Effect of laser fluencies on solar cell characterization of (CdO)_{1-x}:Sb/x/PSi thin films by laser induce plasma.

Majed H. Dwech\textsuperscript{1}, Kadhim A. Aadim\textsuperscript{2} and Ghaith H. Jihad\textsuperscript{2}

\textsuperscript{1}Department of Physics, College of Science, University of Kerbala, Karbala-Iraq

\textsuperscript{2}Department of Physics, College of Science, University of Baghdad, Baghdad-Iraq

majed.dwech@uokerbala.edu.iq, kadhim_adem@scbaghdad.edu.iq, Ghaith.jihad1104@sc.uobaghdad.edu.iq

Abstract: In this paper, Cadmium Oxide: Antimony has been deposited on porous silicon substrate using laser induces plasma technique. The solar cell parameters fill factor and efficiency; have been analyzed through changing of laser energy. The results shown that the change in electron mobility resulting from the change in laser energy leads to significant improvement in fill factor and efficiency. Moreover, there is slight improvement in the efficiency of CdO: Sb/PSi solar cell as a result of changing the thickness of CdO: Sb.

Keywords: Laser Induce Plasma, Cadmium Oxide, Doped Antimony, Porous Silicon, Solar Cell

1-Introduction

The scientists are more focused to design new devices nowadays. In order to have more flexibility in devices design, they have to develop a new semiconductor with specific features. It is being thought that Cadmium Telluride Oxide is very good to use for making solar cell, because CdO is a photovoltaic material and has optimal electronic and optical characteristics to make a solar cell [1].

CdO has been used as a window layer since it has a band gap around 2.4 eV and a pretty high transmittance. Recently there are some researchers who have used the CdO thin films for low resistivity by using different techniques of deposition [2-4]. In this work the
preparation and characterization of large area n-type conducting CdO films have been reported for the first time as low cost technique, viz. the chemical bath deposition.

Thin films of cadmium oxide (CdO) and other materials like SnO₂, ZnO, In₂O₃ are transparent conducting oxides (TCO) and have shown promising perspectives for a variety of applications in modern optoelectronic and photovoltaic devices. The existing preliminary results showed that cadmium oxide has large electrical conductivity and large optical transmittance in the range of visible region. So CdO is a promising material can be used for solar cell devices [5,6].

All previous works have showed that CdO thin films are n-type and have a range of band gap from (2.3 to 2.7) eV [7,8]. Based on these existing results and pervious research results, CdO is very good candidate material that can be used as a window layer, e.g. CdO/CdTe and CdO/CIS hetero-junctions. Several deposition techniques like spray pyrolysis, sputtering, and chemical bath deposition have been used to prepare CdO [9,10,11].

2- Experimental procedure

The CdO:Sb thin films were deposited by Laser induced plasma on porous silicon Fig.(1) shows a schematic diagram for the PLD system. All the work has been done under vacuum pressure of 10⁻² mbar by using Varian DS219 Rotary pump. Nd:YAG laser has been used with a harmonic frequency (λ = 1064 nm, 10 ns, 6 Hz). Quartz lens (f = 10 cm) used to focus Nd:YAG laser onto CdO:Sb target to prepare the CdO:Sb films on Porous Si substrate. The experiments have been done at room temperature. The CdO:Sb target was ablated by 150 pulses. The laser pulse energy was varied in the range (300-700) mJ with increment 200 mJ in each step and laser fluencies was varied in the range (0.2388 -0.557) J/cm².
3-Results and Discussion

The I-V characteristics of n-CdO:Sb/p-PSi solar cell in both dark and under illumination using power densities equal to 102 mW/cm² with the applied forward and reverse bias at different laser fluencies were shown in Figs. (2 to 5). In general the forward current higher than revers current.

Clearly from these figures, the increase of the bias voltage leads to increase the trend of the photocurrent density curve. But the reverse behavior of the depletion region, by increasing the forward voltage the depletion region will be decreased. This increase in the depletion layer will lead to increase the photocurrent density.

The results showed that increase the laser energy increased the photocurrent density. The laser treatment leads to increase in the grain size, as well as it leads to reduce the grain
boundaries. Hence as a result, it will improve the structure of the thin films which is going to lead to increase the mobility and increase the photocurrent density too.

The solar cell parameters such as $V_{oc}$, $I_{sc}$, $I_{m}$, $V_{m}$, FF and the solar cell efficiency were calculated from these figures as shown in Table (1). This table shows that the optimum laser fluencies with highest efficiency for all pure samples, and the samples deposited on porous Si better than that deposited on Si wafers. The figures show, the efficiency of (CdO)$_{1-x}$:Sb$_x$/porous silicon solar cells by different laser fluencies and composition ($x$). The best results come out from this research are at laser fluencies 0.55 J/cm$^2$ and composition at $x=0.5$.

![Graph showing I-V characteristics for (CdO)$_{0.9}$:Sb$_{0.1}$/Porous Si hetero-junction Solar Cell at $X=0.1$ in case of under illumination.](image)

Fig. (2). I-V characteristics for (CdO)$_{0.9}$:Sb$_{0.1}$/Porous Si hetero-junction Solar Cell at $X=0.1$ in case of under illumination.
Fig. (3). I-V characteristics for (CdO)₀.₇:Sb₀.₃/Porous Si hetero-junction Solar Cell at X=0.3 in case of under illumination

Fig. (4). I-V characteristics for (CdO)₀.₅:Sb₀.₅/Porous Si hetero-junction Solar Cell at X=0.5 in case of under illumination
Table (1) I-V Parameters for (CdO)\textsubscript{1-x}:Sb\textsubscript{x} /porous-Si solar cell.

| Target     | Composite (x) | Laser fluencies (J/cm\textsuperscript{2}) | V\textsubscript{max} (V) | J\textsubscript{max} (mA/cm\textsuperscript{2}) |
|------------|---------------|--------------------------------------------|--------------------------|-----------------------------------------------|
| (CdO)\textsubscript{0.9}:Sb\textsubscript{0.1} | 0.1           | 0.23                                       | 0.12                     | 20                                            |
| (CdO)\textsubscript{0.9}:Sb\textsubscript{0.1} | 0.1           | 0.39                                       | 0.135                    | 22                                            |
| (CdO)\textsubscript{0.9}:Sb\textsubscript{0.1} | 0.1           | 0.55                                       | 0.15                     | 24                                            |
| (CdO)\textsubscript{0.7}:Sb\textsubscript{0.3} | 0.3           | 0.23                                       | 0.15                     | 18                                            |
| (CdO)\textsubscript{0.7}:Sb\textsubscript{0.3} | 0.3           | 0.39                                       | 0.16                     | 20                                            |
| (CdO)\textsubscript{0.7}:Sb\textsubscript{0.3} | 0.3           | 0.55                                       | 0.18                     | 22                                            |
| (CdO)\textsubscript{0.5}:Sb\textsubscript{0.5} | 0.5           | 0.23                                       | 0.16                     | 18.5                                          |
| (CdO)\textsubscript{0.5}:Sb\textsubscript{0.5} | 0.5           | 0.23                                       | 0.175                    | 19.5                                          |
| (CdO)\textsubscript{0.5}:Sb\textsubscript{0.5} | 0.5           | 0.39                                       | 0.19                     | 21                                            |
Fig. (5). Variation of efficiency as a function of composition (x) with different laser fluencies.

4-Conclusions

The (CdO)\(_{1-x}\):Sb\(_{x}\)/Psisolar cell was fabricated by laser induce plasma technique. The current–voltage characteristics of the (CdO)\(_{1-x}\):Sb\(_{x}\)/Psisolar cell showed the best results come out from this research was at laser fluencies 0.55 J/cm\(^2\) and composition at x= 0.5 and the efficiency increased from 2.35 to 3.91.

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5- References

[1] S. J. Clark, J. Robertson, S. Lany and A. Zunger, Phys. Rev. B: Condens., Intrinsic defects in ZnO calculated by screened exchange and hybrid density functional , Matter Mater. Phys. 81, 115311 (2010).
[2] I. Akyuz, S. Kose, E. Ketenci, V. Bilgin and F. Atay, Optical, structural and surface characterization of ultrasonically sprayed CdO:F films, J. Alloys Compd, 509, 1947 (2011).

[3] A. K. Singh, A. Janotti, M. Scheffler and C. G. Van de Walle, Sources of Electrical Conductivity in SnO_2, Phys. Rev. Lett. 101, 055502 (2008).

[4] X. Chen and S. S. Mao, Titanium Dioxide Nanomaterials: Synthesis, Properties, Modifications, and Applications, Chem. Rev. 107, 2891 (2007).

[5] Z. Zhao, D. L. Morel and C. S. Ferekides “Electrical and optical properties of tin-doped CdO films deposited by atmospheric metalorganic chemical vapor deposition,” Thin Solid Films, 413203-211 (2002).

[6] M. Su L., N. Grote and F. Schmitt “Diffused planar InP bipolar transistor with a cadmium oxide film emitter” Electron. Lett., 20, 716-717 (1984).

[7] K. L. Chopra and S. Ranjan Das, Thin Film Solar Cells, Plenum Press, New York (1993).

[8] Y. S. Choi, C. G. Lee, and S. M. Cho, Transparent conducting ZnXCdIiXO thin films prepared by the sol-gel process, Thin Solid Films 289, 153, (1996).

[9] Yan Zhi, Guangzhao Wang, Maolin Bo, Junjie He, Mingmin Zhong, Wenxi Zhao, Yadong Li, Xiaojiang Long and Wanli Zhang, Enhanced photocatalytic performance of CdO/g-C_3N_4 heterostructure, Materials Research Express 6, 3 (2019).

[10] Majed H. Dwech, Kadhim A. Aadim, and Luay A. Hamid. "Influence of laser energy on the characteristics of Ag2S/ITO thin films solar cell prepared by PLD technique," AIP Conference Proceedings. Vol. 2213. No. 1. AIP Publishing LLC,

[11] Majed H. Dwech, Kadhim A. Aadim, and Mushtaq T. Mohsen. "The effect of a number of laser pulses on optical properties of CuO thin films deposited by pulsed laser deposited (PLD) technique at 673K." AIP Conference Proceedings. Vol. 2144. No. 1. AIP LLC, 2019.