

Fabrication and characterization of electro-codeposited Ni/Zr-silicate composite coating

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Abstract

Ni–Zr-silicate (Ni–zircon) composite coating was electro-deposited on mild steel using Watt's nickel bath. Fine (5–10 μm) and coarse (40–60 μm) zircon particles were used. The aim of this study is to compare the effect of zircon addition to the electrolyte on the hardness and wear resistance properties of composite coatings. The results obtained in this study indicated that the codeposition of reinforced particles of zircon to Watt's nickel bath improved the hardness and wear resistance of mild steel samples compared with zircon free nickel bath. On the other hand, microstructure of Ni matrix was changed by the addition of the hard Zr-Silicate particles. It is confirmed that the wear resistance of codeposited layer increases with addition of 25 g/l of large Zr-silicate particles. Moreover, wear resistance increases as the amount of fine zircon particles (5–10 μm) increases.

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1. Introduction

Composite electroplating is a method of codepositing fine particles of metallic, non-metallic compounds or polymers in the plated layer to improve material properties such as wear resistance, lubrication, or corrosion resistance. During this process, these insoluble materials are suspended in a conventional plating electrolyte and are captured in the growing metal film. The second-phase material can be powder, fiber or encapsulated particle. Electro-deposited composites are of considerable importance in view of their unique mechanical and protective performance [1–4].

In general, hardness, yield strength, tensile strength and wear resistance are all improved by the presence of the second-phase particles. Such types of coatings are required in different fields of technology including transportation, machine and device construction, machine tools, aircraft, civil and military industries.

The electroplating solution is more stable and faster and has fewer replenishment problems compared with electroless nickel plating.

Composite coatings are mainly used to increase the wear and corrosion resistance and lubrication [5,6]. Examples for such kinds of composite are incorporation of oxide particles like Al_2O_3 and TiO_2 , fibers and whiskers in metals to improve their hardness properties [7–11]. ZrO_2 particles were also used during Ni–P electroless plating to improve the wear resistance and hardness [12]. Coating metals with a metallic matrix composite containing hard particles such as diamond, WC and SiC [13–15], are another means of protection against abrasion. The properties of coatings are governed by the type and size of the inert particles, their content in the coating and the mode of distribution. Sautter [16] found that the volume percentage of Al_2O_3 particles in a nickel matrix increases with increasing particle concentration in the bath. Ni–SiC composite coatings were extensively studied and the results showed that SiC particles improve the friction and wear resistance of the coated surfaces [17–20]. They confirmed that, wear resistance of codeposited layer increases with increasing volume percent of submicron-size SiC.

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Table 1
Operating condition of electro-deposition

Current density (A/dm^2)	2 (for hardness study) and 3 (for wear study)
pH	6
Deposition time, min	30, 120
Temperature ($^{\circ}C$)	50
Amount of zircon particles (g/l)	25–100
Size of zircon particles	Large (40–60 μm) Fine (5–10 μm)

Several authors determined cathodic polarization curves for the codeposition plating bath with and without particles. Most [21–23] found a higher current density for the same cathode potential when particle was present. At high overvoltage the transport of the metal ions to the cathode becomes an important factor and it is known that the addition of inert particles enhances this transport [24], which leads to depolarization of the cathode.

The main objective of this work is to develop a Ni–Zr-silicate codeposited layer on mild steel substrate from Watt's

bath to improve the anti-wear performance of gears designed for machinery parts. The effect of addition of Zr-silicate particles to the electrolyte on the wear resistance, hardness and microstructure will be investigated. Also, a comparison regarding the wear resistance between two different composite coatings deposited using fine and coarse zircon particles will be studied. For that, zircon with fine (5–10 μm) and coarse (40–60 μm) particle size and purity >99.8% was used as ceramic increment particles during Ni electro-deposition. The white-creamy zircon used in this study was the result of the treatment of zircon concentrate separated with other economically minerals from Egyptian beach sand.

2. Experimental

2.1. Materials

Ni–Zr-silicate composite was deposited using Watt's bath solution containing 300 g/l nickel sulfate (ADWIC, Assay min 99%), 60 g/l nickel chloride (NTL, Assay min 97%) and 40 g/l boric acid (Assay 99%). The operating condition for

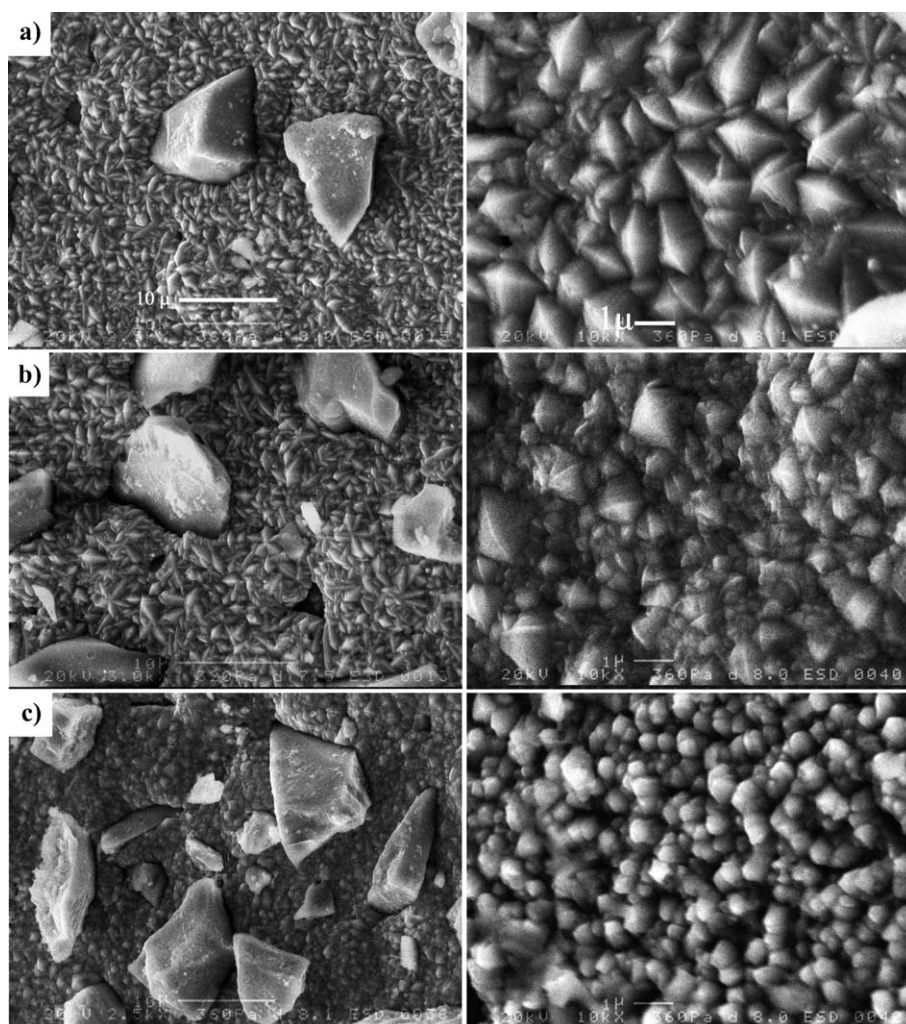


Fig. 1. Scanning electron micrographs showing the distributed zircon particles in nickel matrix at different zircon amounts: (a) 10, (b) 25, (c) 50 g/l and the typical Ni matrix structure.

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