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OPTICAL AND ELECTRICAL PROPERTIES OF ZnTe THIN FILMS USING ELECTRODEPOSITION TECHNIQUE

I. L. IKHIOYA

Department of Physics Industrial Physics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

ABSTRACT: Zinc Telluride (ZnTe) thin films have been successfully deposited on a glass substrate Fluorine Tin oxide (FTO) by electrodeposition technique. The absorbance was measured using M501 UV-visible spectrophotometer in the wavelength range of 200-900nm. Zinc Telluride (ZnTe) thin films were investigated at room temperature. Optical absorption study showed that ZnTe films were of indirect band gap type semiconductor with band gap energy of 2.2-2.4eV.

KEYWORDS: Optical, Electrical, Thin Film, Fluorine Tin oxide (FTO), Electrodeposition.

INTRODUCTION

Group II-VI compound semiconductors with wide band gap energy can be applied to the optoelectronic devices such as light emission devices and photovoltaic solar cells [1-2]. Among of the II-VI compound semiconductors, ZnTe can be applied to green light emission devices and photovoltaic solar cells because the band gap energy of ZnTe is 2.21-2.26eV. The ZnTe thin films grown at room temperature and high temperature are found to be polycrystalline in nature. Zinc telluride (ZnTe) and cadmium telluride (CdTe) have received significant attention due to their low-cost but high absorption coefficients in their applications to photovoltaic and photoelectrochemical cells [3-4]. Tellurium is one of the major components in binary and ternary compound semiconductors and also has itself a semiconductor property. The low electronic affinity and its p-type conductivity characteristics have improved the ohmic contact on CdTe or GaAs p-type semiconductors, which are absorber material in high-efficiency photovoltaic devices. ZnTe thin films have been prepared by several techniques including molecular beam epitaxy (MBE) [5-9] vacuum evaporation [10], Radio frequency sputtering [11] and electrodeposition [12–14]. Among these techniques, electrodeposition offers several advantages: it is relatively economical; it can be used on a large scale; and it is conducted at low-temperature. Although there has recently been a growing interest in the electrodeposition of ZnTe film due to these advantages, two issues have concerned us. The first is that heat-treatment is necessary after deposition in order to adjust the ZnTe stoichiometry, thus forfeiting the advantages of a low-temperature process. The second is that electrodeposition is often performed at a relatively negative potential, indicating that a sub-reaction of hydrogen evolution reduction could arise, leading to a reduction in current efficiency [15]. For these reasons, we have been strongly interested in achieving a single electrodeposition of ZnTe film at a low over potential (a more positive potential) and without heat-treatment.

EXPERIMENTAL DETAILS

Zinc Telluride thin films were prepared by electrodeposition Technique on the glass substrates Fluorine Tin Oxide **(FTO)**. The substrates were cleaned ultrasonically by detergent solution, acetone, and deionized water, respectively, to ensure the complete cleanness. The reaction bath for the deposition of Zinc Telluride **(ZnTe)** was composed of four electrolyte Telluride IV Oxide **($Te0_2$)**, **$ZnSO_4.7H_2O$**, Potassium tetraoxosulphate VI **(K_2SO_4)** and Tetraoxosulphate VI acid **(H_2SO_4)**. The growth of **(ZnTe)** films were determined with respect to the different bath parameters which includes time of deposition and substrate for the deposition. 25cm^3 each of **$Te0_2$** and **$ZnSO_4.7H_2O$** was measured into 100cm^3 beaker using burette. 7.00cm^3 of **K_2SO_4** was measured into the same 100cm^3 beaker containing **$Te0_2$** and **$ZnSO_4.7H_2O$**

respectively to serve as the inert electrolyte which helps to dissociate the Zinc from **$ZnSO_4.7H_2O$** to form the required **ZnTe** film on the substrate and the solution was acidified with 5.00cm^3 of dilute **H_2SO_4** which serves to adjust the P^H value. The entire mixture was stirred with the glass rod to achieve uniformity. In each of the reaction baths prepared, a glass substrate and platinum electrode were connected to a DC power supply source and the voltage was maintained at **5V** for different time intervals.

Table1. Variation of Parameters ZnTe Thin films

Samples	Volume of H_2SO_4 (cm^3)	Volume of K_2SO_4 (cm^3)	Volume of TeO_2 (cm^3)	Volume of $ZnSO_4.7H_2O$ (cm^3)	Voltage (V)	Time (minutes)
T1	7.00	7.00	25.00	25.00	5.00	5.00
T2	7.00	7.00	25.00	25.00	5.00	7.00
T3	7.00	7.00	25.00	25.00	5.00	9.00

ELECTRICAL PROPERTIES OF ZNTE THIN FILMS

ZnTe thin films are known to be of p-type conductivity. The resistivity of the films has a steady increase from 2.62×10^3 – 2.96×10^3 $(\Omega \boldsymbol{m})^{-1}$. The high resistivity of the films helps to improve the conversion efficiency. The resistivity should not be too high or low due to the inevitable defects in solar cells fabricated during the actual production process. Those defects can cause short circuit, but it can drop the open circuit voltage (V) and fill factor (FF). However, the buffer layer with high resistivity can effectively overcome those problems caused by defects. As a result, the ZnTe thin film with 2.96×10^3 $\Omega \boldsymbol{m})^{-1}$ resistivity is quit suitable for a buffer layer in solar cell. The conductivity also increase from sample T1, T2 and T3 with the thickness of the films

Table2. Electrical properties of ZnTe films

SAMPLES	THICKNESS, t $(\boldsymbol{nm})$	RESISTIVITY, $\boldsymbol{\ell}$ $(\Omega \boldsymbol{m})^{-1}$	CONDUCTIVITY, σ $(\Omega \boldsymbol{m})^{-1}$	VOLTAGE (V)	SHEET RESISTANCE	CURRENT (A)
T1	264	$2.62x10^3$	$4.63x10^5$	5	24.4	2.4
T2	282	$2.83x10^3$	$4.82x10^5$	5	26.9	2.8
T3	294	$2.96x10^3$	$4.88x10^5$	5	25.8	2.9

THE OPTICAL PROPERTIES

The optical absorption spectra of ZnTe films deposited onto a glass substrate were studied at room temperature in the wavelength range of 200-900nm and a plot of absorbance of ZnTe thin films as a function of wavelength shows a decay of absorbance with longer wavelength. The absorbance tends to be very high in the UV region for all the samples. There is very low absorption of energy in the near infra-red region. The deposited films have high absorbance in the UV region and low absorbance in the visible region. They can therefore be suitable for coating windscreens, driving mirrors and in p-n junction solar cells and in the production of blue and green light emitting device [15]

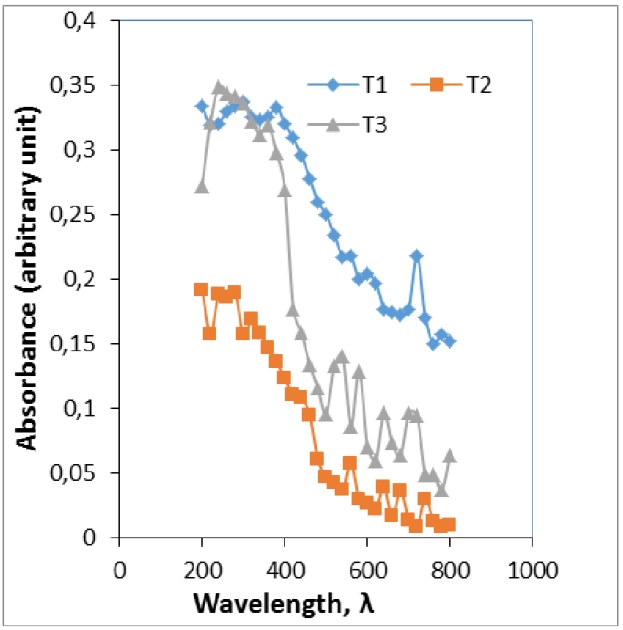

Figure1. Plot of Absorbance as a function of Wavelength

In figure2 shows the transmittance spectra of ZnTe thin films with a very high transmittance in the VIS-NIR regions of the electromagnetic spectrum. It is observed that the transmittance of the films is as high in visible & infrared regions. Both of them have peak transmittance in infrared region but the transmittance of sample T2 film is very high compare to that of sample T1 and T3 which decay as the wavelength increases. The wide transmission range of T2 revealed in the figure makes the materials useful in manufacturing optical components, windows, mirrors; lenses etc for high power infra red laser .The transmittance of (samples T2) increases from UV to the peak value (90%) in infrared region and can be as high as 32% in UV region.

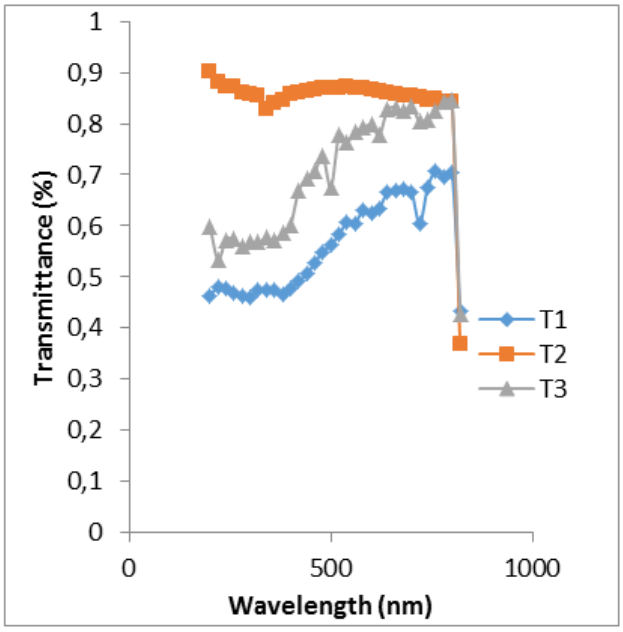

Figure2. Plot of Transmittance as a function of wavelength

In figure3 shows the reflectance of the deposited ZnTe thin films, the films reflect much at UV region and decays in the visible and IR region. The high reflectance of sample T1 and T2 in UV region makes the material useful in formation of p-n junction solar cells with other suitable thin films materials for photovoltaic application. These optical properties make ZnTe thin films nice glazing material for maintaining cool interior in buildings in warm climate regions while still keeping the rooms

well illuminated. To ensure that the thermal radiation from the warm glazing to the interior is inhibited and the thermal energy dissipated in the glazing due to reflection is predominantly transferred to the exterior by enhanced convective heat transfer of the glazing to the exterior. It was suggested in [14] that reflectance in the spectral region should be strengthened while encouraging low thermal emittance.

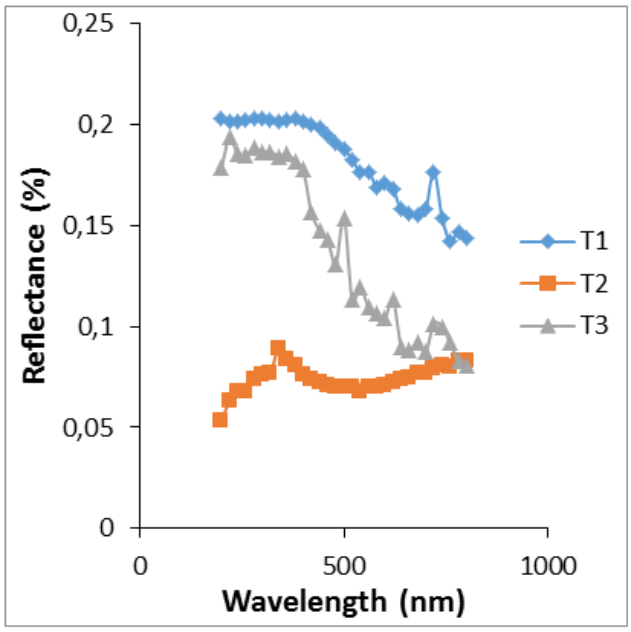

Figure3. Plot of Reflectance as a function of Wavelength

The band gap energy and transition types were derived from mathematical processing of the data obtained from the optical absorbance versus wavelength with the following relationships for near edge absorption:

$$\alpha = (h\upsilon - \varepsilon g)\, n/2,$$

Where υ is the frequency, h is the Planck's constant, while n carries the value of either 1 or 4. The band gap could be obtained from a straight line plot of α^2 as a function of hυ; an extrapolation of the value of α^2 to zero will give band gap. If a straight line graph is obtained from n=1, it indicates a direct transition between the states of the semiconductor, whereas the transition is indirect if a straight line graph is obtained from n = 4 as shown in Fig. 4 and 5, the band gap energy as obtained are 2.2-2.4eV

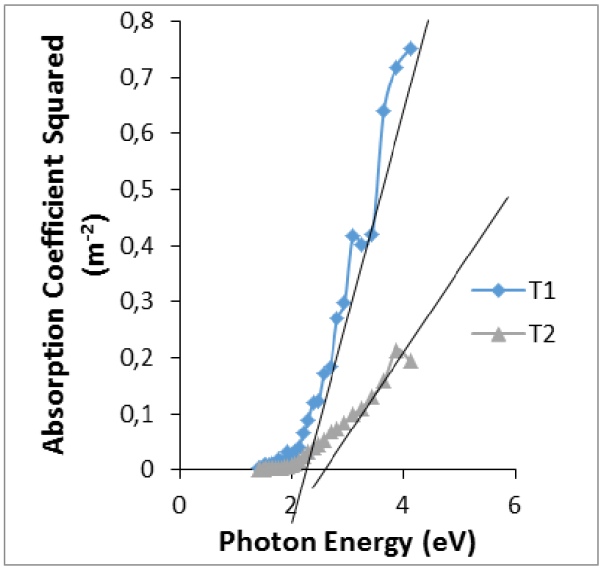

Figure4. Plot of Absorption coefficient as a function of Photon energy

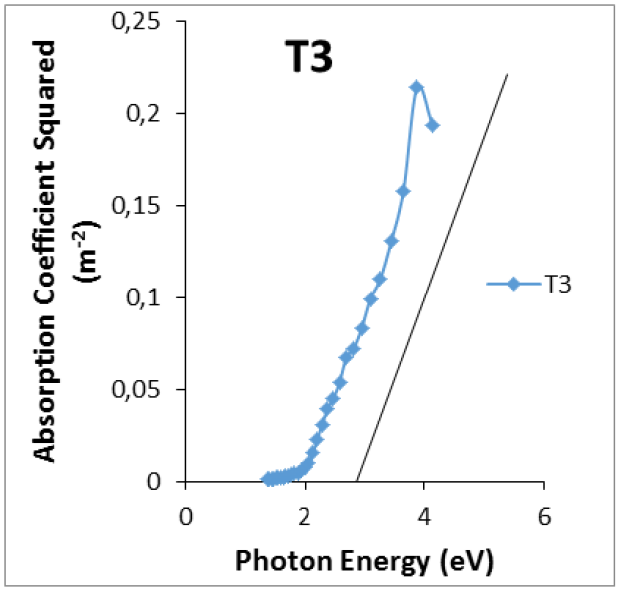

Figure5. Plot of Absorption coefficient as a function of Photon energy

CONCLUSION

Zinc Telluride thin films have been prepared by electrodeposition technique. Absorbance of ZnTe thin films as a function of wavelength shows a decay of absorbance with longer wavelength. The absorbance tends to be very high in the UV region for all the samples. The transmittance of the films is as high in visible & infrared regions. Both of them have peak transmittance in infrared region but the transmittance of sample T2 film is very high compare to that of sample T1 and T3 which decay as the wavelength increases. But both films show a very high transmittance in the VIS-NIR regions of the electromagnetic spectrum which makes the material a good application in the production of blue and green light emitting device. The electrical properties of the films show that the resistivity and conductivity increases as the thickness increases.

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