



NiP/SiC composite coatings: the effects of particles on the electrochemical behaviour

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Abstract

NiP/SiC (17 at.% P) composite coatings were prepared by electrodeposition from a Brenner type plating bath containing SiC particles. Cyclic voltammetry and immersion time were used to evaluate the electrochemical behaviour of these coatings.

The results showed that the presence of SiC particles in NiP alloy increased corrosion properties, because the exposed area of the metallic matrix was reduced due to its recovering by SiC particles. However, the current densities developed by the NiP/SiC composite coatings increased with increasing amount of incorporated particles, and such effect is more remarkable for small particles, after heat treatment and when the systems are polarized.

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1. Introduction

Several studies have been made on the NiP alloys [1–5], particularly on the amorphous phases, because of their good corrosion resistance in environments containing

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a high concentration of Cl^- , NO_3^- , SO_4^- , or SO_3^{2-} ions. For electrodeposited NiP alloys the transition from the crystalline to amorphous structures takes place progressively over a range of several atomic percent of phosphorus and NiP coatings are amorphous when the phosphorus content exceeds 15 at.% [6,7].

Crystallization of the amorphous alloys can be achieved by heat treatment with subsequently decomposition to Ni_3P and f.c.c. nickel crystals at temperature above 350 °C [8].

The corrosion properties of NiP alloys, concerning the nature of its anodic dissolution, ability to passivate and susceptibility to pitting are not yet clearly established.

The NiP passivation can be attributed to the non-complete phosphorus oxidation in high potentials and to the fact that, after polarization, the surface of the alloy becomes phosphorus-rich as result of selective dissolution of nickel during polarization. $\text{Ni}_3(\text{PO}_4)_2$ is then formed, acting as a barrier against dissolution [9]. Diegle et al. [10] suggest that NiP alloy does not developed a classical passive film and proposed that the passivation process is controlled by the formation and adsorption of hypophosphite anion, which forms a barrier layer between the alloy and the electrolyte. Schenzel et al. [11] concluded that the transformation of the amorphous NiP alloy into a continuous layer of Ni_3P containing isolated areas of nickel crystals renders electroless nickel extremely resistant to corrosion pitting. The required time and temperature depend on the phosphorus content of the coating. However, the local corrosion resistance is limited by a high chloride concentration [2], and the phosphorus quantity fluctuation on the coating may lead to the formation of microgalvanic pairs that can be the cause of the local corrosion of these alloys, when there are no macroscopic defects [12].

Krolkowski and Butkiewicz [13] showed that the anodic behaviour of NiP depends very strongly on the structural state of this alloy, and Parente et al. confirm the role of the structural condition of the alloy [4].

NiP coatings containing dispersed particles have received considerable attention lately, specially because of their resistance to wear and improved tribological properties.

The metal matrix composite coatings can be prepared either by electrodeposition or autocatalytic (electroless) deposition. The process consists of incorporating particles to the metallic matrix from an electrolyte containing particles in suspension. Convection forces move the particles straight to the surface that is to be coated, where they are adsorbed before being definitely incorporated to the growing coating.

Due to their high wear resistance and the low cost of ceramic powder, metal matrix composite coatings with SiC have been investigated for the protection of friction parts [14–16].

Many studies [7,14,17–22] concerning the incorporation of silicon-carbide particles in electrodeposited nickel matrix and about the characterization of the tribological properties have been made. Several authors expressed interest in the influence of operational parameters such as particle concentration in suspension, stirring speed, current density, effect of the addition of surfactants and others on the particle incorporation rate, based on the characteristic of volumetric fraction. However, Célis and coworkers [14], using sets of particles of different sizes, showed that the

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