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A structural study of RF-sputtered …Cu/Te… multi-layers

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Abstract

Cu/Te multi-layers with a composition of 50 at% of Te were deposited onto glass substrates by radio frequency (RF) sputtering. Their structure was investigated by the grazing-incidence X-ray diffraction technique (GIXD). The spectra of the as-deposited sample show the formation of hexagonal $Cu_{2-x}Te$ and the presence of free Te. The heat treatments at 450 K during 30 min, 1 h and 2 h show the progressive disappearance of the $Cu_{2-x}Te$ phase and the appearance of a new compound—the orthorhombic rickardite Cu_7Te_5, suggesting that a $Cu_{2-x}Te \rightarrow Cu_7Te_5$ transformation took place.

The samples annealed for a period of 3 h at 450 K show that Cu_7Te_5 completely disappeared in favour of $Cu_{2-x}Te$ and, more precisely, the $Cu_{0.647}Te_{0.353}$ phase dominates the spectra, suggesting that a $Cu_7Te_5 \rightarrow Cu_{2-x}Te$ inverse phase transformation took place.

The results are discussed in light of the strong inter-diffusion that occurred between the Cu and Te layers during the deposition at ambient temperature and to elemental diffusion during annealing. The phase transformations are attributed to a diffusion-induced homogenization of the sample and a loss of Te by sublimation during annealing for an extended time.

Keywords: Cu/Te multi-layers; GIXD; RF sputtering; Phase transformation

1. Introduction

Copper chalcogenides are of paramount scientific and technological interest due to their potential application in thermoelectric devices [1,2], and in various hetero-junction

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electronic components where they are used as p-type semiconductors [3–8]. Aven and Cusano [5] were the first to make p-Cu_2Te/n-CdTe hetero-junction solar cells with an efficiency reaching 7.5%, which subsequently stimulated an extensive investigation of this structure by other researchers [9,10].

Chalcogeneides formed by solid solutions of elements from columns IV and VI of the periodic table are potentially attractive for the following applications: fabrication of visible and infrared (IR) emitting diodes, IR detection and conversion of solar energy [11–15].

One of the interesting properties of the copper chalcogenides stems from the fact that their phases formed at high temperatures have a "mean structure" in the sub-lattice of the cations. The cations are, therefore, statistically distributed on a large number of allowed sites [16], which renders them very mobile, consequently leading to a large ionic conductivity (superionic conductors). In addition, it is well known that these compounds are strongly degenerates [9,10,17] and possess a large electronic conductivity.

The work presented here deals mainly with the structural properties of the Cu–Te alloys obtained by solid-state reaction in thin layers of Cu and Te deposited by RF sputtering.

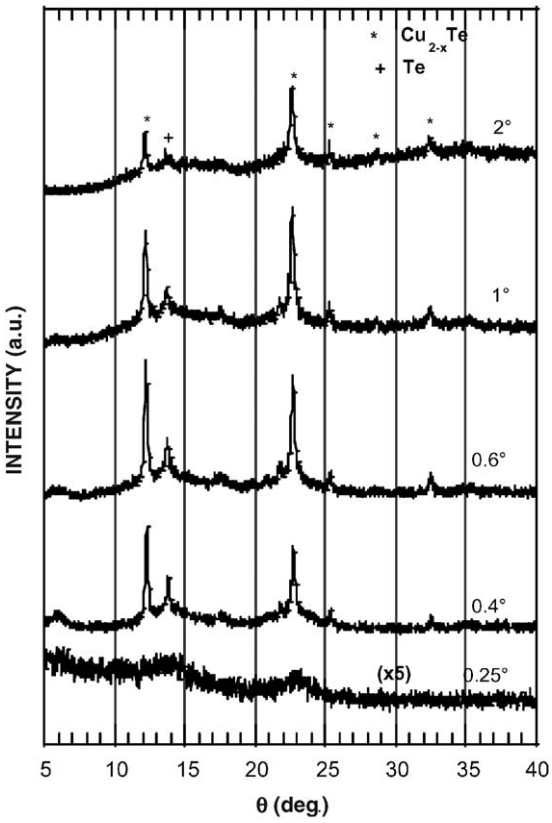

Fig. 1. GIXD spectra obtained at various incidence angles for the as-deposited structure (50 at% Te).