Effective ZnO Doping by pulsed laser deposition to Improve the efficiency of the solar cells of TiO_2at 200 C^0

تأثير تطعيم اوكسيد الخارصين بواسطة ترسيب الليزر النبضي لتحسين كفاءة الخلية الشمسية للأوكسيد التياتيوم عند درجة حرارة C^0 (200)

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Abstract

In this research was prepare TiO_2: ZnO have been deposited on the glass substrates by the pulsed lasertechnique,the use of Nd:YAG laser with wavelength (1064)nm and energy 600mJand have been deposited with different concentration(0.03,0.05,0.07,0.1)% of ZnO at annealing temperature 200 $C^0$with thickness (400 nm). The TiO_2thin films showed n-type conductivity, according to Hall measurements, the carrier concentration of TiO_2 thin films had increasedfrom (18.5×10^{10} to 45.16×10^{10} cm^{-3}). The average absorbance value of TiO_2 thin films was improved from ($3.412*10^{-6}$to $8.654*10^{-6}$)by the doping of ZnO., These improved properties should contribute to the efficiency of the photovoltaic effect of the photogenerated charged carriers. The(I-V) characteristic of (Al / TiO_2: ZnO /n-Si / Al) heterojunction show that the solar cell which is produced at X=0.1% by efficiency (η) =8.769

Keywords:Titanium dioxide (TiO_2) Zinc oxide (ZnO), Silicon wafer, Pulsed laser deposition

الخلاصة

تم تحضير اغشية اوكسيد التياتيوم على قواعد من الزجاج باستخدام تقنية الترسيب بالليزر النبضي حيث تم استخدام ليزر النديميوم- ياك النبضي ذو الطول الموجي(1064nm)وبطاقة (600 mj)ومن ثم تم ترسيب هذه الاغشيةبأوكسيد الخارصين بتراكيز مختلفة%(0.1 , 0.07 , 0.05 , 0.03) وبدرجة حرارة ($200\ C^0$)وبسمك (400nm).وبينت قياسات هول ان الاغشية المحضرة تكون ذات توصيلية سالبة حيث نلاحظ كلما زداد نسبة التراكيز تزداد تراكيز الحاملات من(18.5×10^{10}) الى(45.16×10^{10} cm^{-3}) وكذلك تزداد التوصيليةمن ($3.412*10^{-6}$1/Ω.cm)الى $8.654*10^{-6}$)وهذه الخصائص ساهمت في تحسين كفاءة الخلية الشمسية بينت خواص تيار- فولتية للمفرق الهجين (Al / TiO_2: ZnO /n-Si / Al) الحصول على خلية شمسية حيث عند التركيز%0.1ذات كفاءةعاليه8.769

Introduction

The titanium dioxide (TiO_2) is important material for a many device such as solar cell ,optical detector and sensor. The Physical and chemical properties of TiO_2 (direct optical band gap 3.06eV, n-type , structure is tetragonal, with two TiO_2 recipe units (six atoms) per primitive cell color is white)[1,2]. Lattice parameters are: a, b equal 3.7710 Å and c equal 9.430 Å with c/a proportion of 2.5134 [1] as appeared in Fig. (1),density 4.27(g/cm^3) , melting point 1855 (^oC), boiling point 2972(^oC) and refractive index 2.609.As a champion among the most import direct conductive oxide , TiO_2 and its mixes have been for the most part utilized as a piece of photovoltaic devices, sun oriented cells, clear –gas sensors [3].Wide range of methods utilized for depositing titanium dioxidefilms including laser removal, compound vapor deposition (CVD) [4] and template-directed growth[5],Each of these techniques are hard to dissipate the material titanium dioxide since it has a high dissolving point, the specialists could evaporation materials by the laser pulse[6].

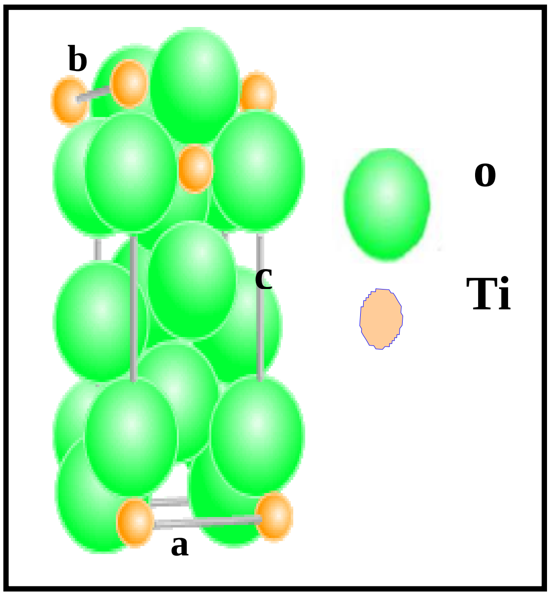

Fig. (1): Ti metastable stage for crystalline TiO2 [1].

Experimental details

(TiO_2) and (ZnO) carried with purity (99.9%) Used to prepare TiO_2 with different doping of ZnO (0.03, 0.05, 0.07and 0.1) wt.%. The mixed powder has blended mechanically so that the mix is reliably scattered. The resultant powder is ground again and was squeezed under 5 tons press to shape a target with 2.5 cm width and 0.4 cm thickness. The got target was as thick and homogenous as possible to ensure a better than average nature of the store. The goal earlier and after that a while later evacuation is appeared in Fig. (2)

Fig. (2): The objective (a) preceding and (b) in the wake of being removed by laser.

I-V characteristic were has been done for n–TiO2:ZnO/p-Si heterojunction by using Halogen light sorce (Philips (120 W)) with forces (100) mW/cm2. Keithley Digital Electrometer 616 utilized as voltmeter and ammeter. The electrical circuit for I-V estimation as shown in Fig.(3)

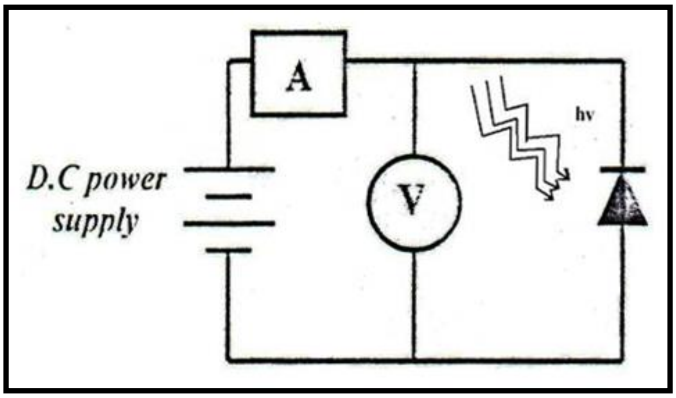

Fig. (3): Circuit chart for I-V estimation of heterojunction under light [7].

Results and Discussion

Some electrical properties of TiO_2 thin films were measured for doping of ZnO into TiO_2 thin films by Nd-Yag laser. The TiO_2thin films in this experiment showed n-type conductivity, according to Hall measurements, after annealing at 200 °C for 2 hour as shown in table (1). The carrier concentration and absorbance of TiO_2 thin films significantly increased with increasing of concentration ZnO , as well as the decreased resistivity, would contribute to the efficiency of the photovoltaic effects, including generation, transport to the built-in field region, and separation of the photogenerated charged carriers[8]

Table (1): The result of electrical measurement for ZnO -doping TiO_2 at different concentration

ZnO-doped TiO_2 (wt.%)	R_H $(m^2/C)*10^9$	Carrier type	$n(cm)^{-3}*10^{10}$	σ $(1/\Omega.cm)*10^{-6}$	μ_H $(cm^2/V.s)$ $*10^3$
0.03	3.670	n	18.5	3.412	3.245
0.05	3.450	n	22.89	4.654	3.124
0.07	3.012	n	32.21	5.789	2.654
0.1	2.215	n	45.16	8.654	2.012

The V_{oc} is the maximum voltage that can be gotten from a solar cell ; when the current is zero, The equation for V_{oc} is given by [9]:

$$V_{oc} = \frac{kT}{q} ln\left(\frac{I_{Light}}{I_0} + 1\right) \text{........................(1)}$$

Where

(k ,I_o ,q ,T) are Boltzmann's consistent , dark saturation current. electron charge and total temperature

The light produced current short circuit current can be approximated by [9]:

$$J_{sc} = qG(L_n + L_p) \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2)$$

Where

(G, q, L_n, L_p) are the generation rate , electron charge, electron diffusion length, hole diffusion length

The fillfactor (This relation is given by [8]:

$$FF = \frac{P_m}{V_{oc}J_{sc}} = \frac{V_m J_m}{V_{oc}J_{sc}} \quad [\%] \text{.............................(3)}$$

Where: ($V_m$and J_m) are the voltage and the current density corresponding to P_m

The conversion efficiency (η) calculate equation (4),[10].

$$efficiency = \eta = \frac{P_m}{P_s} = \frac{V_{oc}\ J_{sc}\ FF}{P_s} \quad [\%] \text{ ....(4)}$$

Where: (P_m , P_s):are the maximum power generated by the cell ,power of the incident light

Figures.((4) to (9)) show that the photocurrent increments with expanding the predisposition voltage, additionally it can be seen that the photocurrent in the invert inclination is bigger than that in the forward inclination. This can be ascribed to the way that the width of the exhaustion locale increments with the expansion of the connected turn around predisposition voltage which prompts to the partition of the electron–hole sets [11] .We can observe that efficiency increases with increasing of ZnO -doping , from 1.077 to 8.769, we can notice that from Table(2) since the expanding of doping causes a reworking of the interface iotas and diminish the dangling bond which prompts to change of the junction qualities [12].

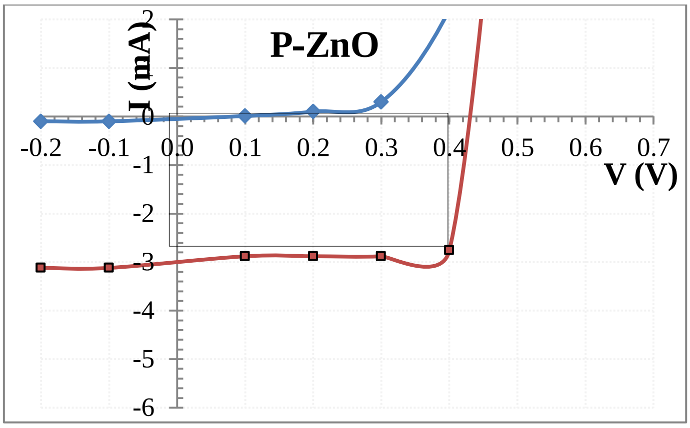

Fig.(4) I-V characteristics under dark and (100) mW/cm^2illumination for P-ZnO.

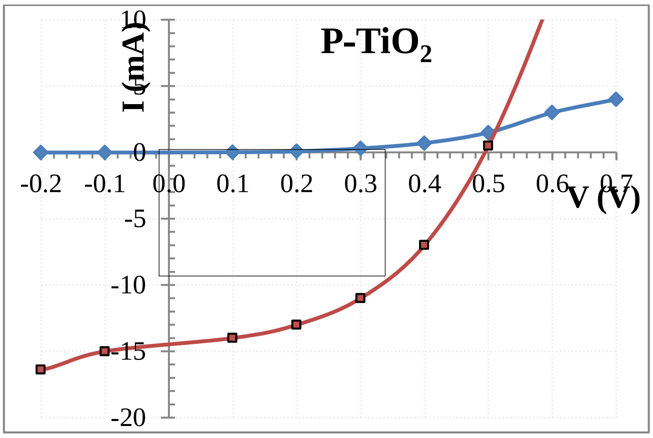

Fig.(5) I-V characteristics under dark and (100) mW/cm^2illumination for P-TiO_2.

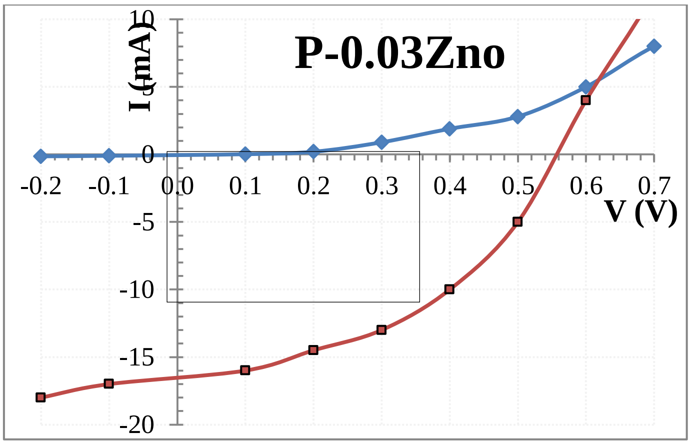

Fig.(6) I-V characteristics under dark and (100) mW/cm^2 illumination for P- 0.03% ZnO-doped .

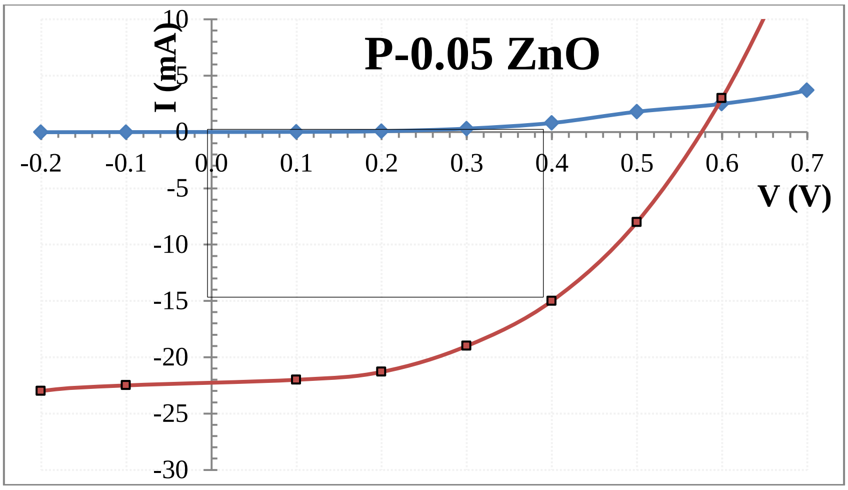

Fig.(7) I-V characteristics under dark and (100) mW/cm^2 illumination for P- 0.05% ZnO-doped

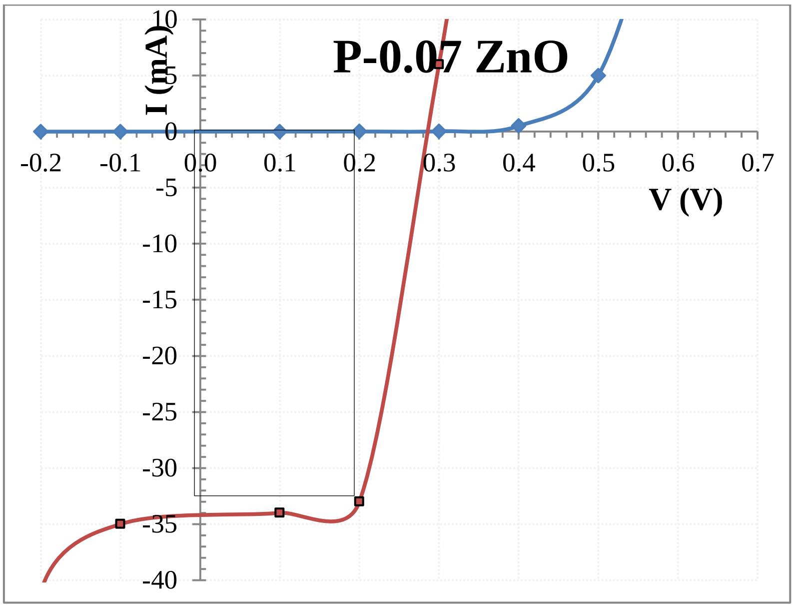

Fig.(8) I-V characteristics under dark and (100) mW/cm^2 illumination for P- 0.07% ZnO-doped .

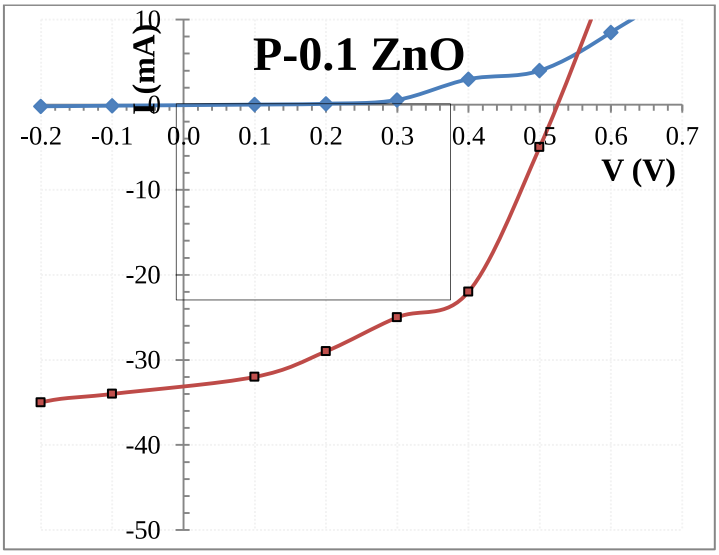

Fig.(9) I-V characteristics under dark and (100) mW/cm^2 illumination for P- 0.1% ZnO-doped .

Table(2)shows the efficiency values obtained for the various concentration.

Ratio of Composition (X)%	V_{oc} (Volt)	I_{sc} (mA/cm^2)	V_{max} (Volt)	I_{smax} (mA/cm^2)	FF %	η %
ZnO	0.430	3.000	0.400	2.800	0.868	1.077
TiO_2	0.500	14.500	0.340	10.000	0.469	3.269
0.03	0.560	16.500	0.360	11.000	0.429	3.808
0.05	0.580	22.000	0.400	15.000	0.470	5.769
0.07	0.280	34.000	0.200	33.000	0.693	6.346
0.1	0.520	33.000	0.380	24.000	0.531	8.769

Conclusion

From I-V can conclude that the best efficiency of the solar cell is obtained when the concentration of the (0.1%) obtained at(8.769) . That's where the concentration helps to improve the structure of the solar cell and also helps to increase the current density and the ones we get the best efficiency**.** The results obtained from Hall effect of ZnO dopingTiO_2substrate at annealing temperature ($200C^0$) Oxygen pressure 10^{-3} were (n-type) .The results show that the increase in doping concentration lead to increase in the value of electrical conductivity and charge carriers but the mobility and Hall coefficient have been decreased. Hall coefficient show that the type of TiO_2 with increase in ZnO concentration. That mean the electrons charge carriers are dominant in increased the electrical conductivity**.**

References

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