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Study the Effect of Illumination on (J-V) Characteristics of Hetero-junction Devices Ray Irradiated by Gamma

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ABSTRACT

In this work we have demonstrated an experimental study and theoretical analysis of the effect of power intensity of illumination on the SnO_2/n-Si Hetero-junction devices that irradiated with 150 min. (Cs 137) Gamma ray. The (J-V) characteristic was plotted as function of power intensity of illumination (1.95, 2.88, 3.78, 5.9, and 9.5) mw/cm^2. This was shown increase in efficiency of this device until reach maximum efficiency at 9.5 mw/cm^2 which represent optimal case. Theoretical analysis of this processes achieve by using "Table Curve 2D version 5.01" program leading to estimate theoretical modeling equation $Y = a + b\,x + c\,e^x$ .We calculate these parameters (a, b, and c) as function of power intensity and testing the equation for power intensity (4 and 8 mw/cm^2). Theoretical (J- V) curves are plotted with experimental data, there is a good agreement between them and the behavior of these two curves contain linear term and exponential term.

Introduction

TIN dioxide, a wide band gap semiconductor with high chemical stability and excellent optical and electrical properties [1]. The wide band gap oxide semiconductor compounds such as In_2O_3, SnO_2 have a band gap more than 3 eV and therefore are transparent to the radiation with the wavelength more then 0.4 μm, i.e for the wavelength from the region of the maximum solar intensity. Now SnO_2 thin films have become an integral part of modern electronic technology, such as a window layer and heat reflectors in solar cells, various gas sensors, liquid crystal displays etc [2].

There are various methods such as spray pyrolysis, electron beam evapouration, chemical vapour deposition, magnetron sputtering and the Pechini method, etc., for the preparation of doped or undoped SnO_2 films [3].

The SnO_2 films are n-type semiconductors [4–6]. Their conductivity could be changed within wide limits, from 10^{-1} ohm^{-1}. cm^{-1} up to10^4 ohm^{-1}. cm^{-1}.

The above mentioned property permits to use this material in solar cell fabrication as frontal layer in SIS structures. The investigation of silicon based SIS structures began in 1979 [7-8].

Hetero-junction device consisting of a wide band gap semiconductor (usually an oxide semiconductor) mated to a much narrower band gap (active) semiconductor have gained considerable prominence during the past few years. The performance of these devices is strongly controlled by the presence of a thin interfacial insulator layer [9-10], since the Si represents semiconductor in the metal-insulator-semiconductor structure, the SiO_2 thin layer represents the insulator and the reduction of SnO_2 will produce the metal. A high resistance at the SnO_2 - Si interface is attributed to the presence of a semi - insulating interface layer existing at least in the silicon part as SiO_2 layer, which plays an important role in determining the device efficiency, i.e., enhancing the photovoltaic characteristics [11-12]. So that, in the present work, the J-V characteristic under illumination of SnO_2/n-Si Hetero-junction devices has been investigated and analyzed after irradiation of γ-rays at 150 min irradiation time.

An analysis study of experimental (J-V) curves was demonstrated to obtain theoretical modeling equation for the effect of changeable of power intensity of illumination by using "Table Curve 2D version 5.01" program.

Experimental Details

The substrate used was (111) n-type single crystal silicon, each of 1×1 cm^2 area, of (1.5-4) Ω.cm resistivities were prepared using a wire-cut machine. The silicon substrates were etched with CP4 solution consisting of (HNO_3, CH_3COOH, HF) of ratios (3:3:5) to remove oxides. They were then cleaned by alcohol and ultrasonic machine (Cerry PUL 125 device) for 15 minutes then they were cleaned by water and ultrasonic waves for another 15 minutes.

High purity of tin (Sn) thin film was deposited on silicon substrate using thermal evaporation technique at room temperature under vacuum pressure of 10^{-6} Torr. SnO_2 film was obtained with aid of rapid thermal oxidation system with halogen lamp as oxidation source. The oxidation condition used to form SnO_2 film was 600 ^oC/90 s.

The silicon sample was used as substrate for TCO's/Si heterojunction. Ohmic contacts were fabricated by evaporating 99.999 purity aluminum wires for back contact and 99.999 pure gold were used as front contact using Edwards coating system.

"Table Curve 2D version 5.01" program was used to estimate theoretical equation for the effect of power intensity of illumination on the (J- V) curve for SnO_2/n-Si Hetero-

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junction devices irradiated by 150min. Gamma ray.

Results and Discussion

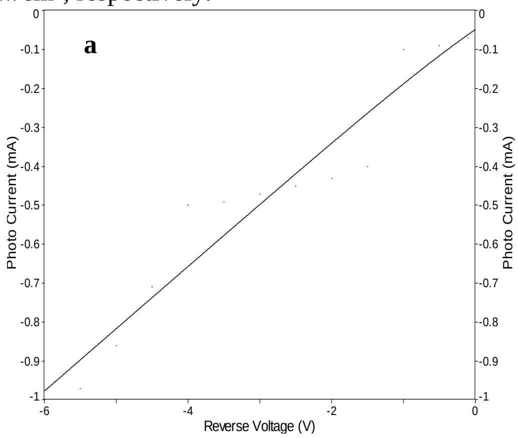
The results in this work classified into two parts; practical part and theoretical modeling part:

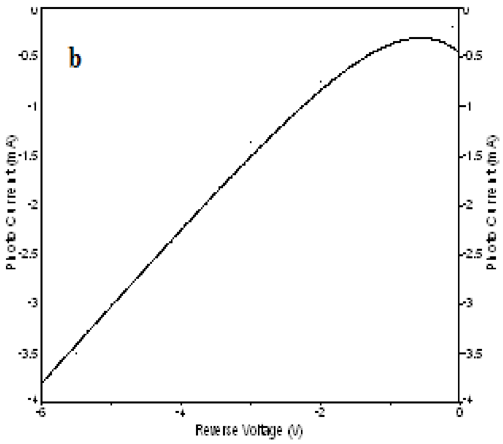
Practical Data

The effect of illumination on the (J-V) characteristics for SnO_2/n-Si Hetero-junction devices irradiated by 150 min (Cs 137) Gamma ray was discussed extensively else were [13].

Theoretical Modeling Part

To estimate theoretical modeling equation, we take first the fitting curves and fitting equation for (J- V) curve at each case of power intensity of illumination. Fig. (2 a, b, c, d, and e) was shown the fitting curves for (1.95, 2.88, 3.78, 5.9, and 9.5) mw/cm^2, respectively.

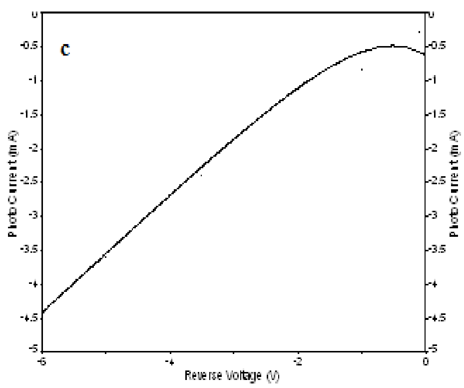


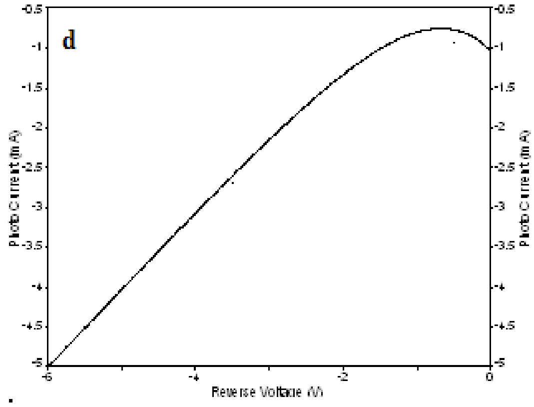


The fitting equation; that is described the estimated theoretical equation is given as follow

$$Y = a + b\,x + c\,e^{x} \qquad \text{……………………. (1)}$$

The parameters (a, b, and c) of this equation are given in table (1).





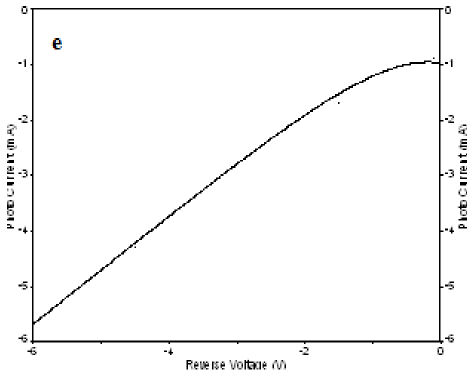


Figure 2. Fitting curve of (J- V) characteristic of SnO_2/n-Si Hetero-junction at different power intensity of illumination (a-1.95mw/cm^2 b-2.88mw/cm^2 c-3.78mw/cm^2 d-5.9mw/cm^2 e-9.5mw/cm^2)

Table 1. The parameters of theoretical modeling equation

parameter	**1.95mw/cm^2**	**2.88 mw/cm^2**	**3.78 mw/cm^2**	**5.9 mw/cm^2**	**9.5 mw/cm^2**
r^2	0.93394781	0.98654198	0.97648263	0.99303263	0.99554651
a	-0.014660442	0.92650509	0.83815806	0.88976577	0.19556622
b	0.16030628	0.785382	0.87562762	0.98119679	0.97807204
c	-0.033342193	-1.3830564	-1.47349	-1.9280001	-1.1749158

Where r^2 represents correlation factor between practical curve and fitting curve. Each parameter was plotted as function of power intensity of illumination as shown in figs. (3-5).

The fitting curve was taken for each curve and the fitting equation is writing over the curve.

Fitting equation

$$y = -3.7053158 + 0.55405702x^2 - 0.40330694x^{2.5} + \frac{14.835513\ln x}{x}$$

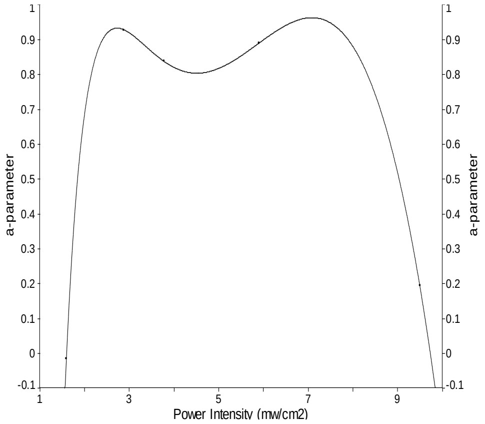


Figure 3. The relation between a-parameter and the power intensity of illumination

Fitting equation

$$y = 8.7488762 + 0.059424533x^{1.5} - \frac{1.6985123x}{\ln x} - \frac{9.8879756\ln x}{x}$$

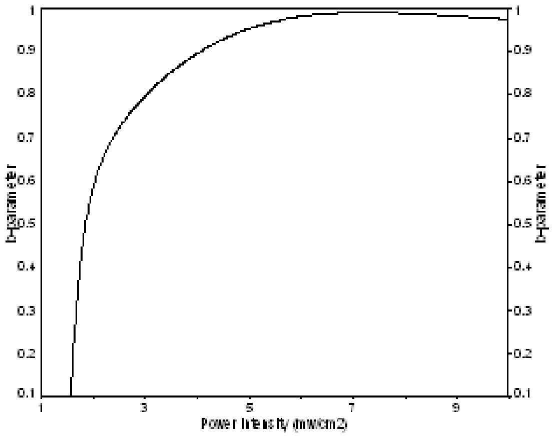


Figure 4. The relation between b-parameter and the power intensity of illumination

***Fitting* equation**

$$y = -7.6850245 + 0.21991095x\ln x + \frac{53.137438}{x^{1.5}} - 93.245691e^{-x}$$

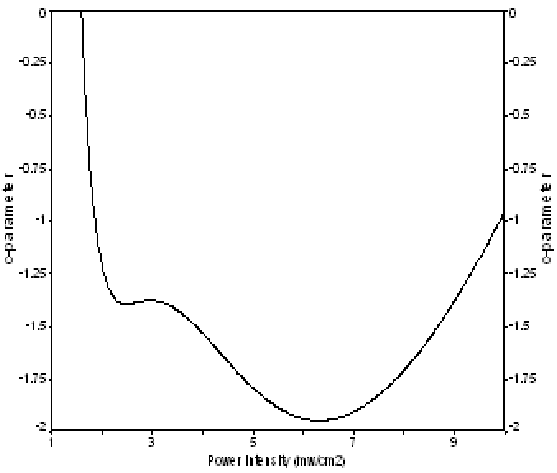


Figure 5. The relation between c-parameter and the power intensity of illumination

After that, we calculate the parameters (a, b, and c) for the estimated theoretical equation (eq.1) by substitute test power intensity of illumination first 4mw/cm^2 and second 8mw/cm^2 in the above fitting curve and equation. So that we get the theoretical modeling equation as follows

For test power intensity 4mw/cm^2

$Y = 0.81983693 + 0.89649072x - 1.5312539e^x$ ………… (2)

For test power intensity 8mw/cm^2

$Y = 0.88079493 + 0.98882241x - 1.709604e^x$ ………….. (3)

These theoretical modeling equations are plotted with experimental data as shown in fig. (6).

We noted that the behavior of both curves is symmetrical and there is a good matching between them.

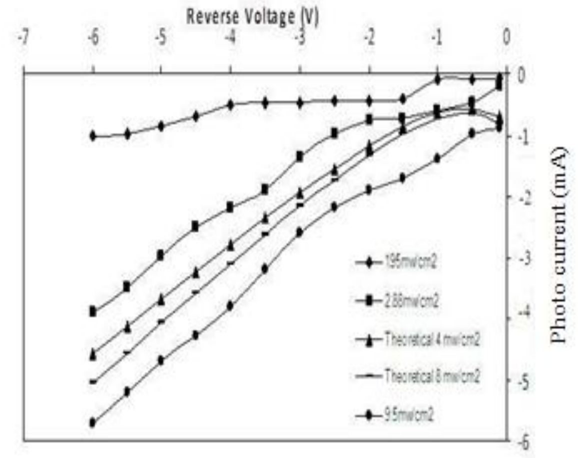


Figure 6. Theoretical and experimental (J- V) curve for SnO_2/n-Si Hetero-junction device irradiated with 150min. Gamma ray at different power intensity of illumination

Conclusion

The effect of illumination on the SnO_2/n-Si Hetero-junction devices irradiated with 150min Gamma ray was achieved in this work experimentally and theoretically.

There is highly symmetric behavior between experimental and theoretical (J-V) characteristics of this device was obtained. The theoretical modeling equation was

$Y = a + bx + c\,e^x$

That is containing linear term and exponential term; which is similar to experimental curve.

References

[1] R. Riveros, E. Romero, and G. Gordillo, "Synthesis and Characterization of Highly Transparent and Conductive SnO_2: F and In_2O_3: Sn thin Films Deposited by Spray Pyrolysis", Brazilian Journal of Physics, vol. 36, no. 3B, September, (2006).

[2] Jochan Joseph, Varghese Mathew, Jacob Mathew, K. E. Abraham, " Studies on Physical Properties and Carrier Conversion of SnO_2: Nd Thin Films", Turk J Phys, 33, 37 – 47, (2009).

[3] Woon-Seop Choi, "Effects of Seed Layer and Thermal Treatment on Atomic Layer Deposition-Grown Tin Oxide", Transactions on Electrical and Electronic Materials, Vol. 11, No. 5, pp. 222-225, October 25, (2010).

[4] Viviany Geraldoa, Luis Vicente de Andrade Scalvib, Evandro Augusto de Moraisa, Celso Valentim Santillic, Sandra Helena Pulcinellic, "Sb Doping Effects and Oxygen Adsorption in SnO_2Thin Films Deposited via Sol-Gel", Materials Research, Vol. 6, No. 4, 451-456, (2003).

[5] J. E. Dominguez, X. Q. Pan and L. Fu, "Epitaxial SnO_2 thin films grown on (1¯012) sapphire by femtosecond pulsed

laser deposition", Journal of Applied Physics , Vol. 91, No. 3, 1 February (2002).

[6] Novinrooz, Abdoljavad, Sarabadani, Parvin, Garousi, Javad, "Characterization of Pure and Antimony Doped SnO_2 Thin Films Prepared by the Sol-Gel Technique", Iran. J. Chem. Chem. Eng. Vol. 25, No.2, (2006).

[7] J. Shewchun, J. Dubow, C. W. Wilmson, J. F. Wager, "The operation of semiconductor–insulator–semiconductor solar cells. Experiments", J. Appl. Phys., 50, 2832-2839, (1979).

[8] R. Plattner, W. Stetter and P. Kohler, "Transparent Conductor Tin– Oxide Layers for Thin–Film Solar Cells", Siemens Forsch- Entwick – Ber Bd. 138-146, (1988).

[9] S. J. Fonash, "Metal-Insulator-Semiconductor solar cells: theory and experimental results", Thin Solid Films, PP 387-392, (1976).

[10] K. L. Chopra, "Transparent conductors-a status review", Thin Solid Films, 102, 1-46, (1983).

[11] G. William, "Intensity effects in SnO_2-Si heterojunction solar cells", Transaction on Electron Devices, Vol. ED-24, No. 4, (1977).

[12] Marwa AbdulMuhsien, Evan T. Salem, and Ibrahim R. Agool, "Preparation and Characterization of (Au/n-SnO_2/SiO_2/Si/Al) MIS Device for Optoelectronic Application, "International Journal of Optics Volume 2013, Article ID 756402, 9 pages.

[13] M. Abdul Muhsien, E. T. Salim, Y. Al-Douri, A. F. Sale and I. R. Agool, "Synthesis of SnO_2 nanostructures employing Nd:YAG laser", Appl. Phys. A (2015) 120:725–730.