Fabrication and Characterization CdO:In/Si Photovoltaic Solar Cell Prepard By Thermal Evaporation

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Abstract

In this work, CdO:In/Si heterojunction solar cell has been made by vacuum evaporation of cadmium oxide doped with 1% of indium thin film onto glass and silicon substrates with rate deposition (3.9A/sec) and thickness(≈250nm). XRD was investigated, the transmission was determined in range (300-1100)nm and the direct band gap energy is 2.43 eV, I-V characterization of the cell under illumination was investigated , the cell shows an open circuit voltage (V_{oc}) of 0.6 Volt, a short circuit current density (J_{sc}) of 12.8 mA/cm^2, a fill factor (*F.F*) of 0.66, and a conversion efficiency (η) of 5.2%.

Key Words: Fabrication, Characterization, Photovoltaic, Solar, Cell .

Introduction

Researchers have focused on transparent conductive oxide (TCO) materials because of their applications, specifically those in the field of optoelectronic devices [1,2] such as photodiodes, phototransistors , photovoltaic cells [3], transparent electrodes [4], liquid crystal displays, IR detectors and antireflecting coatings [5],solar cells[6] and sensors [7].

There are several methods developed for the synthesis of CdO films such as spray pyrolysis , sputtering , chemical bath deposition (CBD) , pulsed laser deposition and thermal evaporation technique. The effect of doping various elements such as Sn, In, F, Cu and Ga on the physical properties of CdO thin films has already been reported.Doping increases its free electron concentration and electrical conductivity. Indium has been used as a suitable dopant for other transparent conducting films to increase the concentration of conduction electrons and improve the electrical conductivity, but there were few studies about In-doped CdO (In-CdO) films[8].

The aim of this paper is to present the results of the fabrication of n-CdO:In/p-Si heterojunction solar cell made by vacuum evaporating technique.

Experimental Work

Two types of substrates were used in this study. Glass slide which is used to study the structural and optical properties of CdO:In films, and p-type silicon wafer substrate with crystal orientation(111).

The glass substrates were cleaned by using detergent with water to remove any oil or dust that might be attached to the surface of substrate and then they were placed under tap water and rubbing gently for 15 minutes. Then they were placed in a clean beaker containing distilled water and then rinsed in ultrasonic for 15 minutes. After that the distilled water with pure alcohol solution which reacts with contamination such as grease and some oxide.

Substrates of p-type single crystal Si wafers of resistivity 2 ohm-cm and orientation (111) were used in the present study. After scribing these wafers into small pieces (typically 0.8cm x 0.8cm in size), with one surface polished with 2HF: 3HNO3: 3CH3COOH mixture (3:5:3) were cleaned ultrasonically by dipping in distilled water, acetone and isopropyl alcohol alternately. After cleaning, the samples were oxidized in dry oxygen. [9]. A specific weight from Cadmium oxide must be taken and put it in a special evaporation molybdenum boat, take (1%) from this weight from Indium and put it in other molybdenum boat. The films of CdO:In were prepared by thermal co- evaporation in vacuum of the order of 10^{-5} torr, the rate of evaporation was ≈3.9A/sec, onto clean silicon mirror-like side substrates at room temperature (~300K). The average thicknesses of the deposits were determined by microbalance method. The maximum error in the determination of thickness was of the order of 10% estimated for the thinnest films (CdO:In/Si films of thickness 250 nm).Ohmic contacts of a study on the electrical properties CdO:In/Si heterojunction aluminum [10] were evaporated on the silicon side and CdO:In/Si side.

Result and Discussion

Figure (1) and table(1) show the XRD spectra obtained at room temperature for CdO:In film. The XRD pattern for Cadmium oxide doped with Indium film at room temperature reveals exhibit a prominent reflection angles at $2\theta^0$=33.02, $2\theta^0$=38.22 and $2\theta^0$=55.28. And the crystal lattice is cubic; these XRD peaks are shown to be the (111),(200) and (220).

The Figure (2) refers to transmission of CdO:In film in the range between (300-1100)nm.

The optical energy gap values (E_g) for CdO:In films have been determined. A plot of $(\alpha h\nu)^2$ versus photon energy for CdO:In film is shown in Fig.(3). The plot is linear indicating as direct band gap nature of the film. Extrapolation of the line to the photon energy axis gives the band gap. The value of the optical energy gap for Cadmium oxide doped with Indium film is equal to (2.43 eV). This result agrees approximately with the result reported by Khalid [11].

Figure (4) shows the I-V characteristics of n-CdO:p-Si solar cell under illumination. The short circuit current (I_{sc}), the open circuit voltage (V_{oc}) , fill factor (*F.F*) and the photovoltaic conversion efficiency(η) have been determined. The fill factor given by the relation[12,13].

$$F.F = V_m I_m / V_{oc} I_{sc} \text{ x } 100\% \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where(I_m) and(V_m) are the current and voltage corresponding to the maximum power point.the photovoltaic conversion efficiency (η) is given by:

$$\eta = p_m / p_{in} = F.F \times I_{sc} \times V_{oc} / p_{in} \times 100\% \ldots\ldots\ldots \quad (2)$$

Where p_m is the area of the maximum power rectangle, and p_{in} is the incident power [12,13].

In the present study, the n-CdO:In/p-Si solar cell has an open-circuit voltage (V_{oc}) of 0.6 Volt, a short-circuit current density (J_{sc}) of 12.8 mA/cm^2, a maximum voltage (Vmax) of 0.51 Volt, and a maximum current (Jmax) of 10.2 mA/cm^2, fill factor (*F.F*) of 0.667, and the value of the conversion efficiency (η) for n-CdO:In/p-Si solar cell is equal to(5.2%). These results are not coincident with Ramis [8] because of the different method and Conditions of preparation.

Conclusion

A CdO:In thin film was successfully deposited on a p-Si substrate to yield a solar cell via thermal evaporation in a vacuum. The XRD pattern showed that the thin film was polycrystalline in nature with a cubic structure. The direct band gap energy of the CdO:In thin film was 2.43 eV. the solar cell conversion efficiency (n-CdO:In/p-Si) was 5.2% under a 100 mW/cm^2 illumination condition using thermal evaporation in a vacuum.

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Table No. (1) X-ray diffraction data for CdO:In thin films

ASTM $2\Theta^0$	Experimental Value $2\Theta^0$	(h k l) Plane
33.00	33.02	(111)
38.28	38.22	(200)
55.25	55.28	(220)

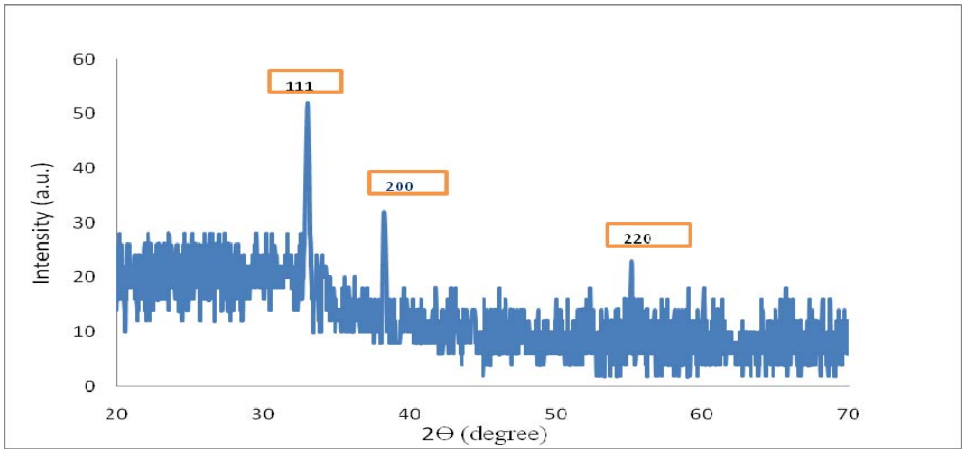

Figure No. (1): XRD of CdO:In thin film on glass substrate

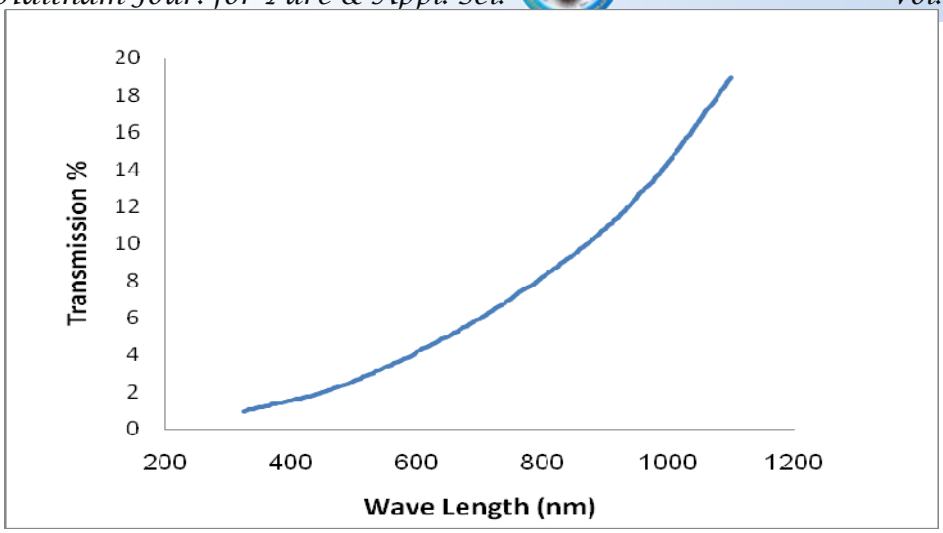

Figure No. (2): The optical transmission (T%) as a function of wavelength for CdO:In film

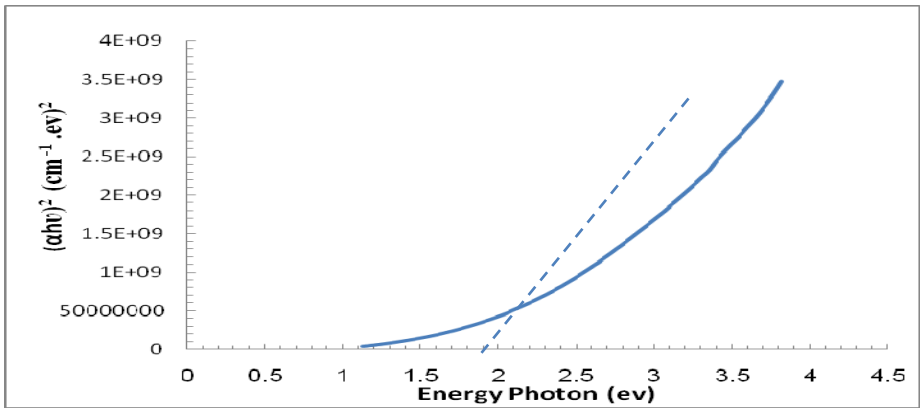

Figure No. (3): The energy gap of CdO:In film

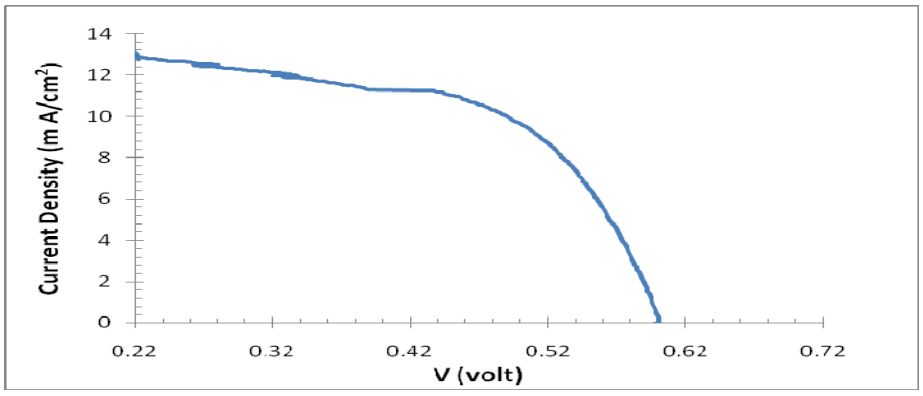

Figure No. (4): Current density-Voltage curves of the (n-CdO:In/p-Si) solar cell

تصنيع وخصائص الخلية الشمسية الفولتائية CdO:In/Si المحضرة بوساطة التبخير الحراري

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الخلاصة

في هذا البحث، صنعت خلايا شمسية هجينة نوع CdO:In/Si ،وذلك بتبخير أغشية الكادميوم المشوب بـ (1%) انديوم على قواعد زجاجية و سليكونية و بمعدل ترسيب (3.9A/sec) وسمك (≈250nm) .درس التركيب البلوري للغشاء بوساطة حيود الأشعة السينية، ومن طيف النفاذية للمدى (300-1100)nm , حسبت فجوة الطاقة المباشرة وكانت قيمتها (2.43)eV ، واجريت قياسات تيار- جهد في حالة الإضاءة فتبين ان للخلية أداء فولتائي جيـــد , اذ إن كثافة تيار الدائرة القصيرة (J_{sc}) (12.8 mA/ cm^2) وان فولتية الدائرة المفتوحة (V_{oc})(0.6 Volt) وبكفاءة تحويل (5.2%) (η) وعامل ملء(*F.F*) (0.66).

الكلمات المفتاحية:تصنيع,خصائص,خلية,الشمسية,الفولتائية.