

## Microstructural Study of Thin Films CuFe Obtained by Thermal Evaporation of Nanostructured Milled Powder

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**Keywords:** Thin film, CuFe solid solution, Microstructure, DRX, MET, VSM.

**Abstract:** Commercial copper and iron powders were used as starting materials. These powders were mechanically alloyed to obtain  $\text{Cu}_{(100-x)}\text{Fe}_x$  supersaturated mixture. The milling duration was chosen in such a way as to obtain a nanostructured mixture and to form a supersaturated solid solution of CuFe; the powder mixture was used to deposit CuFe on a glass substrate.

The elaboration of our films has been carried out using thermal evaporation process (physical vapor deposition) under  $1 \times 10^{-6}$  mbar vacuum from an electrically heated tungsten boat, using the supersaturated solid solution  $\text{Cu}_{(100-x)}\text{Fe}_x$  powder obtained by mechanical alloying. The films deposition has been done on glass substrates. In this study, we present the composition effect on the structural and magnetic proprieties of  $\text{Cu}_{(100-x)}\text{Fe}_x$  powder and thin films. The chemical composition, structural and magnetic proprieties of milled powders and thin films were examined by SEM, TEM, XRD, XRF and VSM.

### Introduction

Fe–Cu alloys have become the subject of intensive experimental and theoretical studies [1-6] due to their applications in giant magnetoresistive (GMR) devices [7-9], which make them good candidates for sensors, and their unique properties (magnetization, coercivities, unusually strong magnetocaloric effects) usually unattainable in permanent magnets [10] mainly caused by the insolubility of the components with each other at room temperature [11].

Therefore, many methods of preparation of such CuFe alloys, typically produced as massive specimens with the use of mechanical alloying [3, 4, 12] have been widely investigated, and much attention has been dedicated to following the formation of the FCC solid solution [13-15]. However, there is much interest in thin films, which is partly due to a prospect that layering can be used to modify the material properties or to obtain new properties which are uncharacteristic of their bulk forms.

In the present work, we combine the mechanical alloying process and thermal evaporation of a nanostructured mixture powder to form thin films. First, we report on the experimental method. Then, we present a detailed study of the microstructural properties of  $\text{Cu}_{100-x}\text{Fe}_x$  powder mixture and thin film deposited by thermal evaporation on a glass substrate using the elaborated nanocrystalline mixture.

### Experimental

#### A. Synthesis of CuFe alloy particles

CuFe supersaturated solid solution particles were synthesized using mechanical alloying, commercial copper and iron powders were used as starting materials.

A planetary RETSCH PM 400 ball mill, was employed for milling with a rotating speed of 200 rpm and a ball-to-powder weight ratio of 20. The experiments were performed under a protective atmosphere of argon [16], to minimize oxidation during the milling process. Also, the milling periods of 1/4 h were alternated with equal periods of rest. The milling duration was chosen in such