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The effect the light trapping on the Performance of simple Si np junction solar cell

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Abstract —Increasing the rate of solar spectrum absorption has an important impact on improving efficiency of thin film solar cells. One of the most common techniques to achieve it is light trapping, where photons' optical path is extended. It is typically characterized by the enhancement of the absorption of a solar cell beyond the value for a single pass of the incident beam through an absorbing semiconductor layer.

In the present work we proposed a technique based on closed-form analytical calculation to analyse the effect of light trapping on the performance of simple Si np junction solar cell. Particular importance is paid to light reflection and the active layer thickness. The incorporation of a mirror on the back of the cell shows a significant improvement on performance. A comparison is carried out between three types of cells, with No back reflection, with coherent reflection, and incoherent reflection. The conversion efficiency increased from 12.52% in a cell with No back reflection to 13.1945%. And the solar cell exhibits a maximum efficiency around 13.1948 % with a incoherent reflection.

Keywords: Solar Cell, Si, Light Trapping.

I. INTRODUCTION

Nowadays, most of solar cells in thin layer produced for industrial use techniques trap light. The reasons to reduce the thickness of the active materials are both technological and economic. This is why the role of light management has played an important part in the design of solar cell architectures since the 1980[1]. The challenge then is how to increase the absorption rate without increasing the physical thickness of materials. Among the possible solutions is the optical confinement in this technique mirrors are placed at the rear of the cell to provide multiple reflections of light to extinction, and depositing an antireflection coating to minimize reflection light.

II. THEORETICAL MODEL

In this paper, we use a compact summation method based on the simple case of a homo-junction with nonzero front and rear reflectivity to produce a full solution to the analytical model, examining both coherent and incoherent reflections. In principle, any digital program capable of solving the semiconductor the basic equations can be used to simulate the solar cell thin films. We use our model at Matlab simulation program to solve the Poisson equation; linking the load to the electrostatic potential, and the electrons continuity equations and holes. All the relationship using in this model are found in references [2,3,4]. Fig. 1 shows the layer structure for the cell and the naming scheme.

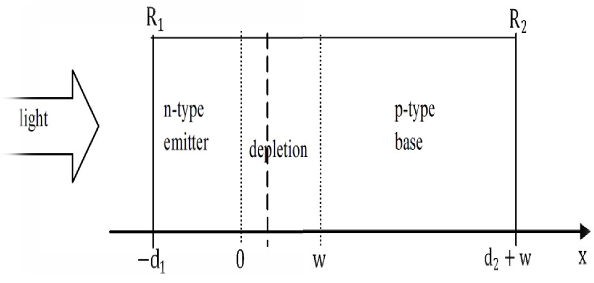

Fig.1 Schematic diagram of the layer structure and naming scheme for the analytical solar cell model.

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The thicknesses of the quasi-neutral region in the emitter and the base are denoted d_1 and d_2 respectively. The depletion thickness is w. The reflectivity of the front and rear surfaces of the solar cell are denoted R_1 and R_2 respectively and the total thickness of the solar cell is the sum of the *n*-type QNR, the depletion region and the *p*-type QNR, $P = d_1 + w + d_2$.

A. *short-circuit current density*

The density of the photocurrent is given by [5]:

$$J_{ph}(\lambda) = J_{p,ph}(d_1) + J_{n,ph}(d_2) + J_{dr,ph}(w) \qquad (1)$$

$J_{p,ph}$ the hole current density, $J_{n,ph}$ the emitter current density, $J_{dr,ph}$ the depletion current density. In this simulation, the optical coefficients of the Si were taken from [6,7]. A detailed discussion of the specific assumptions used and a full derivation can be found in Fonash [4], and only the result is presented here.

1) *Incoherent back reflection*

In the case of incoherent back reflection, the intensities of the multiple reflected beams add at all positions in the cell. Note that if $R_2 = 0$, one returns to the simple case of the solar cell no back reflector**.**

2) *coherent back reflection*

In the case of coherent back reflection, the phase of the multiple reflected beams is conserved and thus the forward and reverse propagating fields interfere.

B. *Tension en circuit-ouvert*

The dark current density is much detail and given by [3,8,9].

$$J_d = J_s + J_{SRH} \qquad (2)$$

$$J_s(\lambda) = J_{p,d}(d_1) + J_{n,d}(d_2) \qquad (3)$$

$J_{p,d}$ the dark hole current density, $J_{n,d}$ the dark emitter current density, J_{SRH} the dark current in the depletion region. The dark depletion current density was assumed to be dominated by Shockley–Read–Hall recombination [3,10,11].

C. *Fill factor and conversion efficiency*

The fill factor FF and the conversion efficiency η of the cell are defined as:

$$FF = \frac{J_m V_m}{J_{ph} V_{oc}} \qquad (4)$$

$$\eta = \frac{P_m}{P_{in}} \qquad (5)$$

III. *Result and Discussion*

Solar cell which have been studied, is a structure np based on Si, without window without BSF layer. Table 1 includes the physical parameters of solar cell Si used in the simulation.

TABLE. 1

THE PHYSICAL PARAMETERS USED FOR SI SOLAR CELL.

Parameters	Emitter (μm)	Base (μm)	Donor doping Nd (cm^{-3})	Acceptor doping Na (cm^{-3})
Si [12]	0.1	15	5e18	5e17

A. *Comparison between the solar cell no back reflection, with incoherent back reflection, and with coherent back reflection*

Fig. 2 show the curve of the spectral response for solar cell based on Si, respectively, with a coherent back reflection, with incoherent back reflection and no back reflection. Along improving the wavelength to spectral response is clearly visible, with pronounced fringes in the incoherent case due to the interference of the forward and reverse propagation in the structure. External parameters of the three cases of solar cell based on Si are grouped in the Table. 2. The coherent and incoherent back reflection produces similar improvements J_{ph} on the device without rear reflector; produce more photocurrent. Fig. 3 are shown the characteristics J = f (V) for solar cells based on Si respectively, in the three cases.

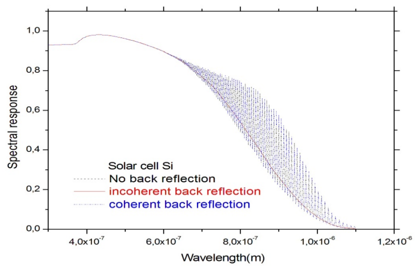

Fig. 2 show the curve of the spectral response for the solar cell based of Si.

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PV parameter	η (%)	FF	$J_{ph}(A/m^2)$	$V_{co}(volt)$
No back reflection	12.5183	0.83	233.66	0.64
Incoherent back reflection	13.1948	0.83	245.6356	0.65
Coherent back reflection	13.1945	0.83	245.6304	0.65

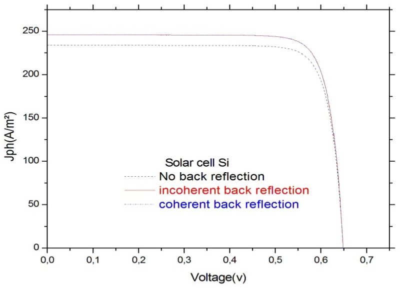

Fig. 3 show the characteristic the curve of J = f (V) for solar cell based on Si.

TABLE. 2

THE PHOTOVOLTAIC PARAMETERS OF SOLAR CELL BASED ON SI IN DIFFERENT CASES.

B. Conclusion

For improved cell performance Photovoltaic, to put a mirror, and to reduce the thickness of the cell it is a promising method for obtaining better performances Electricity at reasonable costs in relation to the cells Current events. We have shown that reflection incoherent a significant improvement of the photo-generated current.

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