Materials and Design 32 (2011) 133–138

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Corrosion resistance enhancement of Ni–P electroless coatings by incorporation of nano-SiO_2 particles

Taher Rabizadeh [a], Saeed Reza Allahkaram [b,*]

[a] School of Metallurgy and Materials Engineering, University College of Engineering, University of Tehran, Tehran, Iran
[b] Center of Excellence in High Performance Ultra Fine Materials, School of Metallurgy and Materials Engineering, University College of Engineering, University of Tehran, P.O. Box 11155-4563, Tehran, Iran

ARTICLE INFO

Article history:
Received 9 March 2010
Accepted 11 June 2010
Available online 16 June 2010

Keywords:
A. Nano-materials
C. Coatings
E. Corrosion

ABSTRACT

Composite coatings were prepared using hypophosphite reduced electroless nickel bath containing 7 g/L SiO_2 nano-particles at pH 4.6 ± 0.2 and temperature 90 ± 2 °C. Deposition rate for SiO_2 nano-composite coatings was 10–12 μm/h. The amount of SiO_2 nano-particles co-deposited in the Ni–P matrix was around 2 wt.%. The analyzes of coating compositions, carried out by Energy Dispersive Analysis of X-ray (EDAX), showed that plain Ni–P and Ni–P/nano-SiO_2 deposits contained around 8 wt.% phosphorus. The X-ray diffraction (XRD) pattern of Ni–P/nano-SiO_2 coating was very similar to that of plain electroless Ni–P coating, whose structure was also amorphous.

Scanning electron microscopy (SEM) morphology of the surface deposits revealed that some agglomeration occurred because of the absence of surfactant.

Electrochemical impedance spectroscopy and polarization tests showed that addition of nano-SiO_2 particles demonstrated significant improvement of corrosion resistance of Ni–P coatings in salty atmosphere.

1. Introduction

Electroless coatings are widely used in different industries because of their high hardness, excellent corrosion, wear resistances and uniform coating thickness. Co-depositing another metallic or non-metallic elements or abrasive/lubricate particles or combination of them in binary Ni–P matrix can further enhance these properties [1–3].

In the field of corrosion, according to one group of researchers, the corrosion resistance of electroless Ni–P composite coatings is believed to be significantly less than that of the electroless Ni–P coatings. The co-deposited second phase particles present in the electroless nickel matrix are thought to reduce both passivity and corrosion resistance. However, the corrosion performance of electroless Ni–P composite coatings was found to be satisfactory by Balaraju et al. [4,5], Huang et al. [6] and Allahkaram et al. [7].

Balaraju et al. [4,5] studied corrosion resistance of electroless Ni–P composite coatings by electrochemical impedance spectroscopy and linear polarization measurements and confirmed that the degree of corrosion protection offered by them is the same or better than that provided by the electroless Ni–P coatings having similar thickness [8].

It can be rationally anticipated that the inclusion of nano-sized particles in electroless Ni–P alloy coating would be significant for broadening the scopes of the coating in engineering, because various types of nano-particles have special natures much different from that of bulk counterparts and could endow the coating with special functionality. This has been primarily verified by the studies on electroless Ni–P alloy coating doped with carbon nano-tubles (CNTs) [9–11].

No doubt, the preparation of electroless Ni–P based composite coatings with excellent comprehensive properties is highly dependent on the stable dispersion of the nano-particles in plating bath, otherwise the so-called composite coatings would have non-uniformly distributed particulates and numerous defects, owing to the segregation and agglomeration of the nano-particles with high surface energy and activity in the plating bath [12,13].

In this context, the present work aims to study the effect of incorporation of hard ceramic nano-particle, nano-SiO_2, on the structure and corrosion protection behavior of electroless Ni–P matrix.

2. Experimental procedures

2.1. Deposition of electroless Ni–P and Ni–P/nano-SiO_2 composite coatings

Ni–P and Ni–P composite coatings were obtained on API-5L X65 steel substrates (30 × 25 × 15 mm) with a composition of

* Corresponding author. Tel./fax: +98 2161114108.
E-mail addresses: t_rabizadeh_1@yahoo.com (T. Rabizadeh), akaram@ut.ac.ir (S.R. Allahkaram).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.06.021