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EFFECT OF MULTI WINDOW LAYER ON THE PERFORMANCE OF A SOLAR CELL USING AMPS-1D

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In our days solar cells to thin films are increasingly used primarily because of their low cost. In recent decades the performance of these cells were significantly improved. In the present work, we simulated solar cells $p(Ga_{1-X}Al_XAs)/p(GaAs)/n(GaAs))$ having a multi-layer window using software of the microelectronics and photonic (AMPS-1D) to analyze certain parameters. In particular the properties of the window layer (thickness, doping ...) play a major role in the performance of the cell, and to optimize them, we studied their influence on photovoltaic cell. In order to demonstrate the importance of the testimony of a window of the type layer $p(Ga_{1-X}Al_XAs)$) of GaAs solar cells, a comparison of three cells, one with a layer window, the other layers with two windows and he third with three windows layers was made. This comparison led to the conclusion that the proliferation of cascading windows layers results in an equivalent cell window. For this optimized cell structure the maximum Jsc =30.17mA/cm2, Voc=1.14V factor=90% are obtained under AM1.5G illumination, exhibiting a maximum onversion efficiency of 32.06%.% (1 sun).

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1. Introduction

The research in the photovoltaic is motivated primarily by the improvement in the performance of energy conversion and by the reduction of the cost of realization. The performance of the cell can be improved by optimization of physical parameters internal to ensure both a short-circuit current, a form factor and a voltage to the open circuit high. The simulation of the solar cell studied is conducted with the aid of the AMPS-1D (One Dimensional Analysis of Microelectronic and Photonic Structures) program which resounded all three equations of basis of the semi-conductor in permanent regime [1].

The Layer window is important enough in the improvement of the performance of the solar cells. They help to reduce effectively the recombination of surface to the surface of the issuer of the solar cell without absorbing the useful light required for the device, unlike the Silicon. Different materials of the layer of window have been studied for III-V on the basis of semi-conductors composed of solar cells [2].

The solar cell simulated in this work is produced in GaAs, may be remote to the thickness of this interface, with a front region formed by one, two and three layers to fixed composition p(Ga(1-x)Al(x)As) which correspond to the energies of band gaps Eg1, Eg2,Eg3.

The radiations from above Eg1; Eg2 and Eg3 are absorbed into the p-layer windows (Ga(1-x)Al(x)As). The carriers generated in the p windows layers (Ga(1-x)Al(x)As) at a distance from the junction close to the value of the diffusion length are transferred to the p-layer (GaAs), where they contribute to photocurrent, insofar as the interface p (Ga(1-x)Al(x)As)/ p (GaAs) has a low density of states [3].

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The majority of authors consider that in general the valence band discontinuity is negligible compared to that of the conduction band, for both materials (Ga(1-x)Al(x)As)/ p (GaAs). [4].

In this work we have used for the optimization of a program of a one-dimensional simulation called (AMPS-1D) analysis of the microelectronics and photonic structures [5]. The Table1shows the structure of the design of solar cells studied in this work:

Table1Structures of solar cells are studying

Solar cell With	One window layer	two windows layer	three windows layer
base layer	N/ GaAs	N/ GaAs	N/ GaAs
emitter layer	P/ GaAs	P/ GaAs	P/ GaAs
The first window layer	$P/Al_{0.26}Ga_{0.74}As$	$P/Al_{0.18}Ga_{0.82}As$	$P/Al_{0.10}Ga_{0.90}As$
The second window layer	/	$P/Al_{0.26}Ga_{0.74}As$	$P/Al_{0.18}Ga_{0.82}As$
The third window	/	/	$P/Al_{0.26}Ga_{0.74}As$

2. Model description

The AMPS model was developed by the group of Dr. S. J. Fonash the University of Pennsylvania and has been updated later [6]. Trapping and recombination in the AMPS model have been determined using the formalism of Shockley-Read-Hall, taking into account ambient temperature. In other words, the approximation of Taylor-Simon's (0K) was not used. AMPS take into account the strengths of effective field caused by variations of drift, diffusion, gap and affinity [6].Border conditions also were general, needing the electrostatic energy of the vacuum level (for the equation of Poisson) and hole recombination velocities and electron contact (TCO) / p and n / metal (for both continuity equations). The AMPS model takes into account the storage and charge recombination by band tail states and the states of dangling bonds. In the final form the dangling bonds are modeled by Gaussian distribution functions [7].

3. Modeling and simulations

In this study, a one-dimensional numerical analysis tool, AMPS-1D, is used to create different models of solar cells and achieve results. AMPS-1D, three, four and five different layers are necessary for modeling of solar cells has a window layer, two layers and three windows layers. More layers can be added provided that the grid points do not exceed the limit, viz. 2000 grid points.

The layers that are used in this modeling is the $P/Al_{0.26}Ga_{0.74}As$(window),$P/Al_{0.10}Ga_{0.90}As$,$P/Al_{0.10}Ga_{0.90}As$. P/GaAs and N/GaAs Table .2 show the description for the parameters used in the simulation and the basic parameters that are used in the study. [8] [9]

Table 2. AMPS-1D GaAS solar cell parameters.

Layer Parameters	P/$Al_{0.26}Ga_{0.74}As$	P/$Al_{0.18}Ga_{0.82}As$	P/$Al_{0.10}Ga_{0.90}As$	P/ GaAs	N/ GaAs
Thickness (μm)	0.04-0.1	0.03-0.04	0.04	1-5	1
dielectric constant ,ε	5.66	5.65	5.65	13.10	13.10
electron mobilityμ_n (cm²/Vs)	2956	4364	5900	8500	8500
mobility of holes μ_p (cm²/Vs)	67.77	171.42	265.60	400	400
carrier density, n ou p (cm^{-3})	P: 8.00e+018	P: 8.00e+018	P: 8.00e+018	P: 1.00e+018	n: 8.00e+016
Bandgap ,E_g(eV)	1.75	1.65	1.55	1.42	1.42
The effective density,N_c (cm^{-3})	4.82e+018	4.56e+018	4.29e+018	3.89E19	4.70e+017
The effective density,N_v (cm^{-3})	1.73e+019	1.68e+019	1.64e+019	2.93E19	7.50e+018
Electronic affinity(eV)	4.42	4.51	4.60	4.33	4.07

4. Results of the simulation

4.1 Voltage and current characteristic of the solar cell

We first use our model to simulate GaAs solar cells whit one window reported by Tobin et al [12-13];the current-voltage (I-V) characteristics as displayed in Fig. 1. The values reported from the experiment are Jsc= 27.89 mA/cm2, Voc= 1.029 V, FF = 86.43%, and η= 24.8%. Our simulation results are very close to the experimental reports shown in Figs. (b) [12-13]; the slight difference is due to the fact that we could not obtain all of the experimental parameters accurately.

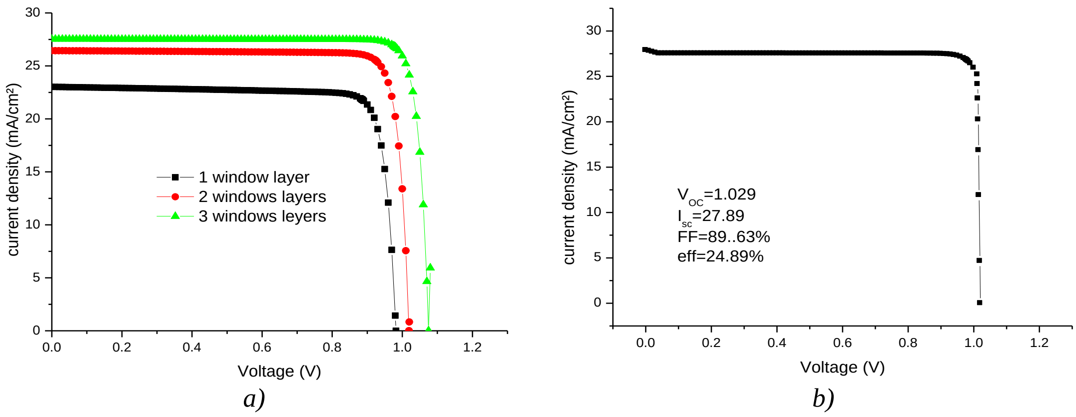

Fig. 1.(a)The current voltage characteristic of the cell Solar calculated from our simulation having a multilayer window for different number of layers windows (one, two, and three); (b) Experimental IV curve (e) [12-13]

From the above results that are obtained through the AMPS-1D software, we can determine the corresponding parameters PV (V_{CO}, J_{SC}, FF and performance) of each cell are summarized in Table 3.

Table 3.Photovoltaic each solar cell parameters

Solar cell	V_{CO} (Volts)	J_{SC} (mA/cm²)	FF (%)	η (%)
One window layer	0.98	23.02	0.855	19.32
two windows layer	1.01	26.43	0.87	23.58
three windows layer	1.07	27.52	0.88	26.24

According to the above results, we conclude that the best solar cell what are those with three layers window, so the solar cell with three layers window were optimized[10] [11].

4.2. The effect of thickness emitter layer

Fig.2 shows the yield in terms of the thickness of the emitter layer. It is noticed that the best performance is for thickness of the emitter = 5 µm with a value of 28.85%.

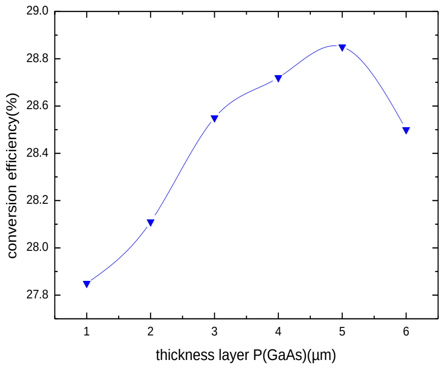

Fig. 2.Efficiency a function of the thickness emitter layer.

4.3 The effect of thickness base layer

Fig. 3 shows the efficiency in terms of the thickness of the base layer. It is found that the best performance is obtained for the base thickness equal to 2 um with corresponding value 32.06%.

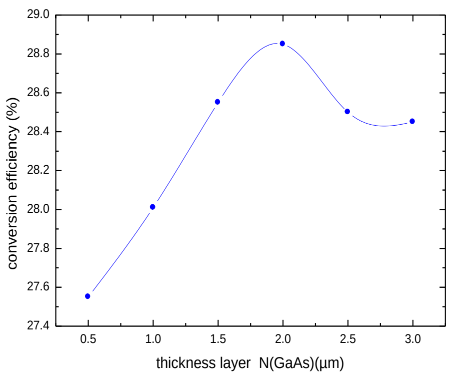

Fig 3. Efficiency a function of the thickness base layer.

5. Result of optimization

Starting from the above results that are obtained through the AMPS-1D software, we can determine the solar cell that has the best efficiency while giving the thickness of each layer of the cell table 4

Table 4. Splicing of each layer of the solar cell GaAs optimize

P/$Al_{0.26}Ga_{0.74}As$	P/$Al_{0.18}Ga_{0.82}As$	P/$Al_{0.10}Ga_{0.90}As$	P/ GaAs	N/ GaAs
0.03 µm	0.03 µm	0.04 µm	5 µm	2 µm

The corresponding PV parameters (open-circuit voltage Voc, short-circuit current Isc, fill-factor FF and efficiency (η) are all summarized in Table 5.

Table 5. Parameters PV of the optimized GaAs device

V_{CO} (V)	J_{SC} (mA/cm²)	FF (%)	η (%)
1.14	30.17	90	32.06

The current-voltage characteristics generated by the GaAs optimized device under the AM1.5G spectrum and one sun are displayed in figure 4 for multijunction solar cell.

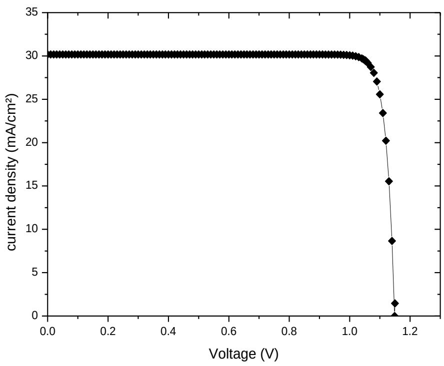

Fig.4. Current density-voltage characteristics GaAs device optimal

The spectral response (QE) for GaAs solar cell optimal from AMPS-1D simulation is shown in Fig. 5; the cell with 3 windows layers. Maintains almost above 99% of QE for the whole visible range of spectra where it is confirmed better energy conversion performance of the cell.

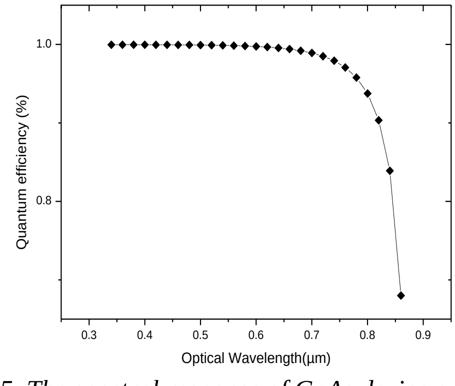

Fig. 5. The spectral response of GaAs device optimal

6. Conclusions

Whatever the structure of a solar cell, an optimization of its parameters is necessary to have a good performance. Usually, among the parameters to be optimized are the cell thickness and the optical confinement. The values of the optimum parameters depend, of course, the structure of the solar cell, the material quality, the surface recombination velocity (front and back), ... etc. The optimization of the solar cell therefore comprises the study of the influence of these parameters on performance to get a structure leading to maximum efficiency.

The optimum efficiency found, under normalized Photovoltaic parameters conditions (AM1.5G, 0.1 W/cm^2, 300 K and 1sun). The results obtained show that the cell multilayer window gives the best efficiency and the thickness of the solar cell is an important parameter for the absorption of photons.

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