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# Annealing duration influence on dip-coated CZTS thin films properties obtained by sol-gel method

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A B S T R A C T

The effect of annealing duration on structural and optical properties of dip-coated crystalline CZTS thin films was studied. The obtained samples were investigated by several techniques such as XRD, Raman spectroscopy, SEM, UV–vis spectroscopy and Photoluminescence. Being confirmed by Raman spectroscopy, XRD analysis reveals the formation of kesterite tetragonal phase with preferential orientation along (112) direction. The grain size tends to increase as the annealing duration increases, a result confirmed by SEM. The last shows smooth, uniform, homogeneous and densely packed grains. Optical measurement analysis reveals that layers have relatively high absorption coefficient in the visible spectrum with a band gap reduction of 1.62−1.50 eV which is quite close to the optimum value for a solar cell. The photoluminescence distinguishes broad bands that have maximums of intensity limited between 1.50 and 1.62 eV, corresponding to the optical band gap of the CZTS.

## 1. Introduction

Because of their abundance and cheapness, the use of $Cu_2ZnSnS_4$ (CZTS) thin films as high absorbers in solar cells has attracted the intention of researchers in the course of the three last decades. Recently, considerable work has been done on the quaternary compound semiconductor, $Cu_2ZnSnS_4$ (CZTS) to make it a good absorber layer for thin film solar cells [1,2] and thermoelectric power generators [3].

CZTS thin films is a kind of p-type direct band gap semiconductor with a band-gap value of Eg ≈ 1.5 eV for the photoelectric energy conversion and are characterized by a large absorption coefficient (> 104 $cm^{-1}$) [4]. Such materials are also of much broader interest given the possibility of varying their chemical composition to optimize their functionality [5]. For this reason, several methods were employed to deposit those films such as thermal evaporation [6], RF magnetron sputtering deposition [7,8], screen printing [9,10], chemical bath deposition [11],electro-deposition [12], spray pyrolys is techniques [13], spin-coating methods [14], SILAR method [15], and sol-gel deposition [16–22].

The importance of the sol–gel processes is the possibility of forming MeOeM bonds in the precursor solution or during the annealing stage [9]. Also, this process permits the production of secondary phases such as binary sulfides and oxides [9]. But, at high temperatures the films become S-deficient which makes the sol-gel process limited in use [9,10].

To overcome S-deficiency problem, a sulfurization operation is often needed by introducing the toxic $H_2S$ for the liquid-based

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