Journal of Alloys and Compounds 484 (2009) 540–544

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

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

Influence of SiC nanoparticles and saccharin on the structure and properties of electrodeposited Ni–Fe/SiC nanocomposite coatings

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ARTICLE INFO

Article history:
Received 15 December 2008
Received in revised form 28 April 2009
Accepted 29 April 2009
Available online 6 May 2009

Keywords:
Electrodeposition
Ni–Fe/SiC nanocomposite coating
X-ray diffraction
Microhardness
Corrosion resistance
Saccharin

ABSTRACT

In this study, Ni–Fe/SiC nanocomposite coatings with smooth and crack-free surface were successfully prepared by means of the conventional electrodeposition in the presence of saccharin in electrolyte. The goal of this work was to investigate the effect of SiC nanoparticles and saccharin on the structure and properties of permalloy nanocomposite coatings. The nanocomposite coatings were characterized using optical and scanning electron microscopy, energy dispersive X-ray (EDX) analysis and X-ray diffraction (XRD) technique. The significant variation in the crystallographic texture of the coatings was observed due to the addition of SiC nanoparticles and saccharin in the electrodeposition bath. Increasing the amount of saccharin in the electrolyte led to a change in the texture from a (2 0 0) fiber texture to mixed (3 1 1) and (2 0 0) textures. Our results indicated that inclusion of SiC nanoparticles suppressed the preferred growth direction of the Ni–Fe matrix, resulting in a decrease in the sharpness of the (2 0 0) fiber texture and formation of a more random texture. The presence of SiC nanoparticles in the metallic matrix also led to the production of composite films with better corrosion resistance and higher microhardness than the Ni–Fe coating.

1. Introduction

In the last decade, a great deal of attention has been paid to the study of permalloy (80% Ni–20% Fe), because of the widespread use of this material in applications involving micro-electro-mechanical-systems (MEMS) and mesoscopic systems [1–4]. Ni–Fe coatings are easily produced using electrodeposition techniques. The deposited films have been shown to have low residual stress, low energy requirement, rapid deposition rate, low cost, capability to handle complex geometry and to control the film thickness, and simple scale-up with easily maintained equipment. Permalloy is introduced as a structural material for the LIGA (Lithographie, Galvanformung, Abformung, equivalent to lithography, electroplating and molding) method which is used to fabricate discrete, free-standing metallic parts and high-aspect ratio microstructures [2]. Saccharin is a strong leveling and grain refinement agent, capable of decreasing internal stress in the permalloy coating [2,4]. Saccharin, as a sulfur-bearing additive, increases the sulfur content in the electrodeposited coating which is insoluble in permalloy. Sulfur segregation to grain boundaries after the coating is exposured to high temperatures, promotes grain boundary embrittlement and intergranular fracture [2].

The codeposition of inert particles in metallic coatings improves physical and mechanical properties of these coatings and forms a nanocrystalline metallic deposit due to the modified growth [5–11]. Since the electrodeposited composite coatings combine the advantages of both the electrodeposited coatings and codeposition of hard particles, Ni–Fe nanocomposite coatings have properties superior to the Ni–Fe alloy coatings [12,13]. Two articles related to the reinforcement of Ni–Fe alloys with ceramic particles have been published in the past five years. Li and Li [12] have studied the effect of Si_3N_4 nanoparticles content and annealing on the microhardness of electrodeposited Ni–Fe/Si_3N_4 nanocomposites. More recently, Starosta and Zielinski [13] investigated the influence of coating composition on corrosion and wear behavior of the Ni–Fe/Al_2O_3 composite coatings. However, to our knowledge, the electrodeposition of Ni–Fe/SiC nanocomposite coatings has not been studied up to now.

Due to the effect of microstructure on the physical and mechanical properties of nanocomposite coatings, it seems to be necessary to examine the influence of some parameters such as embedded nanoparticles and organic additives, on the microstructure of the resulting nanocomposite coating. In this research, we reported the effect of saccharin and SiC nanoparticles on the microstructure of the permalloy nanocomposites, special attention was paid to the distribution of crystallographic orientations because texture can have a great influence on physical and mechanical properties of coating due to the anisotropic properties. The relationship between

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doi:10.1016/j.jallcom.2009.04.146