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Numerical Simulation of the photovoltaic Back Contact Silicon Solar Cell Using PC1d.

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Introduction

•We propose in this work a contribution to the modeling and simulation of back contact silicon solar cell using PC1D,our structure is composed by two different layers of silicon with a total thickness of 60 um , the front side of the cell (substrate) is p-type doped with $1x10^{16}$ doping concentration acceptors ,and the rear side(emitter) is n+ doped with a thickness of 1 um and a $1x10^{17}$ doping concentration donators . The photovoltaic conversion efficiency obtained from this cell is 21.01% with a fill factor of 82.32%

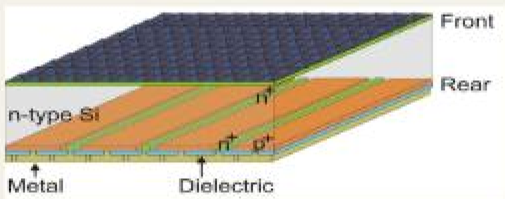

Fig.1 Schematic illustration of an IBC solar cell.[1]

Advantages and disadvantages

1. Advantages of IBC solar cells [nichoporuk 2005]:

-There is no shading rate of contacts,

-The contacts being made on the rear face, they can be large which reduces the series resistance of the cell and improves the optical confinement because the metal contacts serve as rear reflector

-reccombination in the emitter is reduced because it is located on the rear side of the cell

-The series interconnection between various cells can be done at module level, without the need for connecting the front of one cell to the rear of the next one, as is the case in two-side contacted cells

2. Disdvantages of IBC solar cells :

-The complexity of the structure (to realize lithography or screenprinting is required)

-The diffusion length of the minority carriers must be greater than the thickness of the cell. So the quality of the substrate must be good.

-Interdigitated PV cells are very sensitive to surface recombination. So the passivation of the front must be very good.

Carcterestics of the cell

Parameters	value
Device area	1 cm²
Device thickness	57 µm
Emitter doping concentration	1E19
Emitter thickness	0,6 µm
Base doping concentration	1 E17
Rs	0,2 Ω
Rp	1000 Ω
Band gap	1,124 eV
Front surface texture angle	54 °
Front surface texture depth	3 µm
Constant intensity	0.1 wc^{-2}
Spectrum	AM 1.5 G

Tab1. cell parametres for the simulation

Solar cell structure

interdigitated back contact solar cell (fig3) [nichoporuk 2005]

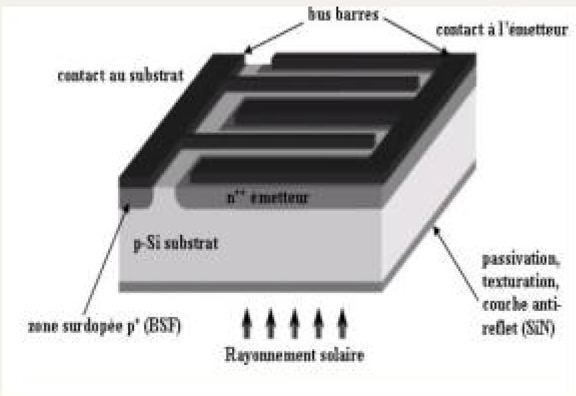

fig2. back contact silicon solar cell structure

Results of simulation

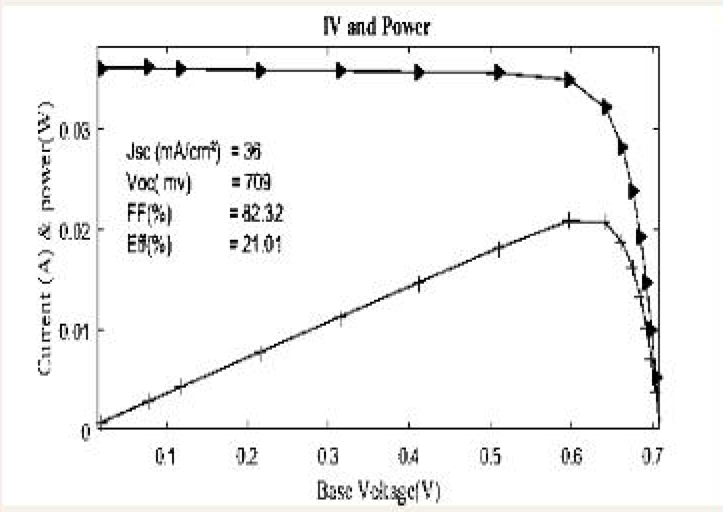

Fig 3 . IV curve of an IBC solar cell

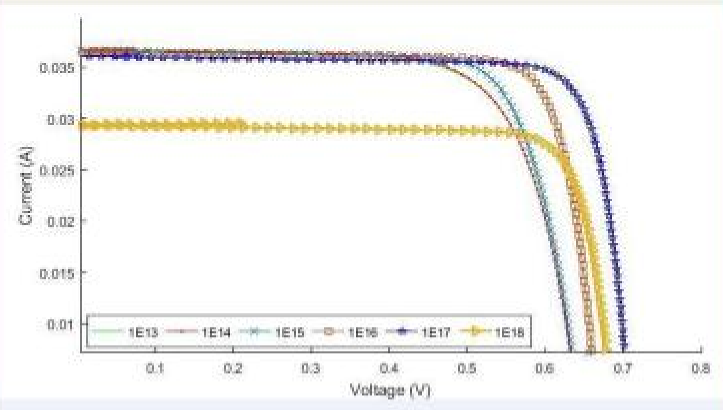

Fig 4 . Influence of base doping concentration on IV caracterestics

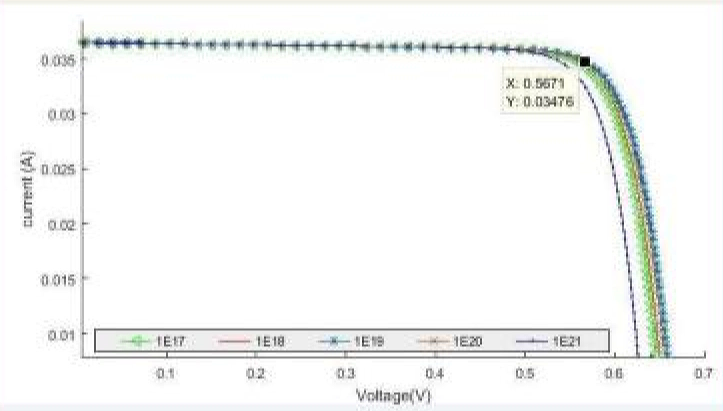

Fig 5. Influence of emitter doping concentration on IV caracterestics

Conclusion / Discussions

Optimization of Emitter Doping Level

From Fig. 5, it is observed that highest Voc is obtained at the emitter dopant density of 1E19 cm-3 and decreases as emitter dopant density decrease from 1E19 cm-3 to 1E17 cm-3. For simulation reported here, Isc is almost unchanged from dopant density of 1E17 cm-3 to 1E20 cm-3.These performances can be explained by sheet resistance values (Tab 2). The sheet resistance of the emitter is an essential process control parameter. large sheet resistances lead to high series resistance and poor fill factors. Additionally[3], the heavily doped emitter is considered as a dead layer with very high carrier recombination. The heavy diffusion limits the Voc in solar cell performance (Cueves 2005). Therefore, cell efficiency is poor for both low and high emitter doping levels.

Optimization of base Doping Level

The mechanism of base dopant density on the cell is similar to that of emitter doping. Five I–V curves with different base dopant densities are displayed in Fig. 4. As shown in Fig. 4, I–V characterization gradually improves and reaches its best at base dopant density of 1E17 cm-3 and then deteriorates at a concentration of 1E18 cm-3

Emitter doping (cm-3)	Sheet resistance (ohm /sq)
1 E17	6224
1 E18	1360
1 E19	309.7
1 E 20	58.9
1 E 21	7.68

Tab .2 sheet resistance variation with emitter doping

Parameter	Optimal simulated cell
Cell thickness	57 µm
Emitter thickness	0,1 µm
Emitter doping	1 E19 cm^{-3}
Base doping	1 E 17 cm^{-3}
Voc	706 mV
Jcc	36 mA
FF	82,32 %

Tab 3 . Parameters of the "optimal simulated case"

Bibliography / References

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