



Co_{100-x}Fe_x magnetic thick films prepared by electrodeposition



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ABSTRACT

Co–Fe films are grown onto plane pre-treated Cu foils; the effects of the alloy composition on the morphology and the crystal texture of the electrodeposited films and their anisotropic magnetic hysteresis properties are explored. Nucleation and crystallization mechanisms in these Co-rich layers are also investigated with pulse-reverse plating techniques, using the first cathodic pulse current–time transients. In the diffusion controlled regime the deposition mechanism is found to involve progressive nucleation with three-dimensional (3D) growth, except for the equiatomic Fe₅₀Co₅₀ solution where nucleation tends to become instantaneous. The different morphologies and size scales observed are described and correlated with coercivity. The films are electrodeposited onto electrochemically pre-treated Cu substrates from feeds of nominal Fe/Co mol ratios between 0/100 and 50/50. The composition of the deposited layers, as determined by energy dispersive X-ray spectroscopy, are quite close to the nominal values. Cyclic voltammetry determinations exhibit only a single reduction process on the cathode, indicating that a unique (Co_{100-x}Fe_x) phase grows. Depending on composition and on the substrate pre-treatment, these layers exhibit textures with features of different sizes. X ray diffraction patterns indicate that the nanostructures with Fe contents above 20 at.% crystallize in a body-centered cubic cell, while samples with Fe contents below this value are *fcc*. Regarding the effect of composition on the morphology, Co and Co-rich layers are compact, with large (100–300 nm) agglomerates of quite equiaxed, densely packed particles (average 50 nm); as the iron content increases above 15 at.%, faceted particles 100 nm in size are observed. All the electrodeposited layers are soft ferromagnetic at room temperature, with an in plane easy axis; coercive fields/forces between 10 mT and 71 mT are measured at 300 K.

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1. Introduction

Co–Fe alloys are important soft magnetic materials due to their unique magnetic properties including high saturation magnetization and magnetostriction, high permeability, low coercivity, and a good thermal stability, parameters that cannot be matched by any other alloy system [1]. Their potential applications on miniaturized products, weapons, coatings, communication devices, and for printed circuit boards, among other applications [2–4] make this alloy of industrial importance.

There is today an increasing interest in the development of nanostructured materials because of the unusual physicochemical properties arising from surface as well as quantum effects [5]. Soft and hard magnetic films may be fabricated using sputtering, evaporation and molecular beam epitaxy (MBE) techniques but the low deposition rate, the high vacuum required and the high costs make

them unpractical for device fabrication. Sputtering, exhibiting the highest merit, is not suitable, however, for fabricating the thick films demanded by many applications. On the contrary, electrodeposition is one of the simplest, most cheap processes available for the fabrication of single component and multilayered thick (about 10 μm) films.

Chemical and electrochemical methods have been reported to prepare magnetic nanostructures and specially micrometric films; in fact, nanostructures and films of Fe, Ni and Co [6–10] and also CoFe [11–15] films have been successfully produced by these techniques.

In this article we present our results related to the synthesis, using template free electrochemical techniques, of CoFe thick (~10 μm) films with different compositions, onto plane Cu substrates. In the first part, the effect of the substrate surface condition on the morphology and the size scale of the nanostructures deposited is examined for compositions near the 50/50 equiatomic one. In the second part, the effect of the alloy composition on the properties of these structures is addressed. The resulting nanostructure

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