ICREN-01/2013 February 16-17, 2013 Constantine, Algeria
First International Conference on Renewable Energies and Nanotechnology impact on Medicine and Ecology

SIMULATION OF THIN FILM CDTE SOLAR CELLS

I. Missoum[a], R. Labbani[a,*]

Laboratoire de physique Mathématique et Subatomique, Département de physique, Université Constantine 1, Route de Ain El Bey, 25000 Constantine, Algérie.

Abstract

In this work, CdTe solar cells are studied by means of simulation using PC1D program. CdTe material has been selected because of its interesting properties in renewable energies field, especially for photovoltaic applications cases.

The PC1D simulation has been run for a solar cell constituted of a thin film CdTe homojonction. Thus, several parameters have been taken into account. In particular, the effects of the p-CdTe thickness layer (TL) and its concentration (C) have been investigated. It was noticed that the CdTe solar cell presented the best performances for optimum values of (TL) and (C) parameters. Indeed, for TL= 4µm a conversion efficiency (η) of 16,49% has been obtained. Moreover, for C= 1×10^{16} cm^{-3}, a value of η= 18,20% has been achieved.

keywords: CdTe, solar cell, homojonction, PC1D, simulation.

1. Introduction

The most commonly used material for solar cell fabrication is crystalline silicon (Si) for which the cost is an obstacle to terrestrial applications. In the last two decades, considerable work has been done in developing thin film solar cells to replace the costly single crystal and wafer based solar cells. Interesting results have been reported and the progress achieved is encouraging [1].

Among the thin film solar cells, Cadmium Telluride is a material particularly interesting because of its direct band energy (E_g) varying from 1.45eV to 1.5eV [2]. However, to make a final engineering decision on this material choice, it is important to predict several phenomena. The best way to go about this is to simulate the required phenomena versus several parameters. Several programs can be used for this purpose such as: AMPS-1D, SCAPS-1D, PC1D, SIM-windows, ASA, ADEPT-F, SC-SIMUL, ASPIN and AFROS-HET [3].

* Corresponding author. Tel.: +213 31-84-43-22; fax: +213 31-84-43-22.
E-mail address: labbanire@gmail.com

In this work, PC1D program has been selected to perform the numerical simulation of CdTe based solar cells. Our choice is justified by the fact that the program was able to study complicated cell structures.

Nomenclature	
P_{max}	Maximum Power
V_{oc}	Open circuit voltage
I_{sc}	Short circuit current
FF	Fill Factor
η	Efficiency
TL	Thickness Layer
C	Doping concentration

2. Simulation

PC1D program has a very clean user interface. Hence, it is possible to define a new layer with new parameters by simply clicking on the appropriate zone in the schematic diagram of the screen [4]. In this work, PC1D has been run for CdTe solar cell homojunction. This material is the only II-VI compound that can be doped either by p or n type. However, it is reported that the doping ability is not the same for the two cases, especially for polycrystalline films[5,6]. For instance, for p type doping, the hole concentration is limited to 10^{17} cm^{-3} because of the boundary effects. In this study, the simulation has been run by changing two parameters which are the p-CdTe thickness layer (TL) and its doping concentration (C). In figure 1, the device structure scheme is displayed. It is constituted of p-n CdTe homojunction with an area of 100 cm^2. The n-type emitter and the p-type base are represented by red and blue areas respectively. The material parameters have been introduced using experimental values reported in literature [2,5,7]. Front and back contacts were assumed to be flat bands for which contact potentials were neglected.

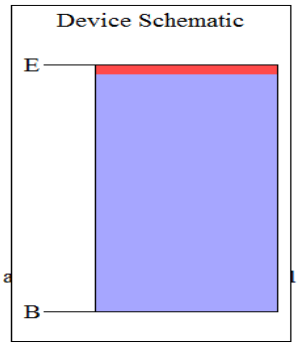

Fig. 1. Illustration of the device structure scheme used during PC1D simulation of a p-n CdTe solar cell.

3. Results and Discussion

3.1. Effect of base thickness

To find the optimum value of the base thickness, we used a doping concentration of 1×10^{14} cm^{-3}. From figure 2, it is clear that the Fill factor and the efficiency decrease with the rise of the absorber thickness (*i.e*. the base). This is attributed to the bulk resistance of the semiconductor. Besides, for thicknesses inferior than 5µm, we note that I_{sc} decreases rapidly. Hence, we conclude that the optimum thickness is obtained for the value of 4µm where the maximum efficiency (16.49%) is reached.

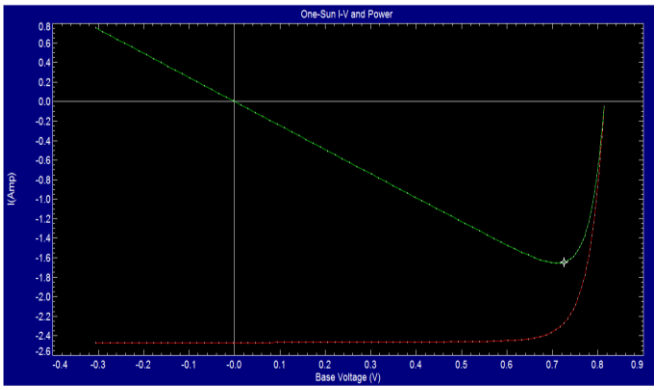

Fig. 2. PC1D simulation of I-V and Power curves of CdTe homojunction solar cell.

Table 1. PC1D simulation results obtained for different values of the base thickness layer .

TL (µm)	P_{max} (w)	V_{oc} (v)	I_{sc} (A)	FF (%)	η (%)
3	1.62	825.0×10^{-3}	2.43	80.67	16.23
4	1.64	818.0×10^{-3}	2.45	81.95	16.49
5	1.63	813.1×10^{-3}	2.46	81.20	16.31
6	1.62	808.6×10^{-3}	2.47	81.13	16.25

3.2. Effect of doping concentration

In table 2, the effect of the base doping level is represented. It is clear that the optimum value is found to be 1×10^{16} cm^{-3} because for inferior and superior levels it is noticed that the cell efficiency sharply drops from 18.20% to 16.12% and 12.45% respectively.

Table 2. PC1D simulation results obtained for different values of the base doping concentration.

C (cm^{-3})	P_{max} (w)	V_{oc} (v)	I_{sc} (A)	FF (%)	η (%)
10^{14}	1.61	813.0×10^{-3}	2.46	80.29	16.12
10^{15}	1.77	866.5×10^{-3}	2.47	82.77	17.79
10^{16}	1.82	897.2×10^{-3}	2.44	82.85	18.20
10^{17}	1.80	925.2×10^{-3}	2.34	82.9	18.01
10^{18}	1.54	907.3×10^{-3}	2.14	79.67	15.48
10^{19}	1.24	871.3×10^{-3}	1.79	79.83	12.45

4. Conclusion

The simulation results show that the appropriate selection of CdTe base thickness and doping concentration level is a key to the performance of CdTe homojunction solar cell. The optimal values of base thickness and doping concentration are found to be 4 μm and $1\times10^{16}cm^{-3}$ respectively. The thickness layer and doping concentration level of the base have strong effects on cell performance especially the open circuit voltage and short circuit current which influence the fill factor and effciency. The results obtained by our simulation are encouraging and can contribute to solve the probleme of solar cell prices. This can be achieved if the CdTe homojunction solar cells are grown on low cost substrates.

References

[1] X. Matthew, J. Pantoja Enriquez, A. Romeo, A.N. Tiwari, CdTe/Cds solar cells on flexible substrates, Sol. Energy 77 (2004) 831-838.

[2] J. Poortmans, V. Arkhipov, Thin Film Solar Cells, Wiley & Sons,New York, 2006, p.281.

[3] D.A. Clugston, P.A. Basore, PC1D version 5:32-Bit solar cell modeling on personal computers, the 26th IEEE Photovoltaic Specialists Conf, October, 1997.

[4] M. Burgelman, J. Verchraegen, S. Degrave, P. Nollet, Modeling Thin film Pv devices, Prog. Phtovoltaic: Res.Appl 1-11 (2003).

[5] J. Poortmans, V. Arkhipov, Thin Film Solar Cells, Wiley & Sons,New York, 2006, p.308.

[6] H. Zhao, Impurity and back contact effects on CdTe/CdS thin film solar cells. In: Thesis, University of South Florida, 2008, p. 29.

[7] J.R. Sites, Device Physics of Thin Film Polycristalline cells And Modules, Annual Report Phase (2003), p.23.