[International Journal of Thin Film Science and Technology](https://digitalcommons.aaru.edu.jo/ijtfst)

Volume 2
Issue 1 *Jan. 2013*

Article 4

2013

Current-voltage characteristics of p-CuO/n-ZnO:Sn Solar cell

E. O. Omayio
Department of Physics, Kenyatta University, Kenya, omayio2008@gmail.com

W. K. Njoroge
Department of Physics, Kenyatta University, Kenya, omayio2008@gmail.com

F. K. Mugwanga
Pwani University College, Kenya, omayio2008@gmail.com

P. M. Karimi
Department of Physics, Kenyatta University, Kenya, omayio2008@gmail.com

International Journal of Thin Films Science and Technology

Current-voltage characteristics of p-CuO/n-ZnO:Sn Solar cell

E. O. Omayio[1], P. M. Karimi[1], W. K. Njoroge[1], F. K. Mugwanga[2]

[1] *Department of Physics, Kenyatta University, Kenya.*
[2] *Pwani University College, Kenya.*

Received: 24 Oct. 2012, Revised: 9 Nov 2012; Accepted: 7 Dec. 2012

Abstract: A p-CuO/n-ZnO:Sn heterojunction solar cell has been fabricated on glass substrate in steps using Edwards AUTO 306 vacuum coater system. Copper oxide has energy band gap of the range 1.21-2.1 eV while tin doped zinc oxide (TZO) has good transmittance properties. A solar cell with thickness of 250nm of p-type copper oxide and thickness of 140nm of n-type TZO with 2% tin doping has been made. Current-Voltage (I-V) measurement has been done on the solar cell using Keithley 2400 sourcemeter interfaced with the computer running labview program. Diode properties determined from I-V measurements are open circuit voltage (Voc), short circuit current (Isc), fill factor (FF), maximum current output (Im), maximum voltage output (Vm), and conversion efficiency (η). The solar cell had Voc of 480 mV, Isc of 326.8mA, FF=0.63 and $\eta = 0.232\%$

Keywords: Fill factor (FF), I-V graph, tin-doped zinc oxide (TZO), copper indium gallium selenide (CIGS), open circuit voltage (Voc), short circuit current (Isc), conversion efficiency (η).

1. Introduction

A combination of p-type copper oxide (CuO) and n-type tin-doped Zinc oxide (TZO) thin films have been studied for applications in solar cells. ZnO has been a preferred candidate of window layer of solar cell because of its wide and direct band gap of 3.37 eV at room temperature, good diode characteristics in the dark especially its very high photocurrent [7]. This gives it a high breakdown voltage and thereby enabling it to sustain large electric fields with lower electric noise. In addition it can operate at higher temperature and high power [4]. The conductivity of ZnO is enhanced by doping it with tin thus producing desirable structural, optical and electrical properties [10]. The advantages of doping ZnO are increased conductivity, perfect crystalline structure, enhanced conducting properties, higher transparency and higher intensity of luminescence. Copper oxide is preferred as an active layer for solar cell due to its low band gap of the range 1.21 – 2.1 eV. The low band gap of CuO makes it possible to absorb throughout the visible spectrum. It has low production costs, low toxicity levels and is abundant on earth [3]. It has been reported that Cu2O (Cuprous Oxide) has high transparency with slightly yellowish appearance [5].

2. Experimental procedure

The process of fabrication of the solar cell was done in stages using Edwards AUTO 306 vacuum coater system. Silver paste acting as the back contact electrode was applies on a clean glass substrate measuring 70mm×27mm. The glass slide was wrapped with strips of aluminium foil 20mm from both ends so as to mask the edges and parts of silver layer film deposition. The glass slide was mounted on revolving substrate holder of the vacuum coater. Then 250 nm thick CuO was deposited on the glass slide at room temperature by reactive dc magnetron sputtering method at oxygen flow of 5 sccm.

Argon was used as the sputtering gas and oxygen as the reacting gas. CuO film was deposited at chamber pressure of 9×10-3 mbars, argon flow of 20 sccm and power of 200W.
Then a 140 nm thick TZO was deposited on CuO layer by reactive evaporation technique at temperature of 750oC, oxygen flow of 20 sccm and base pressure of 3 × 10-5 mbars. Current supplied to the molybdenum boat was 3.5A. The film deposited was doped at 2% tin concentration. Temperature was monitored using digital thermometer attached to the backside of molybdenum boat. A P-N junction of CuO-ZnO:Sn was therefore formed as shown in figure 1.

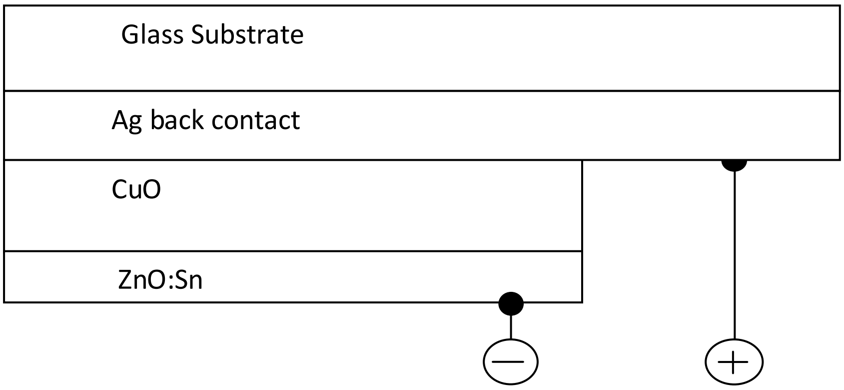

Figure 1: Schematic diagram for Ag/CuO/ZnO:Sn solar cell.

3. Result and Discussion.

The Diode characteristics investigated for the fabricated solar cell are open circuit voltage (Voc), short circuit current (Isc), fill factor (FF), maximum current output (Im), maximum voltage output (Vm) and conversion efficiency (η). Fill factor and conversion efficiency are obtained using the diode parameters as shown in equations 1and 2 below.

$$FF = \frac{I_m V_m}{I_{sc} V_{oc}} \quad (1)$$

$$\eta = \frac{I_m V_m}{P_{in}} \times 100 \quad (2)$$

Where Voc is open circuit voltage, Isc short circuit current, FF is fill factor, Im maximum current output, Vm maximum voltage output, η conversion efficiency and Pin is power of photons incident on solar cell.

Diode properties of the solar cell were determined from measurements of current and voltage generated across the solar cell using four point probe system [1] by use of Keithley 2400 sourcemeter interfaced with a computer running labview program as shown in picture shown in figure 3. The measurement was done with 100W bulb radiating light at power of 640 W/m2 and temperature of 25oC. The power of light from the bulb was measured by a pyranometer.

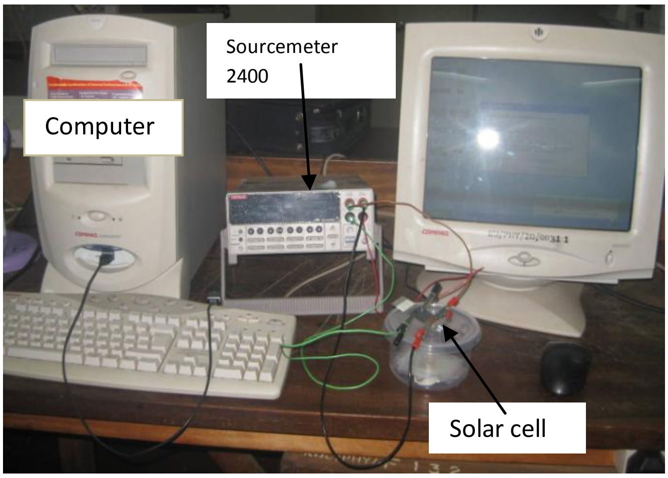

Figure 2: Set up for measuring current and voltage across a solar cell.

The bulb- solar cell separation distance was 15cm. The labview program was such that a voltage of 0.8V was sourced from Keithley sourcemeter to the solar cell and then current across it measured. The appropriate formulas were fitted into the program enabling it to automatically plot current versus voltage graph and determine Voc, Isc, Im, Vm and η for the solar cell. As illustrated from I-V graph in figure 4, the plot of current versus voltage gives Voc, Isc, Im and Vm.

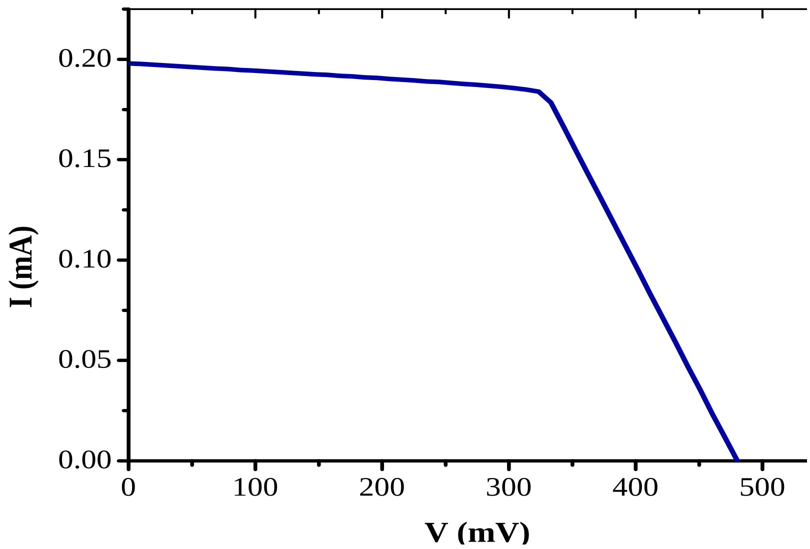

Figure 3: Current versus voltage plot showing of the solar cell.

4. Conclusion.

A solar cell with silver back contact, n-type TZO window layer and p-type CuO absorber layer was fabricated in stages using Edwards AUTO 306 vacuum coater system. I-V characteristics were measured using Keithley 2400 sourcemeter interfaced with computer running labview program. The solar cell had Voc of 480mV, Isc of 0.182mA, FF of 0.63 and efficiency of 0.232%. The values of Voc and fill factor obtained are higher than those of other solar cells like CuSe2 [2], CIGS [8] and CIGS/ZnO whose values of Voc and fill factor are 450 mV and 0.62 respectively but with higher efficiency of 11% [9]. The low efficiency may be attributed to surface reflections of incident photons leaving less radiation for conversion to electricity. Heating also decreases efficiency because at higher temperatures, conductivity decreases. More so series resistance of the cell due to non-ohmic contacts inhibits the flow of electrons. This decreases Voc and makes current of the I-V curve fall slowly. Even though the efficiency of the solar cell fabricated was low, the availability and low cost of the materials makes it relatively affordable as compared to other cell devices like CIGS based cells whose materials are very expensive and not easily available.

Acknowledgment

The authors would like to thank the Department of Physics, School of Pure and Applied Sciences, Kenyatta University for the facilities provided.

References

[1] Agumba, J. O. Department of Physics. Kenyatta University (2010).

[2] Al-Mamun, A., Islam, A., Bhuiyan, H. (2005). Journal of Materials Science, 16 (2005) 263-268.

[3] Chua, S. J., Teng, J. H., Wada, O., De La Rue, R. And Tang, X. H. Advanced Materials Research 31(2007) 129-131.

[4] Fang, X. S., Ye, C. H., Zhang, L., Li, Y., Xiao, Z. D. Chemistry Letters 34(2005)3.

[5] Hideki, T., Takahiro, S., Toshihiro, M., Hirotoshi, S. and Tadatsugu, M. Applied Surface Science 244 (2005) 568-572.

[6] Katayama, J., Ito, K., Matsuoka, M. and Tamaki, J. Journal of Applied Electrochemistry 34 (2004) 687–692.

[7] Kemell, M. University of Helnsiki(2003), Faculty of Science, Finland. 15, 59-61.

[8] Nakada, T., Kume, T., Mise, T., Kunioka, A. Japan Journal of Applied Physics, 37(1998)499-501.

[9] Pethe, S. University of South Florida (2004).

[10] Yung, K.C., Lien, H., Choy, H.C. J. Phys. D. Applied Physics. 42(2009)85002.