Fabrication and Characteristics Study Of CdO/Si Heterojunction

Khalid Z. Yahiya*   Ammar H. Jareeze** & Ammar M. Al-Baldawi*
Received on:4 /9/2007
Accepted on: 8/5/2008

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.

CdO/Si

CdO/Si

1.7eV   -   -

-

170µA   2.93

600±20nm   AM1   120mV

.   800±30nm

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].

*School of Applied Sciences, Univ. of Tech.
**Dept. laser &opto.eng. ,univ. of tech.

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° 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   =β   KT/q(lnJsc-lnJs)   ………….(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 .

Reference

[1] F. A. Benko, F. P. Koffyberg, Solid State Commun, 57, 901 (1986).

[2]Xiaonan Li, Timothy Gessert, Clay DeHart, Teresa Barnes,(**A Comparison of Composite Transparent Conducting Oxides Based on the Binary Compounds CdO and SnO₂**) National Renewable Energy Laboratory 14-17 October 2001

[3]Sharma B.L., Purohit R.K.," **semiconductor heterojunction** " , pergaman press. New York, 1974 .

[4] Morgan D.V. , William R.H.,"**physics and technology of heterojunction devices** ", London 1990.

[5] Gordon Jeffrey, "**solar cell**", Crmwell press , London, 2001.

[6] H.H. Afify, S.H. El-hefnwi, A. Elwia, M. Abd-El Naby " **conference photovoltaic energy conversion** " Osaka, 165, japan 11-18 may,2003.

[7] A. G. Milnes & D.L. Feucht, " **semiconductor and metal-semiconductor junction** ' , academic press , New York, 1972.

[8] S. Dhar and S. Chakrabarti " **Large photoresponse of CdO/porous Si diodes** "Semicond. Sci. Technol. 15 (2000) L39–L40. Printed in the UK.

[9] Raid A. Ismail " **Fabrication and characteristic study of Bi₂O₃/Si heterojunction** " j. semiconductor technology and science ,VOL.6,NO.2,2006.

[10]R. A. Ismail , D.N.Raouf **" high efficiency In₂O₃/Si heterojunction solar cells produced by rapid thermal oxidation**" j.optoelectonics and advanced materials VOL.8,NO.4, 2006.

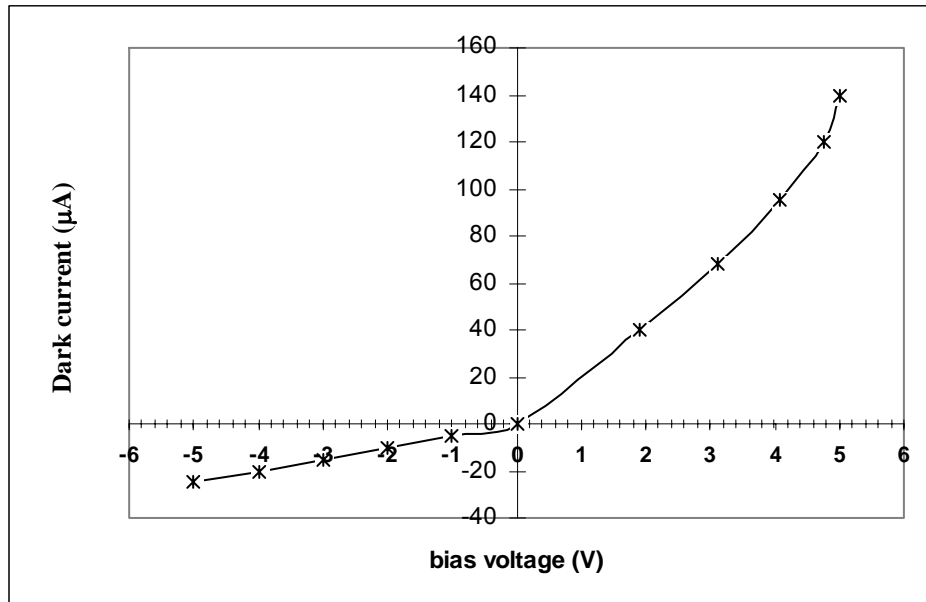[11] S.M.Sze " **physics of semiconductor device** " john weily New York,1989.

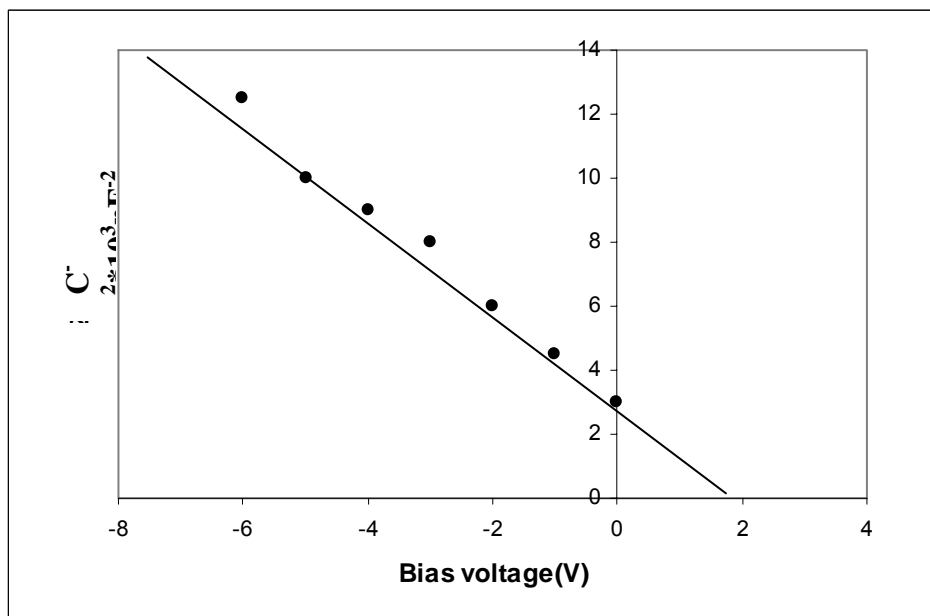**Fig. (1) current-voltage for characteristics CdO/Si heterojunction**

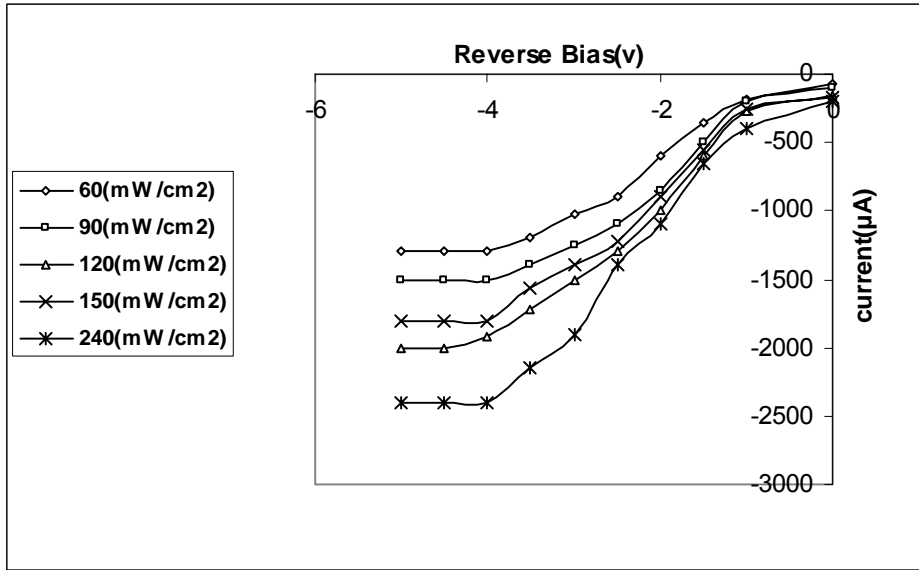**Fig.(2) C^2 versus Bias voltage for characteristics CdO/Si heterojunction**

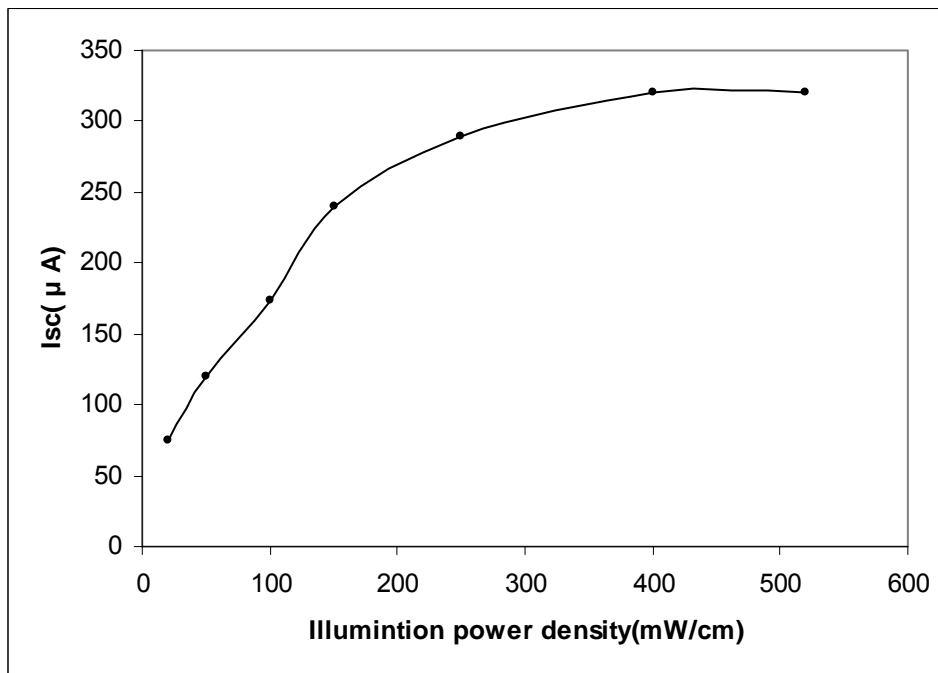**Fig. (3) Current-voltage in illumination condition for characteristics CdO/Si heterojunction**

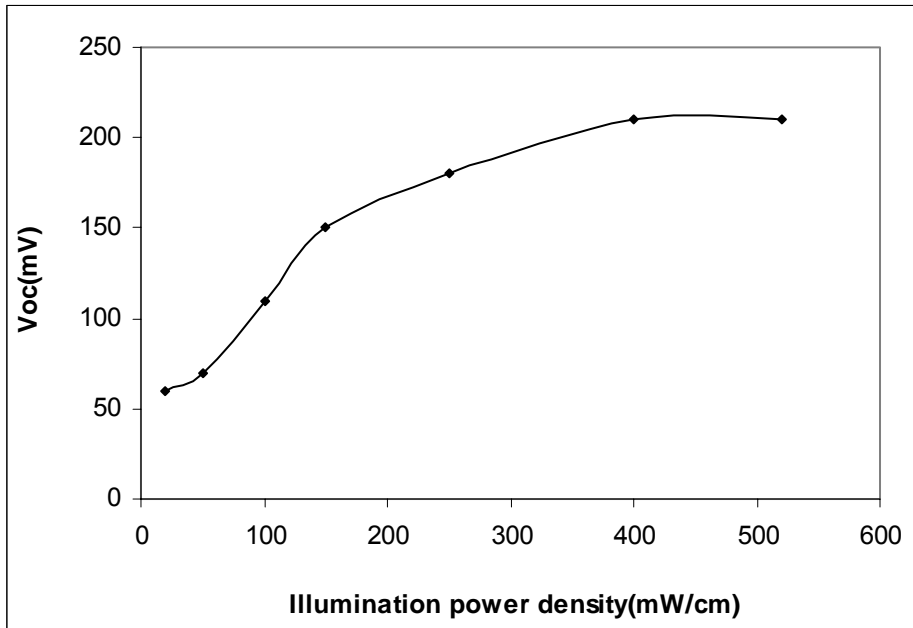**Fig. (4) short circuit Isc current vs illumination power density**

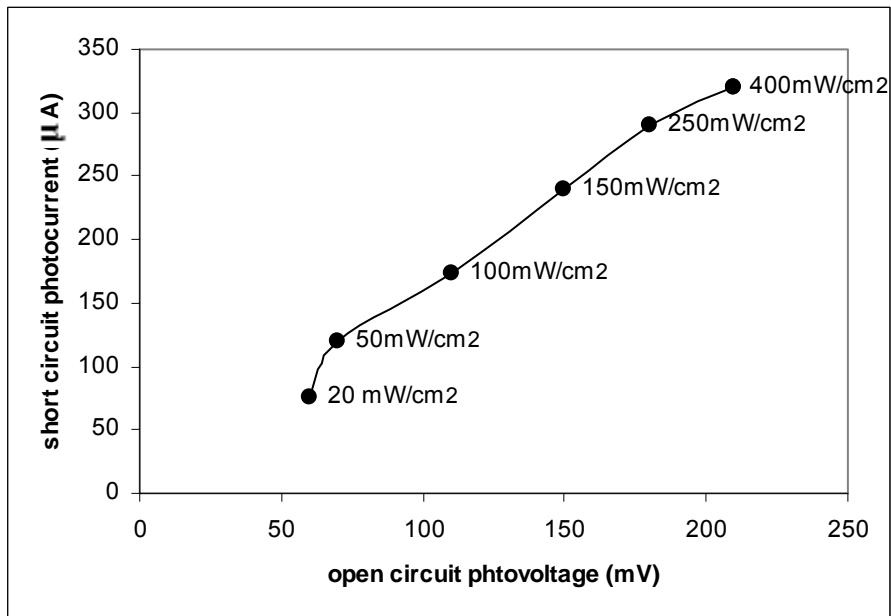**Fig. (5)open circuit voltage Voc as function of illumination power density**

Fig. (6) show Variation short circuit photocurrent with open circuit photovoltge for different illumination power density
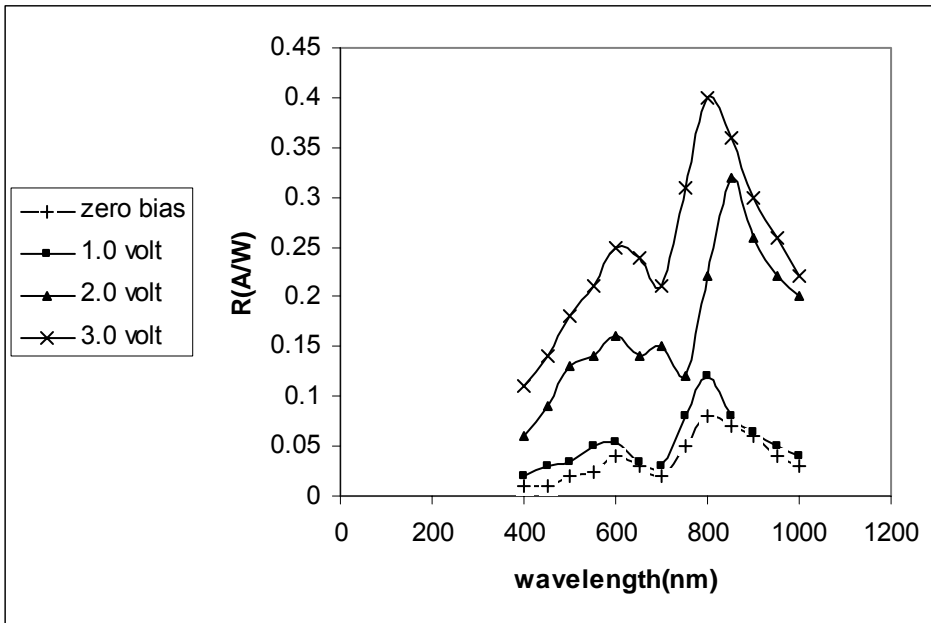
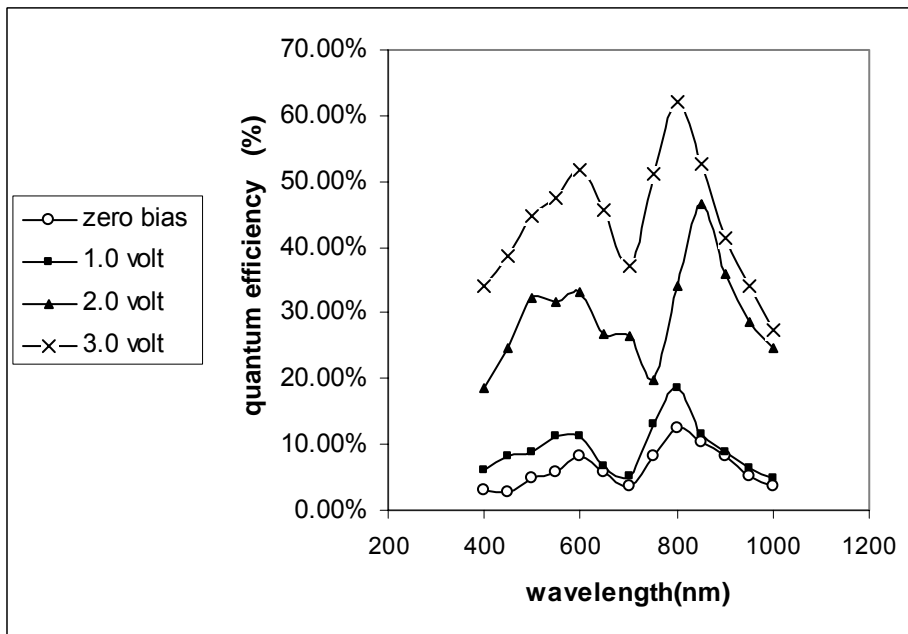**Fig. (7) shown responsivity and as function of the wavelength**

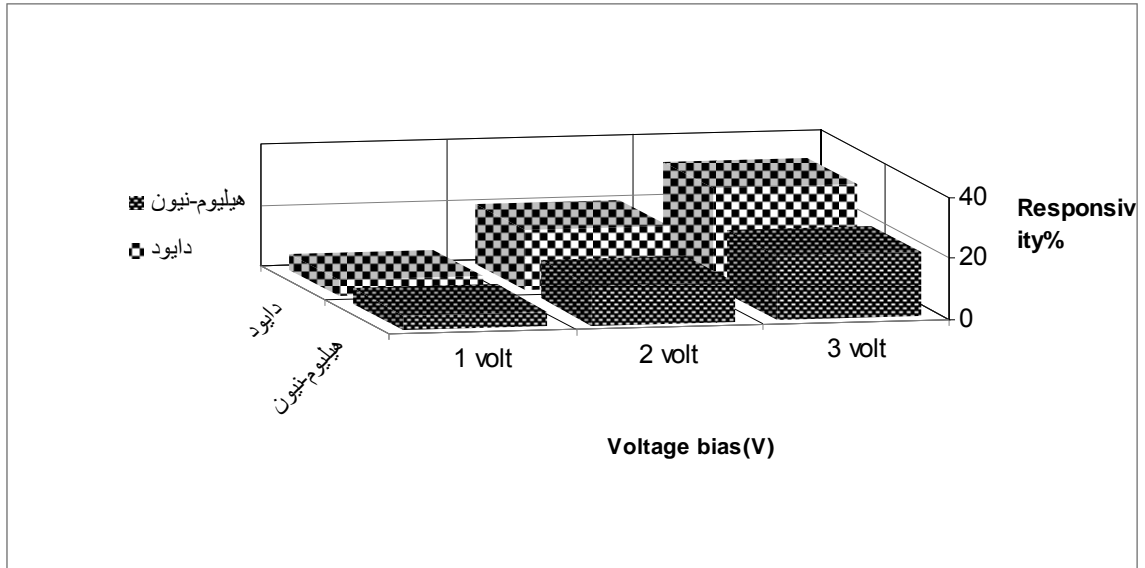**Fig. (8) shown quantum efficiency as function of wavelength.**

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