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ORIGINAL PAPER

# Effect of Deposition Time on Properties of Ni–Cu Alloy Films Electrodeposited on ITO Coated Glass Substrates

**Umut Sarac · M. Celalettin Baykul**

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**Abstract** The structural, magnetic, and surface morphological properties of Ni–Cu films electrodeposited on ITO (indium tin oxide) glass substrates at different deposition times ranging between 2 s and 600 s have been investigated. The structure of the films was studied using X-ray Diffraction (XRD). The XRD results showed that all samples have a face-centered cubic (FCC) structure. From the XRD patterns, it was also found that the crystallographic structure of the films strongly depends on the deposition time. Compositional analysis of Ni–Cu films carried out by energy dispersive X-ray spectroscopy (EDX) indicated that the Ni content within the films increases with increasing deposition time and then almost saturates at deposition time of 600 s. The result of the vibrating sample magnetometer (VSM) measurements revealed that the saturation magnetization increases with increasing Ni content within the film. Atomic force microscopy (AFM) was used to study the topographic properties of Ni–Cu films. It was found that the surface roughness of Ni–Cu alloy films increases with increasing deposition time. Furthermore, the surface texture was found to be isotropic for all films grown at different deposition times.

**Keywords** Deposition time · Surface roughness · Magnetic properties · X-ray diffraction · Surface texture

U. Sarac (✉)
Department of Elementary Education, Bartın University, Bartın 74100, Turkey
e-mail: usarac428@hotmail.com

U. Sarac · M.C. Baykul
Department of Physics, Faculty of Arts and Science, Eskisehir Osmangazi University, 26480 Meselik, Eskisehir, Turkey

## 1 Introduction

Ni–Cu alloy films have been used in many industrial applications such as shipbuilding, power stations, decorative and protective purposes, microelectromechanical systems (MEMS), magnetoresistive sensors, and data storage due to their useful properties such as good corrosion resistance, catalytic, and magnetic properties [1–8].

ITO coated glass substrate is sufficiently conductive to allow electrodeposition directly onto it and that also allows the measurement of the magnetic properties without separating the films [9].

In the present study, the effect of deposition time on the properties of Ni–Cu films deposited on ITO coated glass substrates at a constant potential of −900 mV versus saturated calomel electrode (SCE) has been investigated for the first time in order to better understand the growth conditions.

## 2 Experimental Details

Ni–Cu films were deposited on ITO coated glass substrates from a single electrolyte solution under potentiostatic control. The electrolyte consisted of 0.54 M nickel sulfate, 0.01 M copper sulphate, and 0.3 M boric acid. All chemicals were dissolved in deionized water. The pH was kept around $3.5 \pm 0.1$ and the electrolyte temperature was held at $25 \pm 1$ °C. The deposition was performed in a conventional three-electrode cell using a potentiostat/galvonastat (VersaSTAT 3). A platinum wire was used as counter electrode. ITO served as working electrode and the reference electrode was a saturated calomel electrode (SCE). The working area was $8 \times 10$ mm$^2$. The potentials were measured against a SCE which was placed as close as possible to the ITO surface to minimize the ohmic potential drop in