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# Evolution of surface roughness parameters and microstructure in two-phase nanocrystalline Co–Cu films electrodeposited onto ITO coated glass substrates at different deposition potentials

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**Abstract** In the present research, we have studied the effect of deposition potential on the film composition, structural, and morphological properties of the electrodeposited Co–Cu thin films grown onto indium tin oxide coated glass substrates. For this purpose, the properties of the films were analyzed by means of X-ray diffraction, energy dispersive X-ray spectroscopy (EDX), and atomic force microscopy (AFM) characterization techniques. Structural characterizations showed that all of the Co–Cu films consist of hexagonal close-packed (hcp) Co and face-centered cubic (fcc) Cu phases. The hcp Co (002)/fcc Cu (111) peak intensity ratio was found to increase as the deposition potential decreased towards more negative values. An increase in the Co content in the Co–Cu films was observed as the applied deposition potential was made more negative according to EDX analysis. The decrease of the applied deposition potential towards more negative values also induced a decrease in the average crystallite sizes of both Co and Cu particles. AFM study indicated that a granular structure of the electrodeposited Co–Cu films regardless of deposition potential. As the applied deposition potential was made more negative, the surface roughness and particle size decreased considerably. Besides, two additional roughness parameters, surface kurtosis and the surface skewness were also obtained and discussed by means of the obtained results under the study.

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## 1 Introduction

The characterization of Co–Cu magnetic thin film systems has attracted significant attention for a long time due to their fundamental scientific interest and potential applications in magnetic recording devices and magnetic sensors [1–3]. Electrodeposition is a versatile method for the production of such magnetic thin films and provides a number of advantages such as low cost, simplicity, and very high production rate in comparison with high vacuum growth techniques required expensive equipment [1, 4–11]. It is well known that many physical and chemical parameters influence the properties of electrodeposited films. Cu–Co magnetic thin films have been the subject of many research studies and the effects of different growth parameters on the structural and magnetic properties have been studied. The deposition potential is one of the most important growth parameters, which is strongly affected the properties of electrodeposited films [1]. In recent studies, the effect of deposition potential on the properties of Co–Cu films electrodeposited onto different substrates such as fluorine-doped tin oxide coated glass [12], n-Si(100) [1] and Cu sheets [10, 13] has been reported. On the other hand, surface roughness of materials is well known to influence their properties such as the resistivity, scattering, and electron mobility [14] and moreover, the surface roughness is influenced strongly by the growth parameters. Therefore, in this work, the effect of deposition potential on structural and surface morphological properties of electrodeposited Co–Cu films prepared from the electrolyte of sulfate salts onto indium tin oxide (ITO) coated glass substrates was analyzed. For this purpose, Co–Cu films were electrodeposited at three different deposition potentials such as −1,000, −1,200, and −1,400 mV versus saturated calomel electrode (SCE). We showed that the