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Structural characterization thin film grown by thermal evaporation of nanocrystalline Cu₇₀Fe₃₀

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Commercial copper powders and iron powders were used as starting materials. These powders were mixed to obtain alloy compositions of Cu₇₀Fe₃₀. The supersaturated solid solution was assured by mechanical alloying. The milling duration was chosen in such a way to obtain a nanostructured mixture and to form supersaturated solid solution of CuFe. Powder mixture was used to deposit CuFe films of desired thickness on Glass substrate. The deposition was carried out by thermal evaporation under 9×10^{-7} mbar vacuum from an electrically heated tungsten boat filled with supersaturated solutions Cu₇₀Fe₃₀ powder.

The deposition rate was 0.03 nm s^{-1} . The film was deposited at room temperature without heating the substrates. Then, their properties were characterized with different techniques.

The morphology of the powders (before and after milling) and surface of thin film were characterized using scanning electron microscopy (SEM) (JSM-6830LV, JEOL) equipped with energy dispersive spectroscopy (EDS) and a transmission electron microscope (FEI Talos™ F200A) with an operation voltage of 200 kV. Before the transmission electron microscopy (TEM) observation, a focused-ion-beam (FIB) micro sampling technique was used for preparing cross-sectional TEM specimens from a plan-view TEM specimen. Our sample has been thinned to be a lamellae of about 60–70 nm, which was preferable for TEM studies. In particular, by coupling the TEM with the energy dispersive X-ray spectroscopy (EDX). Accordingly, the TEM/EDX analysis technique was employed to investigate the spatial distribution of constituent elements. The structural properties were investigated by X-ray diffraction (XRD). To calculate the crystallite size and the lattice strain, the Williamson–Hall method is adopted. The AFM characterization was performed using an innova AFM (Digital Instruments, Bruker) in tapping mode at ambient temperature. The topographic and phase images were recorded simultaneously.

The investigation of structural proprieties powder milling shows a dissolution of cc-Fe in fcc-Cu leading to the formation of nanocrystallite with a lattice parameter $a=0.32690 \text{ nm}$, grain size of 14.8 nm , microstrain of about 0.10% and a homogeneous distribution of Cu and Fe. A little amount of contamination with (due to the milling tools), Silicon and oxygen have been detected. It is further confirmed by the scanning image of Si, O, Fe and Cu elements.

The thin film CuFe was prepared by thermal evaporation on a glass substrate. The structural properties and surface were investigated. XRD results showed that there was no difference in crystal structure among CuFe film for the 18 nm and powder milling but there are a progressive shift peak thin film to big angles and their enlargement relative to CuFe powder with a lattice parameter $a=0.360 \text{ nm}$, grain size of 8.67 nm and microstrain about 0.001% . AFM images showed surface morphology. Quantitative AFM analysis showed large spherical islands, The RMS surface roughness measured increased from 4 nm to 9 nm .

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