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FABRICATION AND CHARACTERIZATION OF HIGH EFFICIENT Cd O/SI PHOTOVOLTAIC SOLAR CELLS

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Abstract

In the present work, CdO/Si heterojunction solar cell has been made by vacuum evaporation of CdO thin film onto monocrystalline silicon substrate. XRD was investigated, the transmission was determined in range (400-1000)nm and the direct band gap energy is 2.5 eV, I-V characterization of the cell under illumination was investigated , the cell shows an open circuit voltage (V_{OC}) of 0.4 V, a short circuit current density (J_{SC}) of 40 mA/cm2, a fill factor (F_F) of 0.34, and a conversion efficiency (η) of 5.5%.

Keywords: CdO/Si Heterojunction, Solar Cell, Conversion Efficiency.

Introduction

There has been considerable interest directed towards the development of heterojunction solar cells [1-3]. Such interest is based on the fact that these heterojunctions have a number of advantages over diffused p-n junction solar cells include [4]: (i) a lower junction-formation temperature, (ii) higher spectral response at short wavelengths, and (iii) many of deposited layers have the right indices of refraction to act as antireflection coating. In the last three interest, CdO/CdTe heterojunction solar cells have been reported to have higher power conversion efficiencies of 7.7% [5]. These cells were considered as low–cost and high efficient photovoltaic devices. The cost reduction obviously will be in the junction formation step. The aim of this paper is to present the results of the fabrication of n-CdO/p-Si heterojunction solar cell made by vacuum evaporating technique.

Experimental Procedures

Single-crystal silicon wafers of p-type conductivity with (111) orientation are used as substrates. They have a resistivity in the range of 1-5Ωcm and one face of the wafer is polished to the mirror-like surface. Prior to deposition of CdO, these wafers were chemically etched in dilute hydrofluoric acid to remove native oxides. Subsequently, after oxide removing, the wafers were scribed into individual pieces of 0.5 cm^2 sizes, then they were gone to vacuum chamber to fabricate the CdO/Si heterojunction. The deposition of CdO. films was carried out by vacuum evaporating of high-pure(5N) CdO powder onto silicon substrate.

The evaporation was done by using Balzer coating system at pressure 10^{-5} torr. Thickness of deposition film was about 300 nm which calculated from the gravimetric method. After the deposition of CdO, Ohmic contacts were formed by depositing 200 nm of In and Al on CdO and Si respectively. The sensitive area was about 0.2 cm^2.

J-V measurements were done under illuminated conditions. The illumination was achieved by halogen lamp type “PHILIPS”, 120W, which connected to a Variac and calibrated at AM1 (93mW/cm^2) illumination power density by a silicon power meter. The crystalline quality of the grown layer was investigated with aid of X-ray diffraction (XRD) spectrum recorded with X-ray diffractometer operators with 1.5417A monochromatized CuKα radiation with Ni filter.

Results and Discussion

XRD patterns for CdO thin films on glass from Fig. (1) corresponds to as-growth films deposited onto unheated substrates and reveals a polycrystalline structure of the film. In this diffraction pattern, the peaks at 2θ equal to 38.30 and 44.50 and 65.40 correspond to diffraction from [(111), (200), (220)] planes of the CdO, The XRD shows that the prepared CdO films has a cubic crystal structure with lattice parameter a = 4.69 Å agree with other report ref [7].

In Fig.(2) display the Transmission of CdO in the range (400-1000) nm, it is obviously that the film give a good transparency with the visible and NIR regions. The CdO is a material with a direct band gap lying to be 2.5 eV shown in Fig.(3). For such band to band transitions the dependence of absorption coefficient a versus photon energy the direct allowed absorption processes are the dominant is given by the relations [6]:

$$(ah\nu) = A(h\nu - E_g)^{1/2}$$

The I-V under illumination condition of different illumination power of the sample is shown in Fig.(4) the sample was illuminated by halogen lamp, the photocurrent strongly depends on the bias voltage we observe increase in the current value with power density.

The photovoltaic performance under simulated AM1 condition of the cell is described in Fig.(5). The curve is plotted to represent the power extracted from the cell. It is seen from this figure the low rectangularity indicated the high value of series resistance that results from the high resistivity of CdO layer. Low fill factor is expected from this figure. Fig.(6) demonstrates the variation of the output power (the power generated by the cell under simulated AM1=93 mW/cm^2) versus voltage across the load resistance. This figure reveals that CdO/Si heterojunction is a suitable device to produce high efficient solar cells. Conversion efficiency of 5.5%, fill factor of 0.36 this result is lower than CdO/CdTe see ref [5] may be due to mislattice between CdO&Si materials but is better than CdO/Cu_2O see ref.[8], J_{sc} is 40 mA/cm^2, and V_{oc} is 400 mV were obtained from Figs. (5 & 6).

Conclusions

CdO/Si heterojunction solar cell showed high conversion efficiency. The high performance of this cell is coming from the suitability of CdO bandgap that lies at the interest spectral region of the solar spectrum. High resistivity of CdO layer which leads to low fill factor is the main problem of this cell, this problem can be solved by doping CdO layer with suitable dopant. Improving the cell efficiency by CdO doping is under progress.

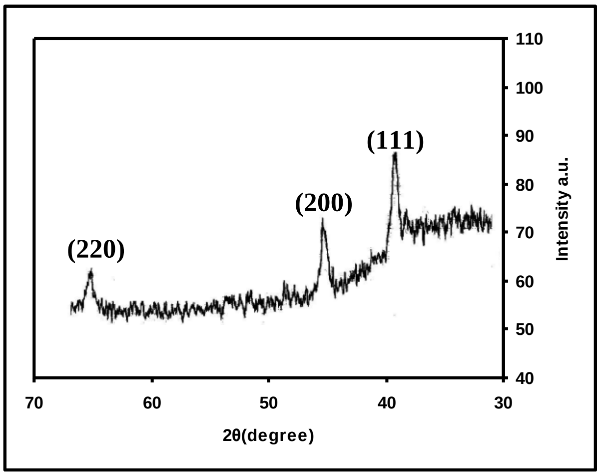

Fig.(1) : XRD spectra of CdO film on glass substrate .

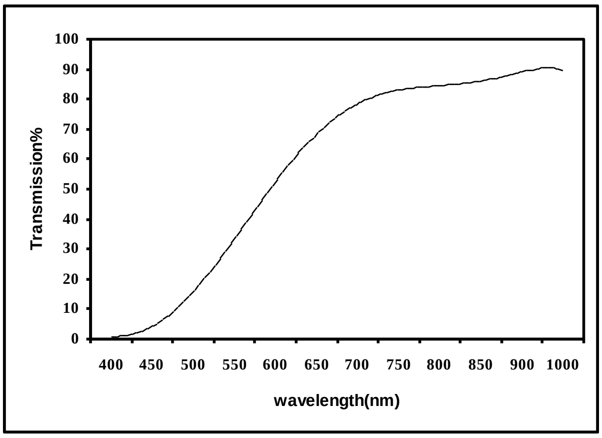

Fig.(2) : The optical transmission (T)% as function of wavelength(λ).

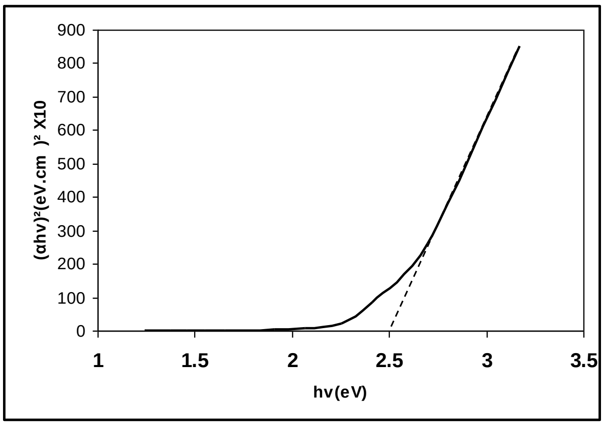

Fig.(3) : Show the (α*hv*)2 versus *hv* of the thin film.

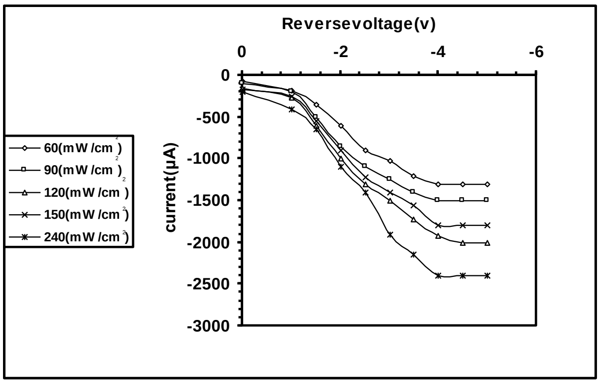

Fig.(4) : (I-V) characteristics under different power density illumination.

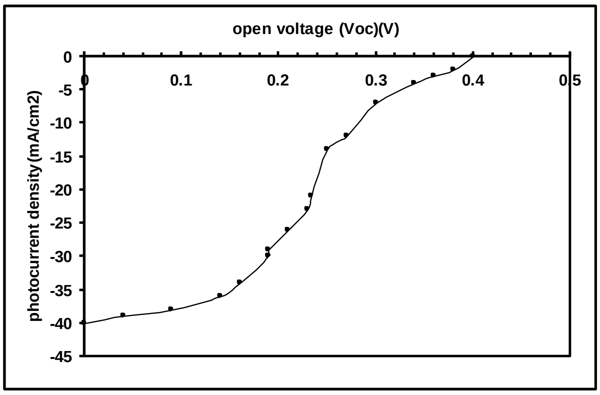

Fig.(5) : The photovoltaic performance of the cell under condition AM1.

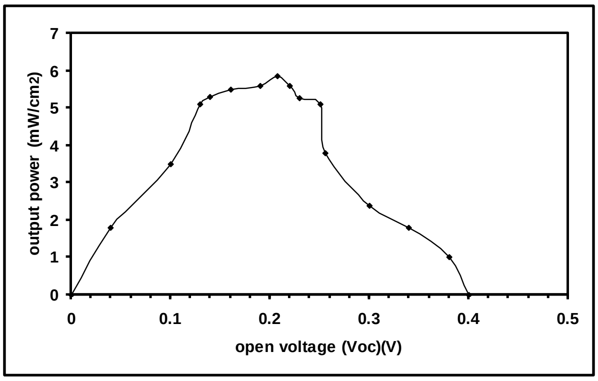

Fig.(6) : The output power generated by the cell.

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الخلاصة

في هذا البحث ، تم تصنيع خلايا شمسية هجينة نوع CdO/Si وذلك بتبخير أغشية CdO الرقيقة على قواعد سليكونية أحادية البلورة . تم دراسة البناء البلوري للغشاء بواسطة حيود الأشعة السينية و تم دراسة النفاذية للمدى (400-1000)nm تم حساب فجوة الطاقة المباشرة وتساوي (2.5)eV وتم دراسة القياسات تيار–جهد في حالة الإضاءة أبدت الخلية أداء فولطائي جيد حيث أن تيار دائرة القصر $(40)mA/cm^2$ وان فولتية الدائرة المفتوحة (0.4)V وبكفاءة تحويل 5.5% وعامل ملئ 0.34 .