

## 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 built-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 170 μA, open circuit photovoltage 120 mV at AM1 condition and two peaks responsivity were found, first peak at region 600 ± 20 nm this peak due to absorb of light in CdO through band-to-band absorption while second region at 800 ± 30 nm which due to the Si bandgap.

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

### CdO/Si

1.7eV

170 μA  
600 ± 20 nm

CdO/Si

2.93

AM1      120 mV  
800 ± 30 nm

### 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 heteroepitaxial layers, the three main factors are (i) lattice mismatch (ii) thermal mismatch (iii) interdiffusion[3,5]

The aim of this paper, CdO/Si heterojunction 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  $(\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O})$  on the single-crystal silicon wafers of p-type with (111) orientation are used as substrate. It has a resistance in the range of 4-5 $\Omega$  and one face of the wafer was polished

Prior to deposition of CdO, these wafers were chemically etched in dilute hydrofluoric acid to remove native oxide, then back contact metallization was accomplished by vacuum deposition of Al. The wafers were scribed into individual pieces of 0.5 cm<sup>2</sup> area then they were sent to spraying apparatus.

The deposition of CdO film was carried by spraying an aqueous solution of  $\text{Cd}(\text{NO}_3)_2$  onto a heated silicon substrate maintained at 450°C 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 agrees 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<sup>2</sup>-V plot, the decrease in capacitance with increase in bias voltage because of increase in width of the depletion region (increase in absorption area). The junction of this heterojunction is abrupt and from Figure the built-in potential  $V_{bi}$  was determined where (C<sup>2</sup>=0) was found to be 2 eV.

#### Photovoltaic characteristics

The Figs.(4),(5) shown short circuit  $I_{sc}$  current and open circuit voltage  $V_{oc}$  as a function of illumination power density. The short circuit current increases with increase in illumination power density. The  $I_{sc}$  tends to saturate. Fig.(5) shows the open circuit voltage  $V_{oc}$  versus different power density. The maximum value of  $V_{oc}$  is 120mV at AM1 condition and 150mV at AM1.5 condition and 250mV at AM3 condition.

Fig. (6) shows variation of short circuit photocurrent with open circuit photovoltage for different illumination power. The result appears to have an ideality factor of 2.53, so there are interfacial states because of lattice mismatch between two materials. The ideality factor can be calculated from eq.

$$V_{oc} = \beta \frac{KT}{q} (\ln I_{sc} - \ln I_s) \quad \dots \dots \dots (1)$$

#### Optoelectronic characteristics

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

The CdO/Si has high responsivity compared with other TCO heterojunction

such as Bi<sub>2</sub>O<sub>3</sub>/Si [9]& little than In<sub>2</sub>O<sub>3</sub>/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 , responsivity 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 SnO<sub>2</sub>** ) 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 Bi<sub>2</sub>O<sub>3</sub>/Si heterojunction** " j. semiconductor technology and science ,VOL.6,NO.2,2006.

[10]R. A. Ismail , D.N.Raouf " **high efficiency In<sub>2</sub>O<sub>3</sub>/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.

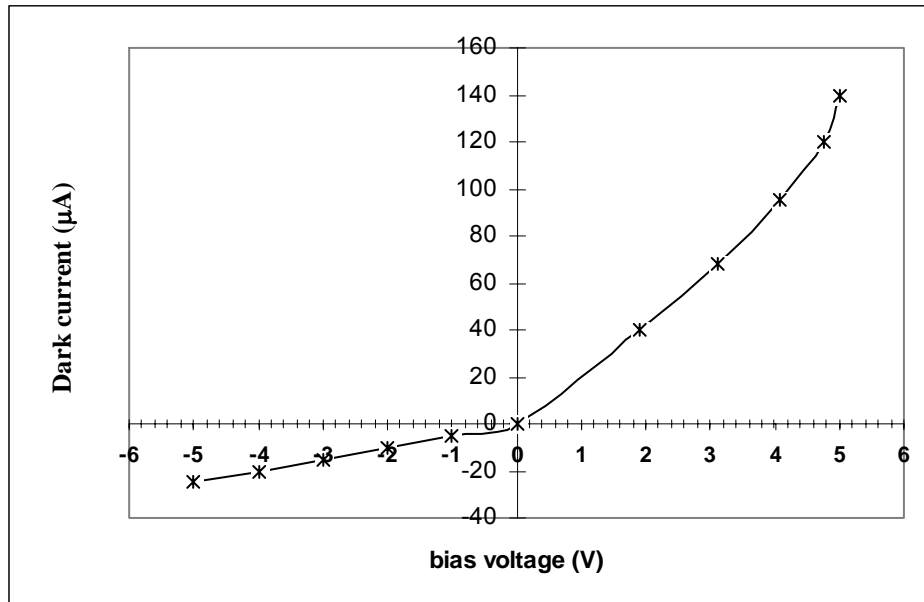


Fig. (1) current-voltage for characteristics CdO/Si heterojunction

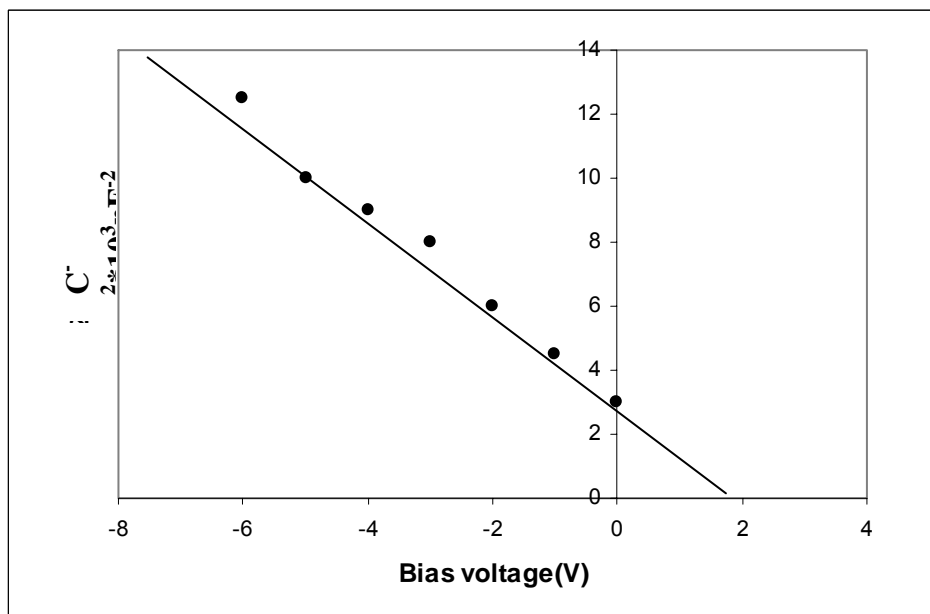
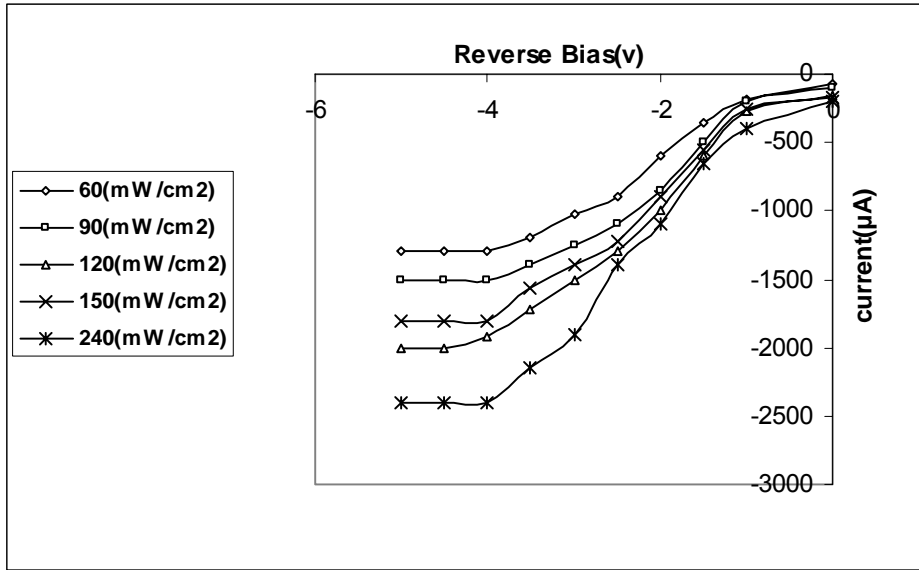
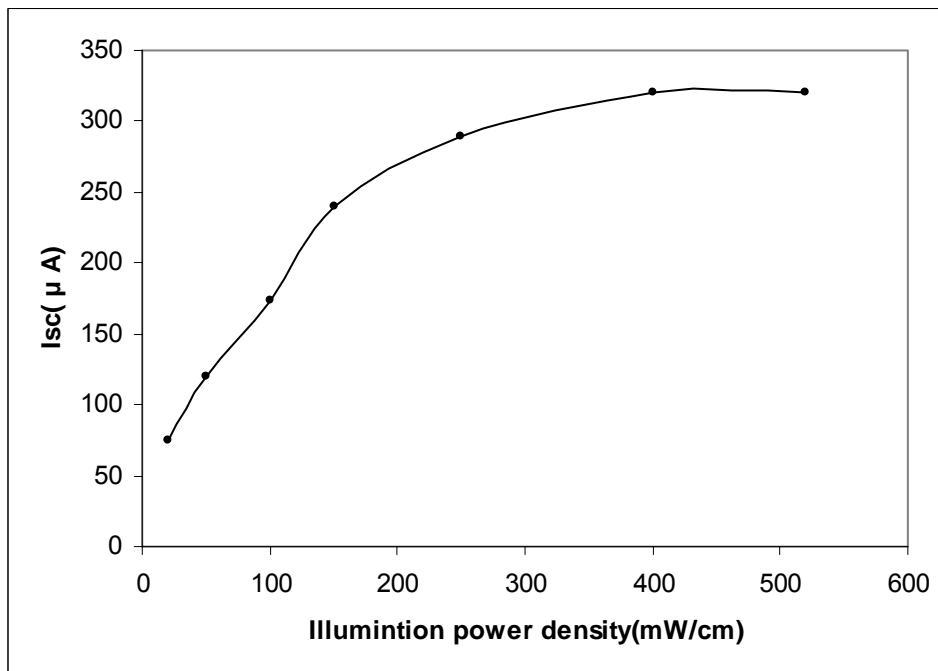


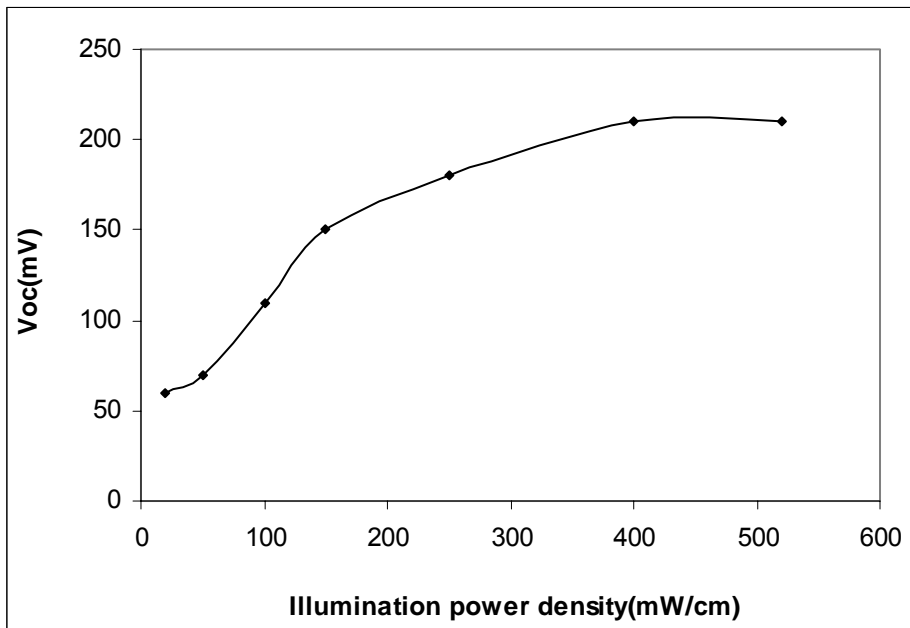
Fig.(2) C<sup>2</sup> versus Bias voltage for characteristics CdO/Si heterojunction



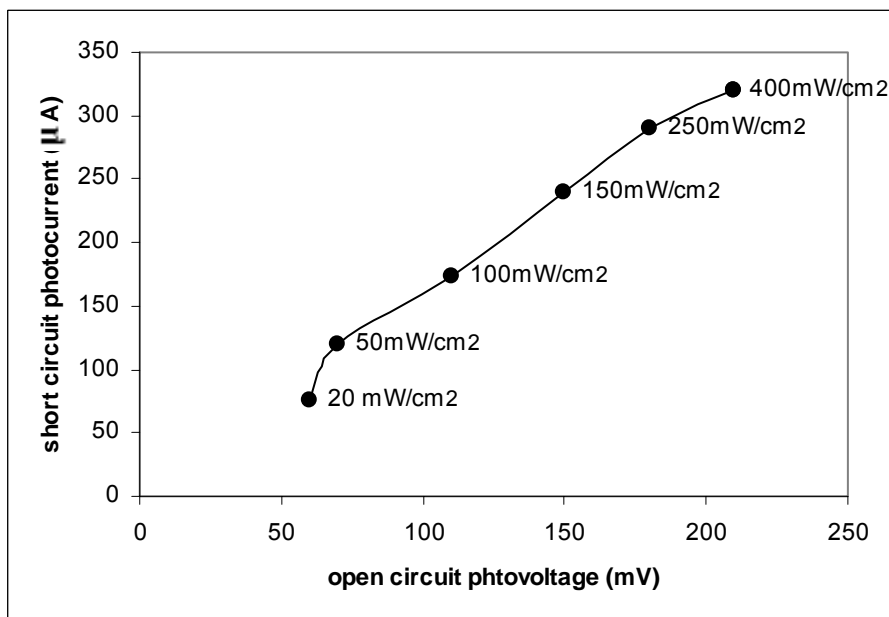
**Fig. (3) Current-voltage in illumination condition for characteristics CdO/Si heterojunction**



**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 photovoltage for different illumination power density**

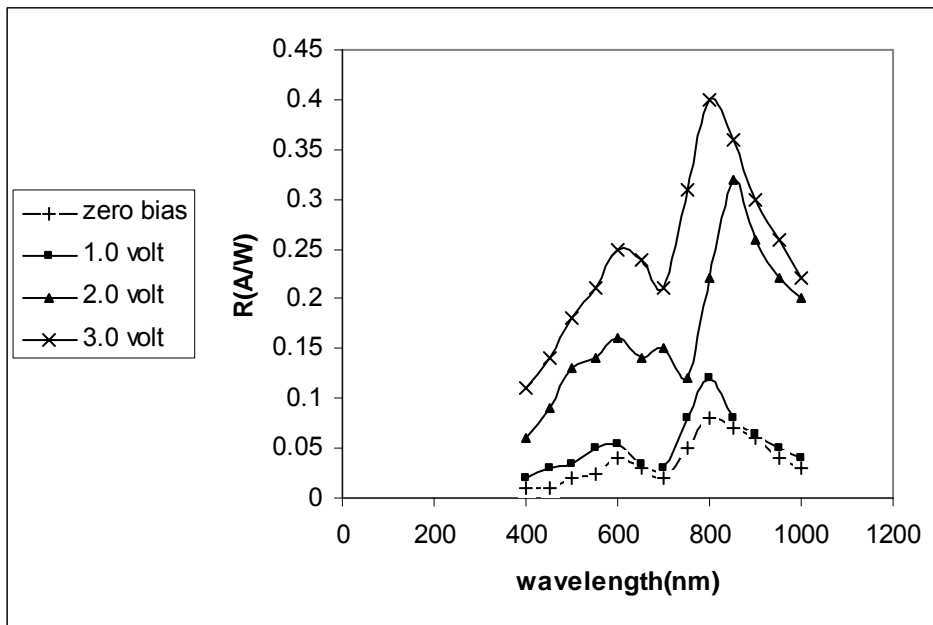


Fig. (7) shown responsivity and as function of the wavelength

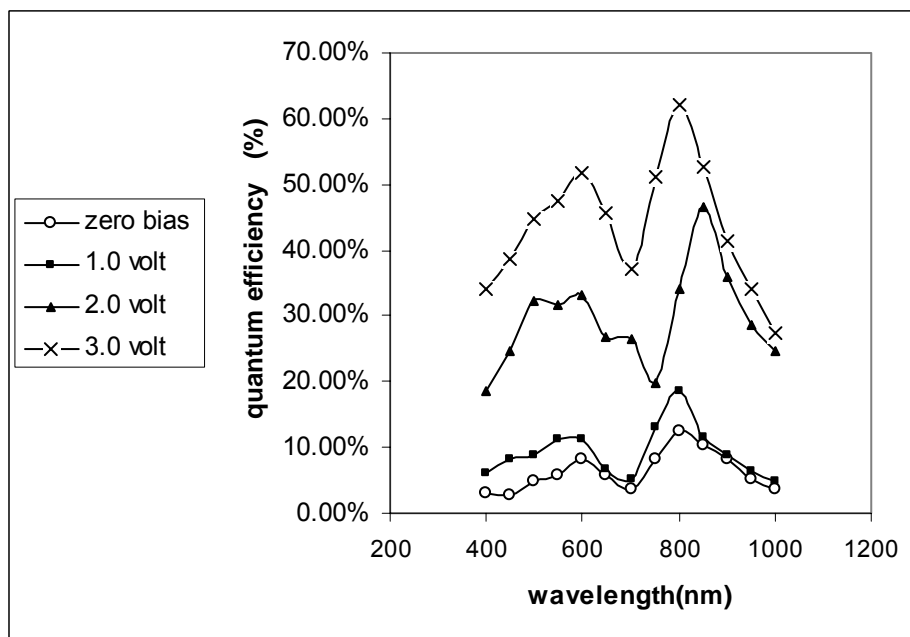
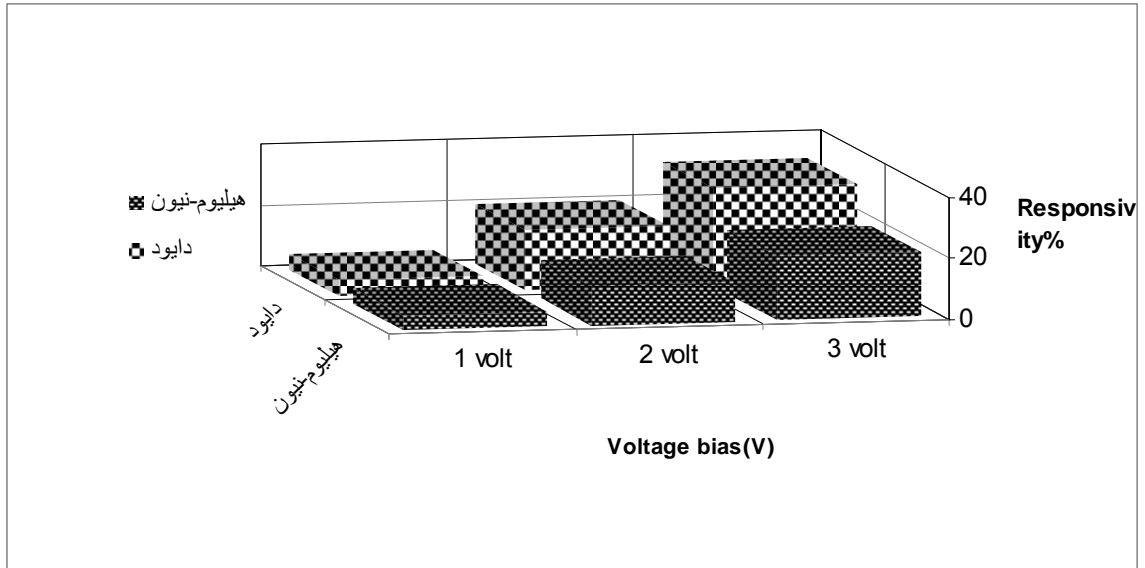


Fig. (8) shown quantum efficiency as function of wavelength.



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