Fabrication and Characteristics Study Of CdO/Si Heterojunction

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Abstract

In the present paper CdO/Si heterojunction has been prepared by spray pyrolysis method , electrical characteristics include I-V , C-V , were studied the build-in-potential equal 1.7 eV and optoelectronic characteristics include I-V illumination condition, photovoltaic, responsivity , quantum efficiency were studied . the ideality factor to be 2.93 and short circuit photocurrent 170µA, open circuit photovoltge 120mV at AM1 condition and two peaks responsivity were found , first peak at region 600±20nm this peak due to absorb of light in CdO through band-to-band absorption while second region at 800±30nm which due to the Si bandgap.

Keyword: Cadmium oxide , heterojunction , thermal oxide , Transparent conducting oxides , spray pyrolysis.

تصنيع ودراسة خواص المفرق الهجين CdO/Si

الخلاصة

في هذا البحث تم تحضير المفرق الهجين CdO/Si بطريقة الرش الكيميائي الحـراري تـم دراسـة الخواص الكهربائية المتضمنة تيار-جهد، سعة-جهد ووجد جهد البناء الداخلي يساوي 1.7eV وتم دراسة الخواص الكهروبصرية المتضمنة تيار-جهد في حالة إضاءة والخواص الفولتائية والاسـتجابية الطيفيـة والكفاءة الكمية وقد وجد ان عامل المثالية يساوي 2.93 وتيار دائرة القصـر 170µA وفولتيـة الـدائرة المفتوحة 120mV عند حالة AM1 ووجد قمتي استجابية الأولى عند 600±20nm بسبب امتصـاص حزمة الى حزمة في الغشاء والثانية 800±30nm بسبب فجوة طاقة السليكون .

Introduction

Transparent conducting oxides(TCO) has been widely studied and received considerable attention in recent years the band gap of these material are large enough to be useful solar spectrum and the resistivity is small enough to avoid series resistance effect [1].

Cadmium oxide CdO is conducting , transparent in the visible region with a direct band gap of 2.5 eV , CdO is a n-type semiconductor , various techniques have been employed spray pyrolysis . spray pyrolysis is particularly attractive since it is relatively fast ,vacuumless , simple , more economics[2].

Heterojunction in general is defined as the interface between two dissimilar materials in electron affinities , energy band gap and work function . such heterojunction can be classified as abrupt or graded according to the distance during which the transition from one material to the other is completed near the interface other classification of heterojunction

depend on the type of conductivity present on either side of the junction if two semiconductors involved have similar types of conductivity then the junction is called isotope heterojunction otherwise it is called anisotope heterojunction [3,4].

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It is interesting to consider various theoretical factors which influence the properties of the grown heteroxpitaxial layers , the three main factors are (i) lattice mismatch (ii) thermal mismatch (iii) interdiffusion[3,5]

The aim of this paper , CdO/Si hetrojunctuion thin film solar cells have been prepared by spray pyrolysis method, spray pyrolysis deposition is particularly attractive since it is relatively fast , vacuumless , simple and more economics [6].

Experimental

The thin film of CdO has been prepared by spray pyrolysis technique from ($Cd(NO_3)_2.4H_2O$) on the single – crystal silicon wafers of p-type with (111) orientation are used as substrate . it has a resistanc in the range of 4-5Ω and one face of the wafer was polished

Prior to deposition of CdO , these wafers were chemically etched in dilute hydrofluoric acid to move native oxide , then back contact metallization was accomplished by vacuum deposition of Al . the wafers were scribed into individual pieces of 0.5 cm_2 area then they were sent to spraying apparatus.

The deposition of CdO film was carried by spraying an aqueous solution of $Cd(NO_3)_2$ onto a heated silicon substrate maintained at 450C^o after the deposition of CdO , frontal metal electrode is formed by Al.

The thin film thickness was calculated by gravimetric method. the optoelectronic and electrical measurement included current-voltage and capacitance-voltage .reverse I-V under different illuminations , and an open circuit voltage and a short circuit current and spectral response and quantum efficiency were characterized.

Result and Discussion

I-V characteristics

The forward and reverse bias voltage under dark condition of CdO/Si heterojunction is shown in Fig.(1) in forward bias current increase with voltage as expected , but reverse bias , the current was found to increase slowly with voltage (soft breakdown) without any sharp breakdown [7] this result agree with [8].

The I-V under illumination condition of different illumination power of the sample is shown in Fig.(3) the sample was illuminated by halogen lamp calibrated at three intensity levels under simulated AM(1-3) condition from Fig.(3) the photocurrent strongly depends on the bias voltage we observe increase in the current value with power density

C-V characteristics

The Fig.(2) shown C^{-2}-V plot, the decrease a capacitance with increase bias voltage because increase width of the depletion region (increase absorption area) The junction of this heterojunction is abrupt and from Figure the built-in – potential V_{bi} was determined where (C^2=0) was found to be 2 eV.

Photovoltaic characteristics

The Fig.s(4),(5) shown short circuit Isc current and open circuit voltage Voc as function of illumination power density the short circuit current increase with increase the illumination power density the Isc tend to saturate Fig.(5) show the open circuit voltage Voc versus different power density the maximum value of Voc is 120mV at AM1 condition and 150mV at AM1.5 condition 250mV at AM3 condition .

Fig. (6) show Variation short circuit photocurrent with open circuit photovoltge for different illumination power the result appear ideality factor to be 2.53 so there are interfacial states because mislattice between two materials the ideality factor can be calculated from eq.

$$Voc = \beta\ KT/q(\ln Jsc-\ln Js) \quad \ldots\ldots\ldots\ldots(1)$$

Optoelectronic characteristics

Fig. (7),(8) shown responsivity and quantum efficiency as function of the wavelength at range spectral (400-1000)nm the Fig. has two peaks first peak at region 600±20nm this peak due to absorb of light in CdO through band-to-band absorption while second region at 800±30nm which due to the Si bandgap.[11]

The CdO/Si has high responsivity compared with other TCO hetrojunction such as Bi_2O_3/Si [9]& little than In_2O_3/Si [10] .

Fig. (8) shown quantum efficiency as function of wavelength we have peak quantum efficiency 60% at wavelength 800nm.

The CdO heterojunction investigated spectral responsivity of two lasers He-Ne and diode (810nm) lasers were used versus bias voltage applied the two laser optimized to output power 1mW, Fig.(9) obvious laser diode more response than He-Ne, because of laser diode near the peak photoresponse of the heterojunction.

Conclusion

1- CdO/Si can be prepared by spray pyrolysis .
2- CdO/Si heterojunction is abrupt type and built-in-potential equal 1.7 eV.
3- CdO/Si has two peaks first peak at region 600±20nm this peak due to absorb of light in CdO through band-to-band absorption while second region at 800±30nm which due to the Si bandgap , responsivisty increase with apply bias voltage .

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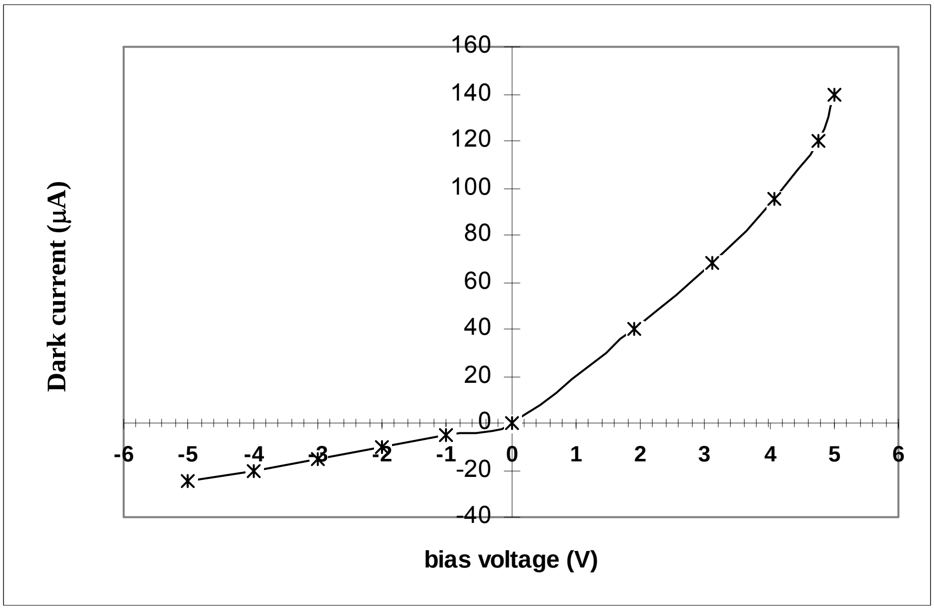

Fig. (1) current-voltage for characteristics CdO/Si heterojunction

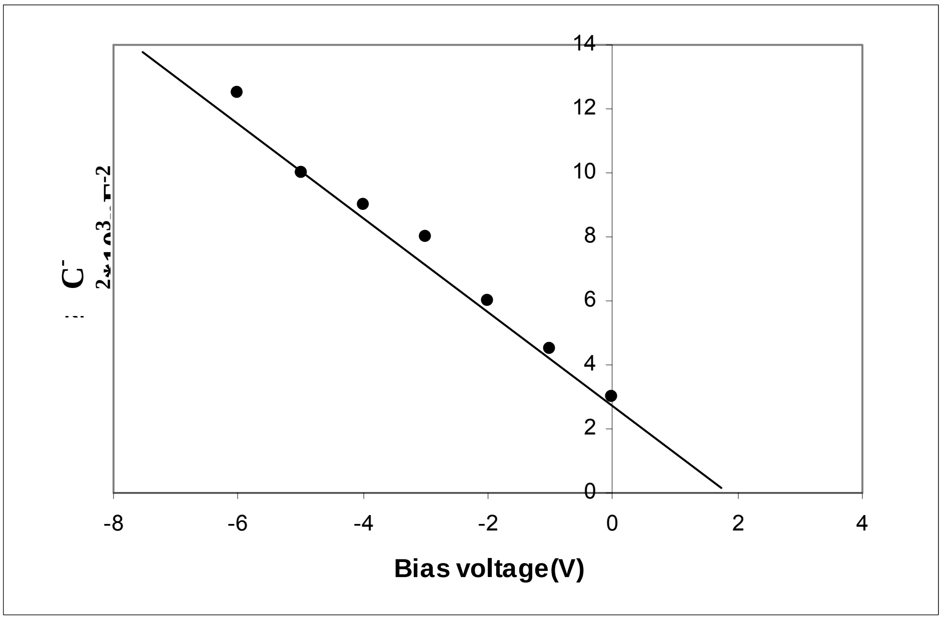

Fig.(2) C^2 versus Bias voltage for characteristics CdO/Si heterojunction

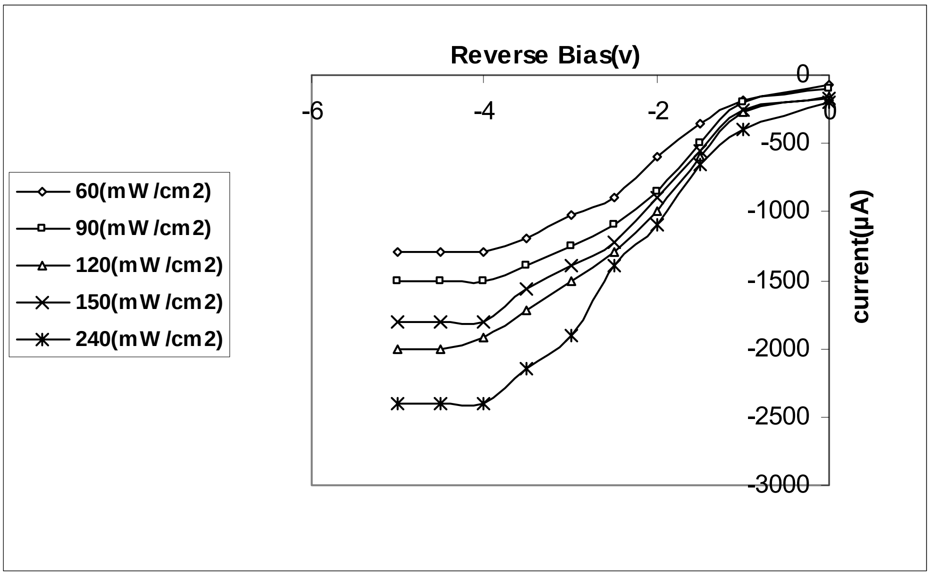

Fig. (3) Current-voltage in illumination condition for characteristics CdO/Si heterojunction

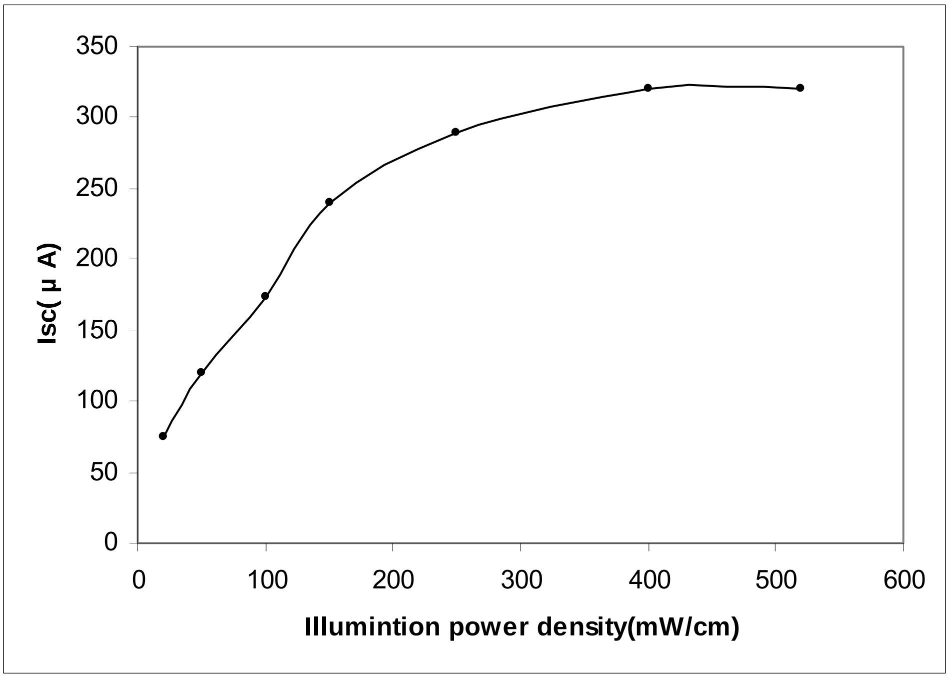

Fig. (4) short circuit Isc current vs illumination power density

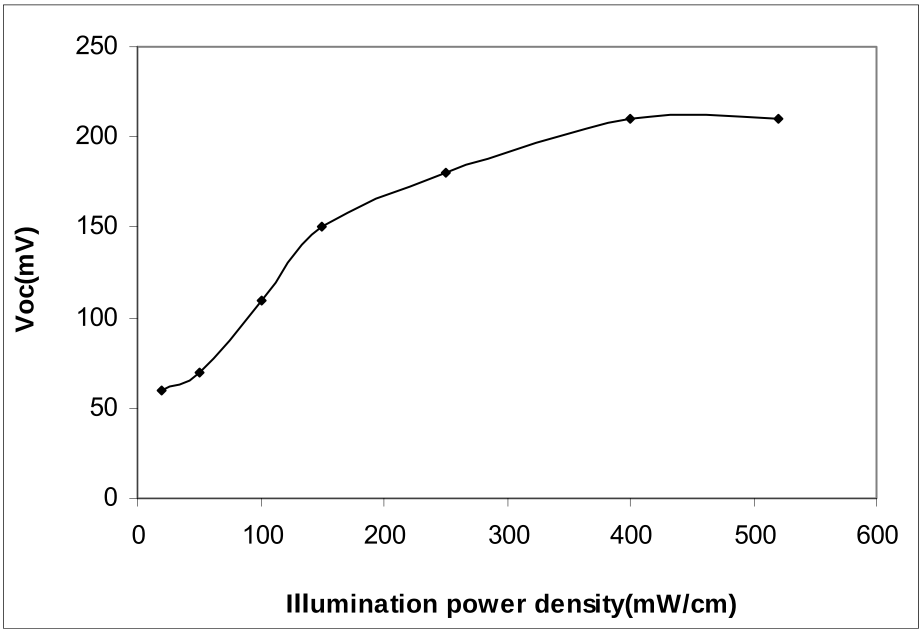

Fig. (5)open circuit voltage Voc as function of illumination power density

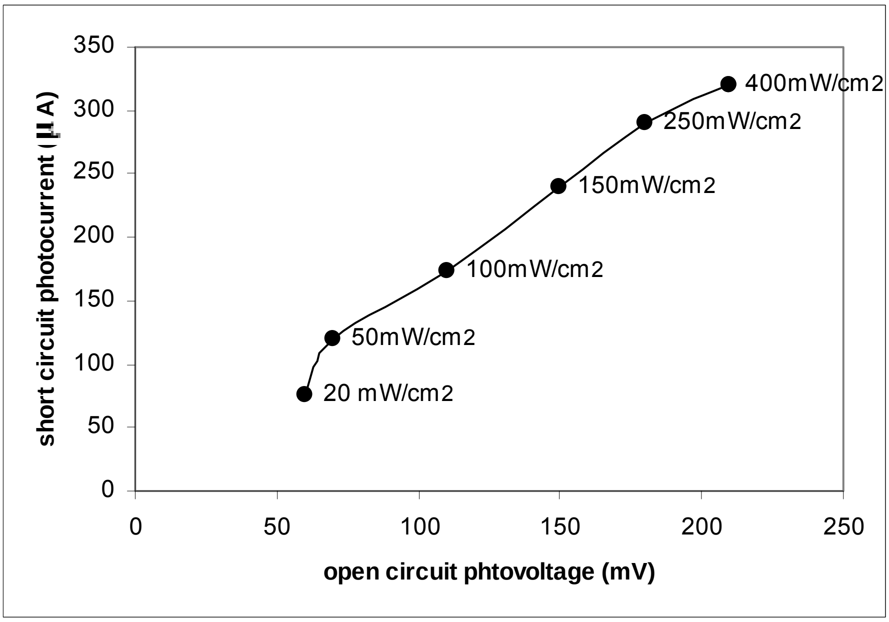

Fig. (6) show Variation short circuit photocurrent with open circuit photovoltge for different illumination power density

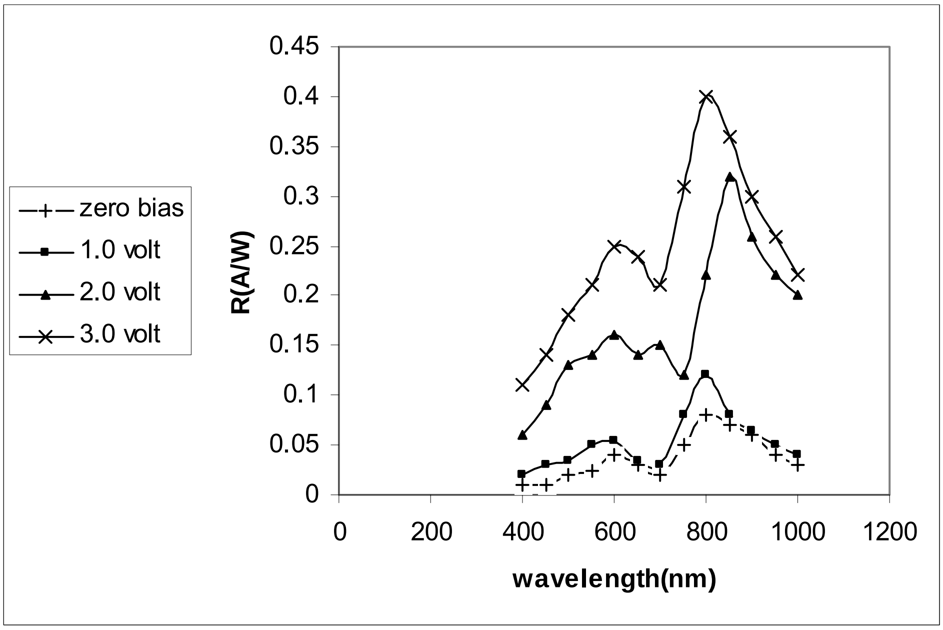

Fig. (7) shown responsivity and as function of the wavelength

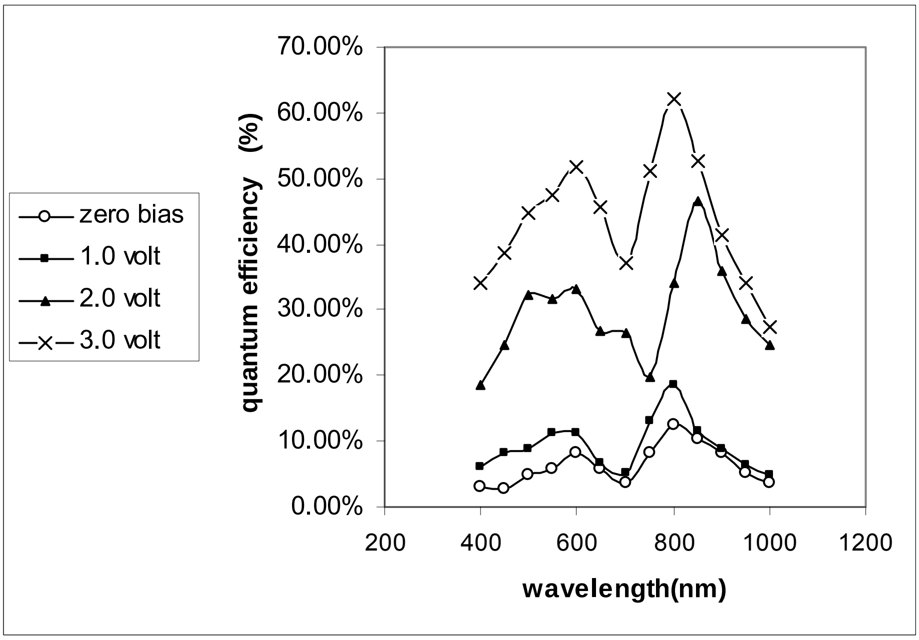

Fig. (8) shown quantum efficiency as function of wavelength.

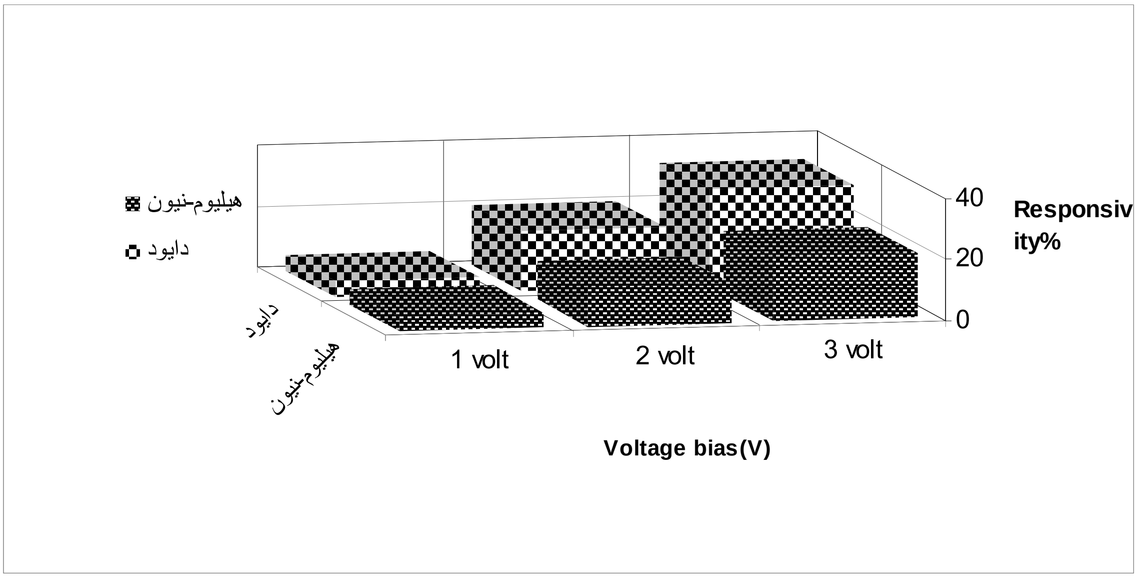

Fig.(9)spectral responsivity of two lasers red He-Ne (1mW) and IR diode (810nm) (1mW)