"OPTICAL AND ELECTRICAL PROPERTIES OF ZnTe AND ZnTe:O THIN FILMS DEPOSITED BY CSVT TECHNIQUE"

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I. Abstract

Zinc Telluride (ZnTe) thin films were deposited onto glass and CdTe substrates by CSVT (Close Space Vapor Transport) technique. Some samples were treated with oxygen during 15 – 60 min. The analysis of the chemical compositions for the as-deposited as well as annealed ZnTe thin films was estimated by using the method of energy dispersive analysis of x-ray (EDAX). The optical properties were studied using photoacoustic and photoluminescence measurements by another hand the electrical properties of ZnTe films have been studied in detail.

Keywords: CdTe, ZnTe, CSVT, Thin films.

II. Introduction

CdTe has a high electron affinity and a high work function metal is required to form a good ohmic contact on p-type CdTe. Most metals don't have high enough work functions [2]. Thus back contacts on CdTe/CdS solar cells often show a non-Ohmic behavior in their I-V characteristics which is usually attributed to a Schottky barrier at the back contact. This Schottky barrier acts as a diode reverse biased to the CdTe/CdS junction diode and increases the contact resistance, thereby reducing the solar cell performance [3].

An approach to overcome this problem is lowering the barrier by introducing an intermediate degenerated semiconductor which increases the conductivity and creates a tunneling barrier. For this purpose the CdTe surface is etched to produce a Te rich surface [1]. The Te rich surface layer has an increased conductivity and is p+ type.

ZnTe is a low cost semiconducting material of the II-VI family. This compound usually has a cubic crystal structure; it is a material of high absorption coefficient and shows a p-type. ZnTe has direct transition of wide band gap of 1.7 to 2.4 eV at room temperature [4]. Zinc telluride can be easily doped, and for this reason it is one of the more common semiconducting materials and It can be used for solar cells, for example, as a back-surface field layer and p-type semiconductor material for a CdTe/ZnTe structure.

III. Experiment

The CdTe thin films were deposited by using CSVT technique (fig. 1), SnO2:F substates were used. The deposition temperatures used for the samples were 530 °C and 630°C for the source (T1) and substrate (T2) respectively and in another case 480 °C for source (T1) and 580 °C for substrate (T2) (fig. 2), under the following conditions: 0.1 Torr, controlled atmosphere (50% O2 and 50% Ar). 0,013 g was placed in a boat CdTe with three divisions (fig. 3), this was for three minutes.

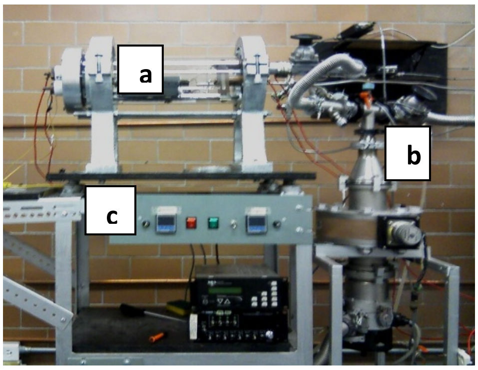


Figure 1. CSVT System: a) Evaporation Chamber, b) electrical system of measurement and control and c) vacuum system

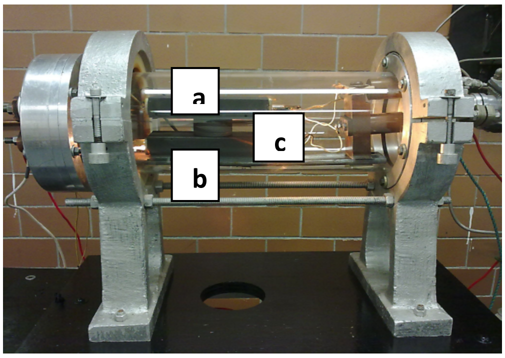


Figure 2. Evaporation Chamber consists of a: a) block of substrate, b)block of source and c) graphite furnace

Then CdTe samples were doped with ZnTe. Placed 0,02 g of ZnTe in their own evaporation chamber and the deposition was under the following conditions: temperature of source: 500 °C and 550 °C, for 3 minutes in a controlled atmosphere 100% O_2 with a pressure of 100 mtorr.

Figure 3. Evaporation Chamber for the CdTe

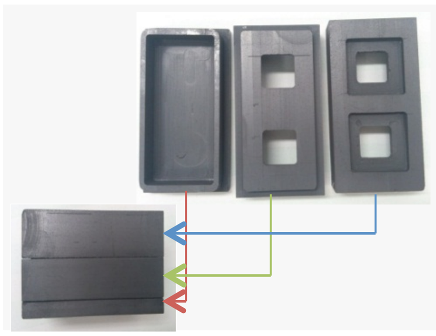


Figure 4. Evaporation Chamber for the ZnTe

IV. Results

Chemical analysis

Table I shows Cd and Te quantities included on the CdTe and ZnTe/CdTe thin films. This quantity is important due to we need a p+ region (Te rich surface) on CdTe films.

Table 1. Comparative chemical quantification of CdTe and ZnTe/CdTe thin films.

Sample	Substrate	Temperature of CdTe deposition		Temperature of ZnTe deposition		EDS (%)		
		Source (T1) °C	Substrate (T2) °C	Source (T3) °C	Substrate (T4) °C	Te	Cd	Zn
A1 CdTe	SnO_2: F	630	530	---	---	49.7	50.3	--
A2 CdTe/ZnTe	SnO_2: F	630	530	550	---	52	47	1
G1 CdTe	SnO_2: F	580	480	---	---	48.8	51.2	--
G1a CdTe/ZnTe	SnO_2: F	580	480	500	---	51	49.3	--

The chemical analysis of CdTe thin films is conducted through a mapping of chemical energy dispersive spectroscopy (EDS) area of 5 μm for different samples, all under the same conditions of analysis. The chemical composition of the films was determined on the basis of the atomic concentration and it can be seen that the samples that were doped with ZnTe increased amount of Te. A2 was the best Sample because it has the highest percentage of Te, this ensures a p+ type material.

Morphological measurements

Figure 5 show images of scanning electron microscopy (SEM) of CdTe and ZnTe/CdTe thin films. The magnifications used were: 10000X and 5000X to have a better analysis of the morphology. Figures 5 (a), (b), (c), (d) show images of SEM of the CdTe samples deposited at different temperatures to compare the properties of the material. In these images we observed how change the surface morphology, as can be seen as the ZnTe was doped on the CdTe.

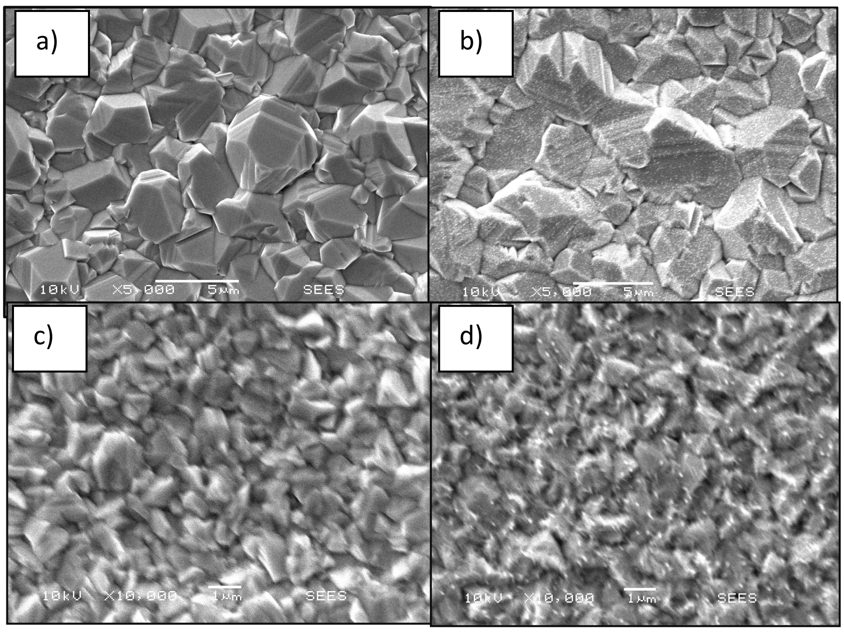


Figure 5.SEM images of the samples: a) CdTe deposited at T1=630°C and T2=530°C, b)ZnTe/CdTe deposited at T1=630°C and T2=530°C; doped at T3=550°C , c) deposited at T1=580°C and T2=480°C , d) deposited at T1=580°C and T2=480°C; doped at T3=500°C

In Fig. 5 c is observed, a distance of border due to the small size of grain. In Fig. 5a. Is observed the increase in grain size characteristic of the CdTe Crystallographic faceted well defined, uniform and compact growth, desirable characteristic to prevent "short" and the possible dissemination of ohmic contact.

Electrical properties

The semiconductor conductivity type can be determined by hot probe method. The conductivity type is determined by the sing of the thermal emf (electro motiveforce) or seebeck voltage generated by a temperature gradient. Two probes contact the sample surface: one is hot; the other is cold, thermal gradients produce currents in semiconductor [5]. This probe was realized for anteriors samples and only the sample deposited at T1=630°C, T2=530°C and doped whit ZnTe at T3=550°C had a good results because it has a conductivity p-type, we can check it whit a chemical composition.

Table 2 shows a summary of the results obtained in where you can observe the effect of the optical reflectance to be deposited in the CdTe, decreasing in most cases the resistance of this.

Table 2. Resistance and resistivity of some samples

Muestra	Deposite CdTe	Dope ZnTe (min)	Espesor (µm)	Electrical properties	
				Resistance	resistivity
A1	✓	------	4.75	$3.5x10^{6}$	$1.2 x10^{3}$
A2	✓	3 min	6.6	$2.0 x10^{6}$	$8.7 x10^{2}$
G1a	✓	3 min	5.73	$3.0 x10^{6}$	$1.3 x10^{3}$

Optical properties

Photoluminescence spectroscopy is a contactless, nondestructive method of probing the electronic structure of materials. Light of ****λ= nm is directed onto a sample, where it is absorbed and imparts excess energy into the material in a process called photo-excitation. The intensity and spectral content of this photoluminescence is a direct measure of various important material properties [5], for example material defects. Figure 6 show a photoluminescence spectra of CdTe deposited onto different substrates; we can observe how the energy band located in 1.535 eV change in their intensity related with the other bands located in 1.525 and 1.527 eV.

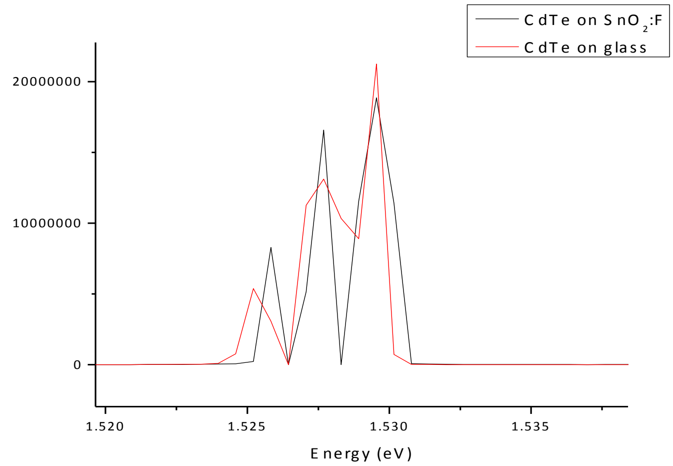
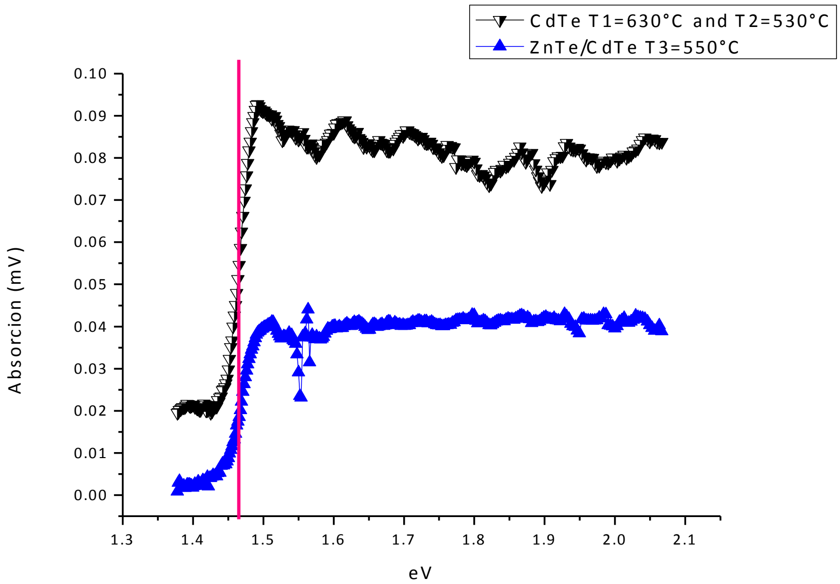


Figure 6. Photoluminescence of CdTe deposited on Glass and SnO_2:F

One way to study the behavior of a semiconductor is to affect photons of energy known to arousing electrons from states of lower energy states until higher energy overcoming the energy band forbidden Eg.



Conclusions

Deposited thin films of CdTe using the CSVT technique; these thin films were doped with ZnTe to create a region p+. Chemical quantification shows samples of CdTe doped ZnTe increased the amount of tellurium. On the other hand the temperature that showed best results was deposited whit CdTe at T1=630°C, T2=530 and doped whit ZnTe at T3=550°C, Which found is of type p+ through hot probe, this will attach to the temperature gradient used.

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