IJRCE

**International Journal of**
**Research in Chemistry and Environment**
**Available online at: www.ijrce.org**

**ISSN 2248-9649**

***Research Paper***

# Optical and Electrical Properties of Copper Telluride Thin Films

**Ikhioya I. L.**
Department of Physics Industrial Physics, Nnamdi Azikiwe University, Awka, Anambra State, NIGERIA

**(Received 24th March 2015, Accepted 18th June 2015)**

***Abstract:*** *Copper Telluride (CuTe) 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. Copper Telluride (CuTe) thin films were investigated at room temperature. Optical absorption study showed that CuTe films were of indirect band gap type semiconductor with band gap energy of 2.4-2.8eV.*

**Keywords:** Thin Film, Fluorine Tin oxide (FTO), Electrodeposition, Optical and Electrical properties.


## Introduction

Copper Telluride have attracted much interest because of their potential applications in thermoelectric devices and in herterojunction structures [1].Thin film solar cells using copper telluride (CuTe) absorber layers are one of the primary contenders for large-scale commercialization of photovoltaic. Numerous applications based on CuTe have been deployed worldwide such as in radiation detectors, electro-optical modulators and solar cell fabrication [2]. Currently, many techniques are used and have been reported to grow the CuTe thin films such as vacuum evaporation, sputtering, electrodeposition, metal vapor organic deposition, closed spaced sublimation and spray pyrolysis. Among these techniques, electrodeposition technique has become an attractive and potential technique due to its many advantages: low cost photocell fabrication, easily adapted from the laboratory to industrial scale, no wastage of materials, short deposition time, simple process and higher deposition rate [3]. CuTe nanocrystal films onto dielectric polymer thin film [4] and quantum dot sensitized solar cells with improved efficiency [5] have been prepared by using electrodeposition technique.

The coating can be made in any shape and the film thickness can be controlled by the deposition conditions [6]. Copper Telluride thin films have a number of applications in various devices such as solar cells, super ionic conductors, photo-detectors, photothermal conversion, electroconductive electrodes, and microwave shield coating [7].

An optical characteristic of metallic nanowires is the one of the emerging area of application of nanotechnology, ultrahigh density magnetic recording, ultrafast optical switching, and microwave devices. Copper telluride belongs to the copper chalcogenide (group's II–VI compound) group of materials. Controlled hydrothermal synthesis and growth mechanism of various nanostructured films of copper and silver telluride is explained [8]. The deposition of metal chalcogenide thin films by successive ionic layer adsorption and a reaction (SILAR) method is reported in [9]. The preparation and characterization of copper telluride thin films by the modified chemical bath deposition (M-CBD) method is also reported in [10]. The hydrophilic nature of electrodeposited copper telluride and stress, mass, fringe width and thickness of the CuTe thin film is reported in [11].

## Material and Methods

Copper 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 Copper Telluride (CuTe) was composed of four electrolyte Telluride IV Oxide ($TeO_2$), ($CuSO_2.5H_2O$), Potassium tetraoxosulphate VI ($K_2SO_4$) and Tetraoxosulphate VI acid ($H_2SO_4$). The growth of (CuTe) films were determined with respect to the different bath parameters which includes time of deposition and substrate for the deposition. 20cm$^3$ each of $TeO_2$ and ($CuSO_2.5H_2O$) was measured into 100cm$^3$ beaker using burette. 5.00cm$^3$ of $K_2SO_4$ was measured into the same 100cm$^3$ beaker containing $TeO_2$ and ($CuSO_2.5H_2O$) respectively to serve as the inert electrolyte which helps to dissociate the Copper from ($CuSO_2.5H_2O$) to form the required CuTe 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 7V for different time intervals.

**Table 1: Variation of Parameters CuTe 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 ($CuSO_2.5H_2O$) (cm$^3$)** | **Voltage (V)** | **Time (minutes)** |
|---|---|---|---|---|---|---|
| CuTe1 | 5.00 | 5.00 | 20.00 | 20.00 | 7.00 | 5.00 |
| CuTe2 | 5.00 | 5.00 | 20.00 | 20.00 | 7.00 | 7.00 |
| CuTe3 | 5.00 | 5.00 | 20.00 | 20.00 | 7.00 | 9.00 |

**The Optical Properties of Copper Telluride Thin Films**

In Figure 1, the absorbance of Copper Telluride thin film of sample CuTe1 increase and decreasing with the wavelength while sample CuTe2 and CuTe3 decreases as the wavelength increases. The absorbance generally shows high in the UV region and IR regions. The high absorbance in UV region makes the material useful in formation of p-n junction solar cells with other suitable thin film materials for photovoltaic application. These optical properties make Copper Telluride 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 absorption is predominantly transferred to the exterior by enhanced convective heat transfer of the glazing to the exterior as reported in [12].

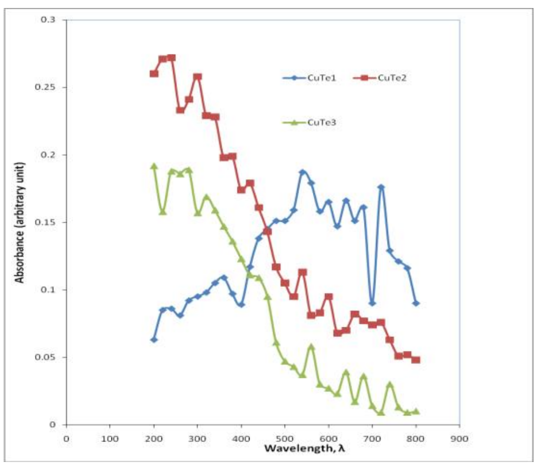



**Figure 1: The Plot of Absorbance as a function of Wavelength**

In Figure 2 shows the transmittance spectra of the Copper Telluride thin films deposited. The transmittance spectra shows a sinusoidal form of wave motion, which means Copper Telluride increase and decreases with the wavelength, but both films shows 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 as reported in [13,14].

The optical reflectance of copper Telluride thin films shows that the films shows a sinusoidal form of wave motion; which means Copper Telluride increase and decreases with the wavelength. Both samples show a high reflectance in UV and IR region of the electromagnetic spectrum.

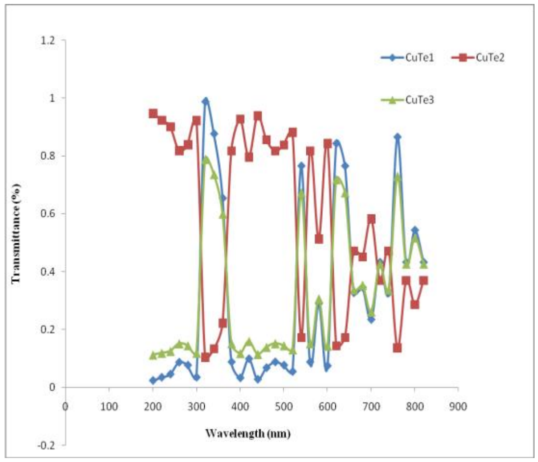
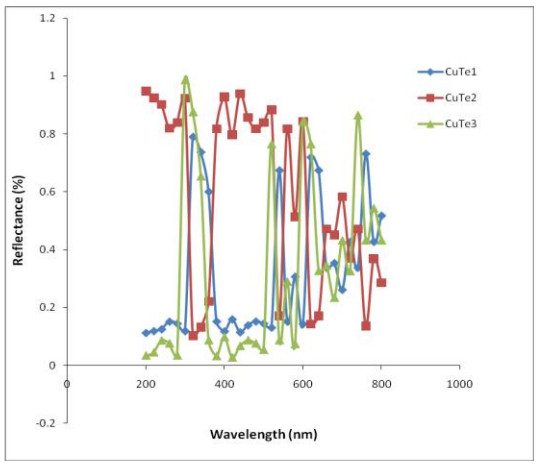



**Figure 2: The Plot of Transmittance as a function of Wavelength**




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

$$\alpha = (h\upsilon - \varepsilon_g)\ n/2 \qquad (1)$$

Where υ is the frequency, h is the Planck's constant, while n carries the value of either 1 or 4. The band gap $\varepsilon_g$ could be obtained from a straight line plot of $\alpha^2$ as a function of hυ; an extrapolation of the value of $\alpha^2$ 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. The band gap energy of 2.4eV - 2.8eV was obtained with an indirect transition shows in figure 3-4.

**Electrical Properties of CuTe Thin films**

The electrical properties of the deposited copper selenide films were studied using a standard four point probe technique. The arrangement was made in such a way that the voltage across the transverse distance of the films was measured using silver paste on top of the coated slide to ensure good ohmic contact to the film. The four point probes were arranged such that the two outer probes were connected to current supply and the two inner probes to a voltage supply. As current flows between the two outer probes, voltage drop across the inner probes was measured. The sheet resistivity of the thin film depends on the current, voltage and thickness values of prepared thin film. Equations:

$$\ell = \frac{\pi}{In2}\frac{V}{I} = 4.523t \qquad \text{……………(2)}$$

$$R_s = \frac{resistivity}{4.523\ x\ thickness} = \frac{\ell}{4.523t} \qquad \text{...…………(3)}$$

$$\sigma = \frac{1}{\ell} \qquad \text{……………(4)}$$

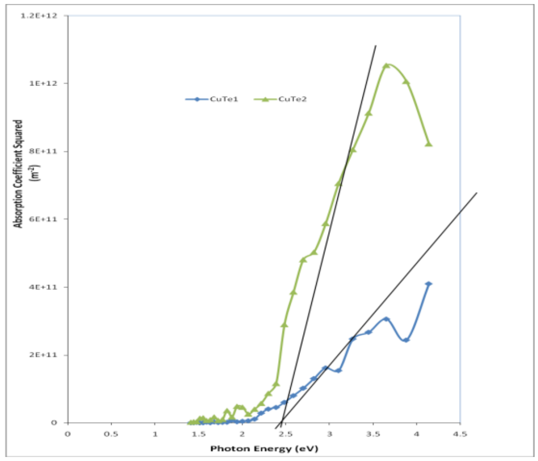



**Figure 3: The Plot of Absorption Coefficient Square as a function of photo Energy**

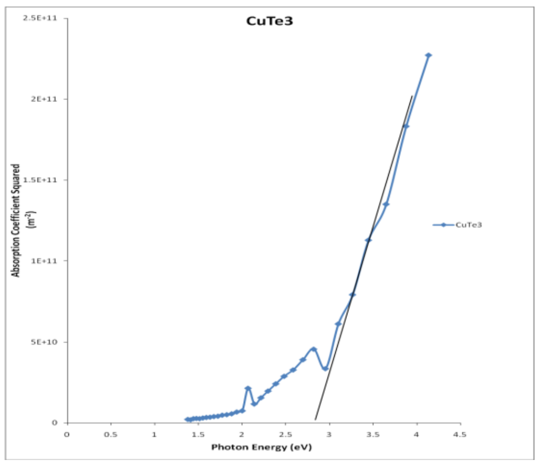



**Figure 4: The Plot of Absorption Coefficient Square as a function of photo Energy**

**Table1: Electrical property of CuTe films**

| Samples | Thickness, t $(nm)$ | Resistivity, ℓ $(\Omega m)^{-1}$ | Conductivity, σ $(\Omega m)^{-1}$ |
|---|---|---|---|
| CuTe1 | 289 | $4.85 \times 10^6$ | $6.98 \times 10^5$ |
| CuTe2 | 307 | $7.95 \times 10^6$ | $8.77 \times 10^5$ |
| CuTe3 | 343 | $9.78 \times 10^6$ | $9.99 \times 10^5$ |

Table 2 shows the results obtained. The results clearly show that CuTe films have high resistivity and conductivity. As the thickness increases the resistivity and conductivity increased as well which makes the resistivity and conductivity of CuTe suitable for blue, green light and buffer layer in thin film technology. It is a semiconductor that has large potential applications in thin films like photo luminescence and electroluminescent devices as reported in [15,16].

**Conclusion**

Copper Telluride thin films have been prepared by electrodeposition technique. The absorbance of Copper Telluride thin film of sample CuTe1 increase and decreasing with the wavelength while sample CuTe2 and CuTe3 decreases as the wavelength increases. The absorbance generally shows high in the UV region and IR regions. The transmittance spectra shows a sinusoidal form of wave motion; which means Copper Telluride increase and decreases with the wavelength, but both films shows 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.

**References**


1. Gorbatchev V. V., Semiconducting AI2BVI compounds, Metallurgia, Moscow, Russia, **1980**.

2. Chen W.S., Stewart J.M., and Mickelsen R.A., Polycrystalline thin-film Cu2-xSe/CdS solar cell, *Applied Physics Letters*, **46(11)**, 1095–1097, (**1985**)

3. Cusano D.A., CdTe solar cells and photovoltaic heterojunctions in II-VI compounds, *Solid State Electronics*, **6(3)**, 217–218, (**1963**)

4. Lv B., Di X., Li W., Preparation of Cu2Te thin films and back-contact formation of CdTe solar cells, *Japanese Journal of Applied Physics*, **48(8)**, 0855011–0855014, (**2009**)

5. Yun J.H., Kim K.H., Lee D.Y., and Ahn B.T., Back contact formation using Cu2Te as a Cu-doping source and as an electrode in CdTe solar cells, *Solar Energy Materials and Solar Cells*, **75 (1-2)**, 203–210, **(2003)**

6. Wu X., Zhou J., Duda A. et al., Phase control of CuxTe film and its effects on CdS/CdTe solar cell, *Thin Solid Films*, **515(15)**, 5798–5803, **(2007)**

7. Lorenz G. and Wagner C., Investigations on cuprous selenide and copper tellurides, *The Journal of Chemical Physics*, **26(6)**, 1607–1608, **(1957)**

8. Chen W.S., Stewart J.M., Mickelsen R.A., Polycrystallinethin-film solar cell, *Appl Phys Letter*, **(46)**, 1095, **(1985)**

9. Neyvasagam, Soundararajan K. N., Okram G. S. et al., Low-temperature electrical resistivity of cupric telluride (CuTe) thin films, *Phys Status Solidi* B, **245**, 77, **(2007)**

10. Okimura H., Matsumae T., Makabe R., Electrical properties of thin films and their application for solar cells, *Thin Solid Films*,**71**, 53, **(1980)**

11. Korzhuev M.A., Dufour effect in superionic copper selenide, *Physics of Solid State*, **40**, 217, (**1998)**

12. Dhere N.G., Recent development in thin films solar cells, *Thin Solid Films*, **193**, 757, **(1990)**

13. Zhang L., Ai Z., Jia F., Controlled hydrothermal synthesis and growth mechanism of various nanostructured films of copperand silver tellurides, *Chem Eur J.*, **12**, 4185, (**2006)**

14. Pathan H. M., Lokhande C. D., Deposition of metal chalcogenide thin films by successive ionic layer adsorption and reaction (SILAR) method, *Bull. Mater. Sci.*, **27**, 85, **(2004)**

15. Pathan H. M., Lokhande C. D., Amalnerkar D. P. et al., Preparation and characterization of copper telluride thin films by modified chemical bath deposition (M-CBD) method, *Appl. Surf. Sci.*, **218**, 290, **(2003)**

16. Fulari V. J., Malekar V.P., Gangawane S.A., Measuremnt of properties of copper telluride films using holography, *Progress in Electromagnetic Research*, **12**, 53, **(2010)**