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THE EFFECT OF OPTICAL ENERGY GAPS ON THE EFFICIENCY OF ZINC OXIDE SOLAR CELLS DOPED BY (Al, Cd, Co, Li and Mg)

Shadia Tageldeen*[1], Mubarak Dirar Abd Allah[2], Abdalsakhi S. M.H[3] & Sawsan Ahmed Elhouri Ahmed[4]

[*1]Sudan University of Science &Technology-College of Science-Department of Physics-Khartoum-Sudan
[2]Sudan University of Science &Technology-College of Science-Department of Physics &International University of Africa- College of Science-Department of Physics-Khartoum-Sudan
[3]AlNeenlen University, Faculty of Science and Technology- Physics Department, Khartoum-Sudan
[4]University of Bahri- College of Applied & Industrial Sciences Department of Physics-Khartoum-Sudan

ABSTRACT

In this study, we investigated the effect of optical energy gaps on the efficiency of Zinc Oxide solar cells doped by (Al, Cd, Co, Li and Mg). The samples were prepared by chemical treatment using ITO glass at 70ºC. The photo conversion efficiency (η) values of the samples were (0.168 %, 0.191 %, 0.204 %, 0.205 % and 0.297 %) respectively. While the energy gaps values were (3.699, 3.687, 3.685, 3.644 and 3.505) eV, both at 0.55 mW/cm^2 light intensity and dark.

Keywords: *Zinc Oxide, optical energy gaps, solar cells, efficiency*.

I. INTRODUCTION

The recent advances in photovoltaic technology have triggered considerable interests in the field of solar power as an alternative and renewable source of electricity. Desensitized solar cells (DSCs) devised by Prof. M. Gratzelhave attracted much attention over the last decade because of their potentially high-energy conversion efficiency and possible low production cost [1,2,3].Since the Mazur group first reported that silicon surfaces micro structured with high-intensity femto second laser pulses in an atmosphere of sulfur hexafluoride (SF6) have strong optical absorbance over a broad spectrum from ultraviolet (250 nm) to infrared (2500 nm) in 1998 [4,5,6,7,8,9], several groups have investigated the structure and properties of silicon doped with sulfur beyond the equilibrium solubility limit, with a focus on the potential presence of an impurity band and its relevance to photovoltaic [10,11,12,13].

II. MATERIAL AND METHOD

Five samples of Zinc Oxide solar cells doped by (Al, Cd, Co, Li and Mg) on ITO glass manner spin coating, Gold was fabricated on the doped layers to represent the anode and ITO the Cathode. A clean glass plate with a thin layer of ITO (Indium Tin Oxide) is needed. The ITO acts as the first part of the solar cell, the first electrode. However a bit of the ITO has to be removed, to avoid short-circuiting for the purpose of the present study. The fabrication process started by preparing the Zinc Oxide Doped by (Al, Cd, Co, Li and Mg) and the dye of interest then spin coated on indium tin oxide glass. Zinc nitrate hexahdate, 2-metoxyethanol, and ethanolamine, DEA, were used as starting material, solvent and stabilizer respectively. The dopant source of (Al $(NO_3)_3$,$9H_2O$, Cd $(NO_3)_2$,$9H_2O$, Co $(NO_3)_2$,$9H_2O$, Li (NO_3), $9H_2O$ and Mg $(NO_3)_2$,$9H_2O$).

The choice of nitrate coming from the fact that hydrolysis of nitrate group give products which are soluble in the solvent medium and get easily decomposed into volatile compounds under heat treatment [14]. In a typical synthesis, two different solutions of 0.5 M of zinc nitrate and Aluminum nitrate was slowly dissolved in

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2-metoxyethanol followed by addition of DEA. The molar ratio of DEA to zinc nitrate and Aluminum nitrate. The resulting mixture was stirred for 1 h at 70ºC of ZnO Sol-gel, respectively. Those samples were stirred for 1 h at 70ºC. The synthesized Zn Al_2 O_4. Steps were repeated for all samples. Samples were connected in electrical circuit containing the (voltmeter and ammeter and a light source lamp and a solar cell).Cells were exposed to light source and the results of the current and voltage were recorded. The UV spectrometer in as as to display energy band gap and spectrum for the five samples was also used.

III. RESULTS AND DISCUSSION

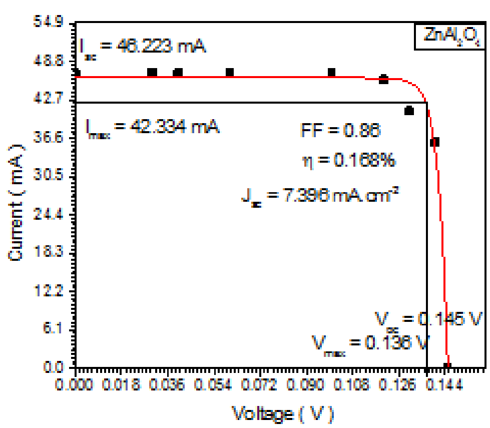
Table (1) and (2) summarizes the average electrical parameters of the Zinc Oxide Doped by (Al, Cd, Co, Li and Mg) Solar Cells. It also shows that the short circuit current (I_{SC}) and the open circuit voltage (V_{OC}), and the fill factor (*FF*), the maximum output power (P_m) and the conversion efficiency (E_{ff}) The energy gaps values are shown below.

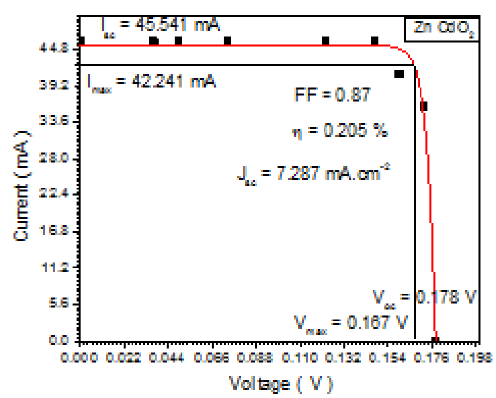
Table (1) is Factors for characterization of Zn doping by different Oxides solar cells performance for five samples

Sample	η %	E_g (eV)	J_{sc} ($mA.cm^{-2}$)	FF
$ZnAl_2O_3$	0.168	3.699	7.396	0.86
$ZnCdO_4$	0.205	3.644	7.287	0.87
$ZnCoO_2$	0.204	3.685	6.872	0.82
Zn Li_2 O_2	0.297	3.505	7.270	0.86
$ZnMgO_2$	0.191	3.687	7.144	0.86

Table (2) is Factors for characterization of Zn doping by different Oxides solar cells performance for five samples

Sample	I_{sc} (mA)	I_{max}(mA)	V_{oc}(V)	V_{max}(V)
$ZnAl_2O_3$	46.223	42.334	0.145	0.136
$ZnCdO_4$	45.541	42.241	0.178	0.167
$ZnCoO_2$	42.947	39.414	0.200	0.179
Zn Li_2 O_2	45.439	42.038	0.261	0.244
$ZnMgO_2$	44.648	41.534	0.171	0.157





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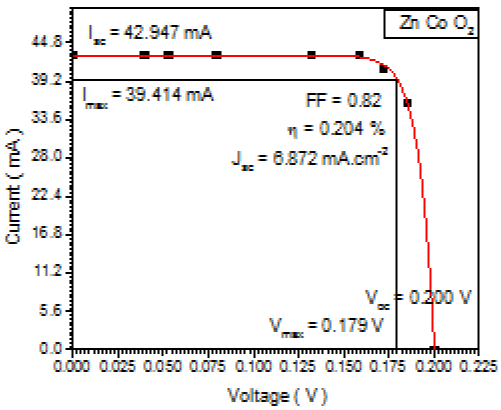

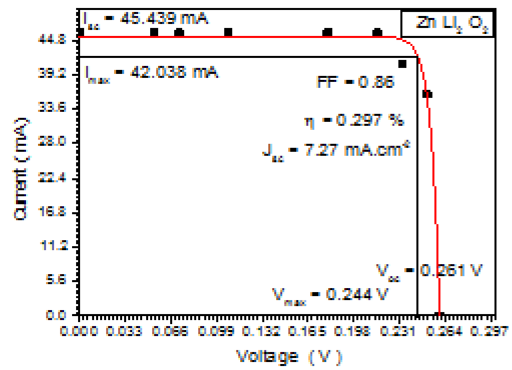

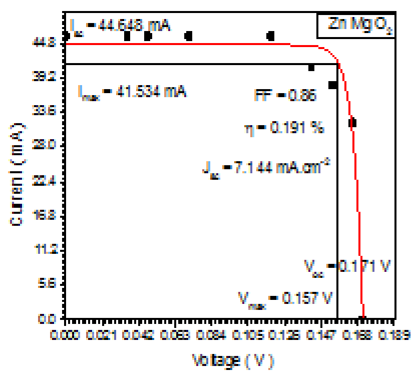

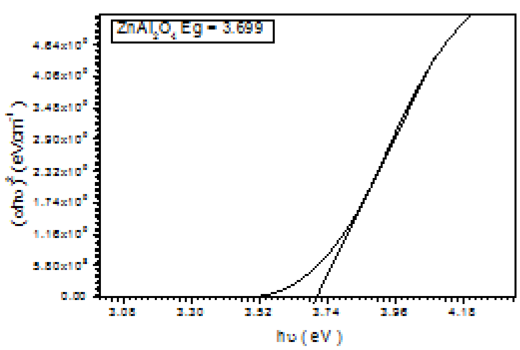

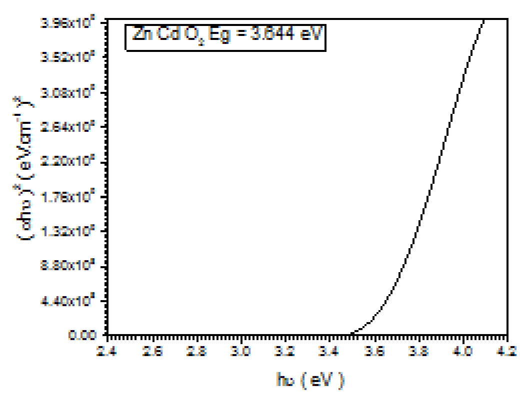

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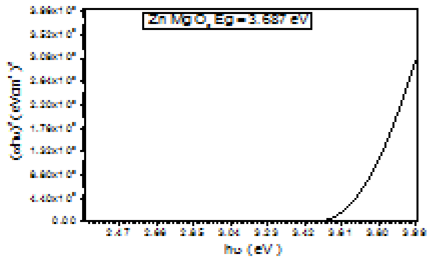

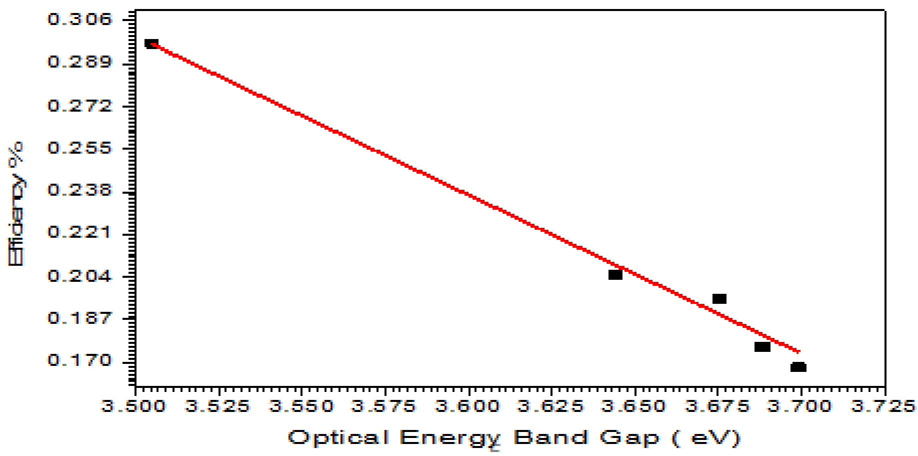

Fig (9) The relationship between energy band gap and efficiency of ZnO samples

IV. DISCUSSION

From top to bottom, then start from left to right; fig (1) shows the current-voltage characteristics obtained from the measured values. This measurement was taken from solar cell of $Zn\ Al_2\ O_4$ the short-circuit current (I_{sc}) is 46.223 mA, the open-circuit voltage (V_{oc}) is 0.145 V, fill factor (FF) is 0.86, and the efficiency is 0.168 %.fig (2) shows the current-voltage characteristics obtained from the measured values. This measurement was taken from solar cell of $Zn\ Cd\ O_2$ the short-circuit current (I_{sc}) is 45.541 mA, the open-circuit voltage (V_{oc}) is 0.178 V, fill factor (FF) is 0.87, and the efficiency is 0.205 %.fig (3) shows the current-voltage characteristics obtained from the measured values. This measurement was taken from solar cell of $Zn\ Co\ O_2$ the short-circuit current (I_{sc}) is 42.947 mA, the open-circuit voltage (V_{oc}) is 0.200 V, fill factor (FF) is 0.82, and the efficiency is 0.204 %.fig (4) shows the current-voltage characteristics obtained from the measured values. This measurement was taken from solar cell of $Zn\ Li_2\ O_2$ the short-circuit current (I_{sc}) is 45.439 mA, the open-circuit voltage (V_{oc}) is 0.261 V, fill factor (FF) is 0.86, and the efficiency is 0.297 %. fig. (5) shows the current-voltage characteristics obtained from the measured values. This measurement was taken from solar cell of $Zn\ Mg\ O_2$ the short-circuit current (I_{sc}) is 44.698 mA, the open-circuit voltage (V_{oc}) is 0.171 V, fill factor (FF) is 0.86, and the efficiency is 0.191 %.The energy band gap of $Zn\ Al_2\ O_4$ is determined using the absorption spectra. According to the absorption coefficient (α) for direct band gap material is given by the relation $\alpha h\nu = B(h\nu - E_g)^n$ where E_g the energy gap [10], constant B is different for different transitions, ($h\nu$) is energy of photon and (n) is an index which assumes the values 1/2, 3/2, 2 and 3 depending on the nature of the electronic transition responsible for the reflection. And by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been to found be (3.699 eV) for $Zn\ Al_2\ O_4$ sample, (3.644 eV) for $Zn\ Cd\ O_2$ sample, (3.685 eV) for $Zn\ Co\ O_2$ sample, (3.505 eV) for $Zn\ Li_2\ O_2$ sample and (3.687 eV) for $Zn\ Mg\ O_2$ sample as show in fig (1) to fig (8).

Fig (9) show that relationship between energy band gap and efficiency of Zinc Oxide doped by (Al, Cd, Co, Li and Mg) Solar Cells it shows that the increases of energy band gap decreases the efficiency by 0.6309 %.eV^{-1}.

V. CONCLUSION

The samples have a direct allow electronic transition with optical energy (E_g) values decreased from (3.966) eV for Zn Al_2O_3 sample to (3.505) eV for the $ZnLi_2O_2$ sample.

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