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ORIGINAL PAPER

The Influence of Applied Current Density on Microstructural, Magnetic, and Morphological Properties of Electrodeposited Nanocrystalline Ni–Co Thin Films

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Abstract Electrodeposited Ni–Co nanocrystalline thin films were grown onto indium tin oxide (ITO)-coated glass substrates from an electrolyte consisting of their sulfate salts and boric acid without stirring at ambient temperature. The effect of applied current density on the microstructural, compositional, magnetic, and morphological properties was investigated using different characterization techniques such as X-ray diffraction (XRD), energy dispersive X-ray (EDX) spectroscopy, vibrating sample magnetometer (VSM), and scanning electron microscopy (SEM). It was observed that the Ni content within the films increases as the applied current density increases. X-ray diffraction (XRD) analyses of Ni–Co films showed the formation of single phase face-centered cubic (FCC) structure and <111>crystallographic orientation. Morphological characterizations revealed that the applied current density affects the surface morphology of the films. The film electrodeposited at high current density has smaller grains than those prepared at lower current densities. Magnetic measurements showed that the coercivity field and remanence ratio of the films decrease as the applied current density increases. Consequently, Ni–Co thin films exhibited different microstructural, compositional, magnetic, and morphological properties according to current density applied during electroplating process.

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1 Introduction

Alloy films of iron group metals (Fe, Co, and Ni) are known to possess very good magnetic properties [1]. The production of Ni, Co, and their alloy films by electrodeposition has been widely studied because of their useful properties for applications like high strength, hardness, anti-corrosion, specific magnetic, heat-conductive, and electrocatalytic properties and their anomalous codeposition behavior [2]. Therefore, they have become an important component in micro electrical mechanical system (MEMS) applications [3]. It is well known that the magnetic properties of electrodeposited iron group thin films are strongly related to the microstructural, compositional, and surface morphological properties which can be significantly affected by the experimental deposition factors (electrolyte pH, temperature, current density or cathode potential, electrolyte composition etc.), film thickness, substrate properties etc. Thus, the investigation of the microstructural, compositional, morphological, and magnetic properties of electrodeposited iron group films grown under different conditions is an important issue for possible applications.

The aim of the present study, therefore, is to investigate the properties of the electrodeposited Ni–Co thin films as a function of current density applied during the electrochemical process. For this purpose, Ni–Co films have been electrodeposited at different applied current densities onto indium tin oxide (ITO)-coated glass substrates at room temperature and the results of their compositional,