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Effect of Applied Current Density on Morphological and Structural Properties of Electrodeposited Fe–Cu Films

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A detailed study has been carried out to investigate the effect of applied current density on the composition, crystallographic structure, grain size, and surface morphology of Fe–Cu films. X-ray diffraction (XRD) results show that the films consist of a mixture of face-centered cubic (fcc) Cu and body centered cubic (bcc) α-Fe phases. The average crystalline size of both Fe and Cu particles decreases as the applied current density becomes more negative. Compositional analysis of Fe–Cu films indicates that the Fe content within the films increases with decreasing current density towards more negative values. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) have been used to investigate the surface morphology of Fe–Cu films. It is observed that the surface morphology of the films changes from dendritic structure to a cauliflower structure as the applied current density becomes more negative. The surface roughness and grain size of the Fe–Cu films decrease with decreasing applied current density towards more negative values.

KEY WORDS: Electrodeposition; Surface morphology; Current density; Grain size; Composition

1. Introduction

Ferromagnetic thin films have been used in industrial applications due to their electrical, mechanical, magnetic *etc.* properties for a long time[1]. Firstly, Fe–Cu alloys are used as master alloys to grow new copper alloys for very special purposes[2]. They have applications in electronic industry as materials for electrical device components such as semiconductor lead frames, electrical connectors, and electrical fuses[2]. The electrodeposition technique is widely used in the production of single or alloy thin films due to the cost-effectiveness, simplicity, minimum waste of components, fast production, and easy deposition irrespectively of surface size and area[3–12]. In the electrodeposition technique, it is well known that the physical properties of the films are very strongly affected by many factors such as electrolyte composition, electrolyte temperature, additives, electrolyte pH, and deposition potential or current density[6,12–17]. Among them, especially, current density and pH are two key processing variables that identify physical properties of the electrodeposited films during the growth process[18].

The aim of this study was to investigate the effect of applied current density on the grain size, composition, crystallographic structure, and surface morphology of electrodeposited Fe–Cu films. The films were prepared at different current densities of -5, -20, and -40 mA/cm^2, respectively. The surface morphology of Fe–Cu films was significantly affected by the applied current density. Furthermore, it was found that the grain size and surface roughness of Fe–Cu films decreased with decreasing applied current density towards more negative values.

2. Experimental

Fe–Cu films were prepared from an electrolyte composed of 0.1 mol/L $FeSO_4{\cdot}7H_2O$, 0.02 mol/L $CuSO_4{\cdot}5H_2O$, and 0.1 mol/L H_3BO_3 under the gal-

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