were subjected to plasma atmosphere comprising of 80% N_2–20% H_2, at 500 °C, for 5 h. The surface morphology investigated, using a scanning electron microscope (SEM) and the surface roughness was measured by use of contact method. Chemical composition was analyzed by X-ray fluorescence spectroscopy and formation of AlN phase was confirmed by X-ray diffraction. The corrosion resistance of composite coatings was measured by potentiodynamic polarization in 3.5% NaCl solution. The obtained results show that plasma nitriding process leads to an increase in microhardness and corrosion resistance, simultaneously.

1. Introduction

Adding ceramics and intermetallics into regular metal coatings is becoming a common method to improve surface properties like friction coefficient, wear, corrosion, oxidation, etc. Electro-deposition is a well established method for fabrication of such materials because of advantages in uniform depositions on complexly shaped substrates, low cost, good reproducibility and the reduction of waste [1]. During this process, these insoluble particles are suspended in a conventional plating electrolyte and are captured in the growing metal film.

Nickel and nickel alloys are reasonably easy to be electrodeposited, vastly investigated and successfully applied in several applications [2]. Enhancement in different materials properties may be achieved by reinforcing metallic coating by different ceramic or metal particles. Hence effect of micro and nano sized particles such as SiC [3–6] and Al_2O_3 [6–8], on different material properties were investigated. Other ceramics like WC [9], CeO_2 [10] and TiO_2 [11] were successfully electrodeposited and examined too. These composite coatings are of particular importance due to their increased microhardness and improved wear resistance. Another type of composite coating can be produced by co-deposition of metallic particles and metallic ions to fabricate electrodeposited metal matrix/metal particle composite (EMMC) coatings [12–16].

Subsequent treatment of these composite coatings may result in formation of new phases which would be difficult or impossible to produce using conventional electro-deposition methods and can improve high temperature oxidation, hardness, corrosion properties, etc. Ni–Al composite coatings are one of the most popular of these composite coatings. Susan et al. [12] and Napyoszek-Bilnik et al. [13] have reported the co-deposition mechanism of Al particles and the influence of operating parameters on the co-deposition of these particles incorporated in nickel. Zhou et al. [15] have also reported the Al particles size effect on the microstructure of the co-deposited Ni–Al composite coatings. Earlier works revealed that co-deposited Al particles and heat treatment of them improved the oxidation resistance of pure Ni due to formation of Ni_3Al phase at high temperature [17–20].

In order to improve of coating properties, the surface of electroplated coatings can be modified by plasma nitriding. Plasma nitriding is of particular interest as it is an environmentally friendly process with rather low operating temperature [21–23]. The presence of a dense nitride layer on the surface cause an improvement in corrosion and wear resistance [24,25]. Diffusion of nitrogen is assisted in plasma atmosphere which in controlled conditions can bring about nitrogen rich solid solutions and nitrogen containing compounds [26]. Reduced treatment gas and energy consumption, fewer environmental problems and formation of very low porosity single phase compound layer facilitate extension of plasma nitriding market in comparison with conventional gas or salt bath nitriding [27].

By plasma nitriding, aluminum particles are converted to aluminum nitride (AlN). Aluminum nitride is a wide-band gap semiconductor material that is finding applications in a number of technologies due to its unique combination of desirable properties such as chemical and thermal stability, low thermal expansion coefficient, and high mechanical hardness.

* Corresponding author.
E-mail address: mahboubi@aut.ac.ir (F. Mahboubi).

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