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Optimization of GaInP solar cell performances

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***Abstract*- In this paper we study a BSF layer structure of a GaInP solar cell and we search for technological parameters of this last leading to its optimized performance (using PC1D simulator). The optimized structure gives the following results: η=19% and FF=85,2%. We also compare these cell performances with those of an optimized GaInP single junction solar cell to show the BSF layer improvement.**

I. Introduction

GaInP material presents good crystal properties, as a high-quality crystal without Oxigen incorporation [1][3], and a low-recombination interface with GaAs, (S=1,5cm/s [2]) due to the low lattice mismatch between these two materials (0,1% [1][4]). These properties added to the high conversion efficiency of GaInP/GaAs tandem solar cells give to the study of the GaInP solar cell a big importance in photovoltaics. Our work consists of studying and optimizing the performance of this last under 1sun AM1. 5 G illumination, using PC1D program. (Figure.1) shows our solar cell structure. The material used is Ga0.5In0.5P (abbreviated as GaInP). We have assumed a front and back contacts in Au, an anti-reflective coating of MgF2/ZnS witch reduces the average reflectivity in the wavelength region between 400 and 900nm to less than 2%, and a window layer in AIInP witch reduce the surface recombination velocity to S=5800cm/s [1].

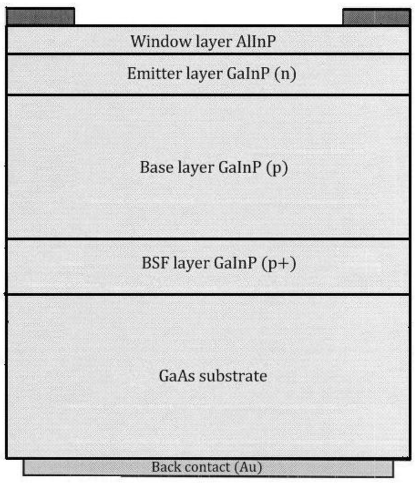

Fig.1: Schematic GaInP cell structure

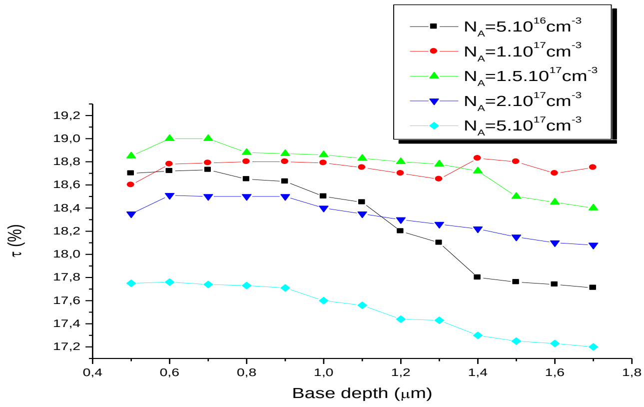

Fig.2: Dependence of conversion efficiency of GaInP cell on the base device makeup.

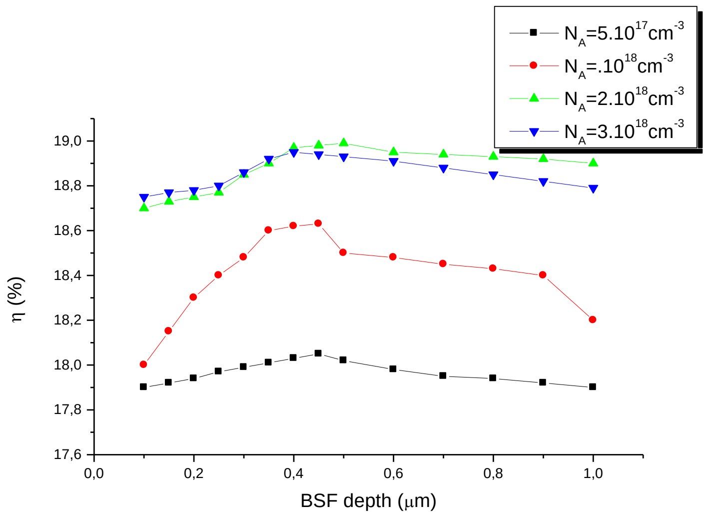

Fig.3: Dependence of conversion efficiency of GaInP cell on BSF device makeup.

II. Procedure

The cell structure consists of three regions, Emitter, Base, and BSF layer. In order to optimize its performance, we have searched for technological parameters of these three regions (doping concentration and thickness) leading to the best output characteristics of the cell. For this, we have used the following procedure:

1-We have fixed emitter and BSF layer parameters and we have varied those of the base region in order to study their influence on output characteristics of the cell. We have chosen a heavily and thin emitter layer (ND=1.1018 cm-3, xE=0,05 µm) and a BSF layer with the following parameters: NA+=2.1018 cm-3 and XBSF=0,5 µm. Results of PC1D simulation (using these assumptions) are shown in(Fig.2) witch represents the dependence of conversion efficiency (η)of the GaInP cell on the base device makeup. From this figure, we can conclude that an optimized performance (η=19% and FF=85, 04%), for our cell can be achieved for the following base parameters: NA=1, 5.1017 cm-3 xB=0,6 µm.

2-Using the found base parameters and following the same steps as in the first simulation, we have searched for optimal emitter layer parameters. We have varied the emitter thickness between 0.01 and 0.1µm and its doping concentration between 5.1017 cm-3 and 3.1018 cm-3. Simulation results are illustrated in (table1). We can note that emitter parameters, leading to the optimized cell performance (η=19%), are: ND =1.1018 cm-3, xE =0.05 µm.

3-After optimizing base and emitter parameters, we have searched for BSF layer parameters (using the two last simulations). We have varied BSF layer thickness between 0.1 and 1µm and its doping concentration between 5.1017 cm-3 and 3.1018 cm-3 . Simulation results are presented in (figure.3). This last shows the dependence of conversion efficiency of the GaInP cell on the BSF device makeup. BSF layer parameters offering the optimal cell performance (η=19% and FF=85.2%) are: NA =2.1018 cm-3 and XBSF =0.475 µm. As we have seen in the optimization of base parameters, there are other BSF layer parameters witch give a few more elevated conversion efficiency values. However, their fill factor still be less important than that given by the chosen parameters. The (table 2) summarizes optimized parameters for each region of our cell (abbreviated as cell 1) and its optimized performance, and compares these values with those of an optimized single junction GaInP solar cell (abbreviated as cell 2). We can note that the BSF layer has improved η and FF at the same time it has decrease the base depth (in comparison with the single junction cell characteristics). I (V) characteristic and the internal quantum efficiency of the two cells are shown in (fig.4,5). We can note too, that BSF GaInP cell presents an improvement in internal quantum efficiency (IQE), comparing to the single junction cell, in the range of [450nm, 650nm] (fig.5). However, this leads to a little increase of short current Isc (because of the decrease of recombination velocity at the rear of the cell due to the BSF layer) (fig4)..

TABLE 1

Emitter doping concentration (cm^{-3})	Best η (%)	Corresponding thickness (µm)
5.10^{17}	18.6	0.05
1.10^{18}	19	0.05
2.10^{18}	18.75	0.04
3.10^{18}	18.8	0.04

TABLE 2

	Base		Emitter		BSF		Isc	Voc	η	FF
	N_A (cm^{-3})	X_B (µm)	N_B (cm^{-3})	X_E (µm)	N_A (cm^{-3})	X_{BSF} (µm)	(mA)	(V)	(%)	(%)
Cell 1	$1,5.10^{17}$	0.6	1.10^{18}	0.05	2.10^{18}	0.475	22.6	0.985	19	85.2
Cell 2	$1,5.10^{17}$	1	1.10^{18}	0.05			21.9	0.984	18.5	85

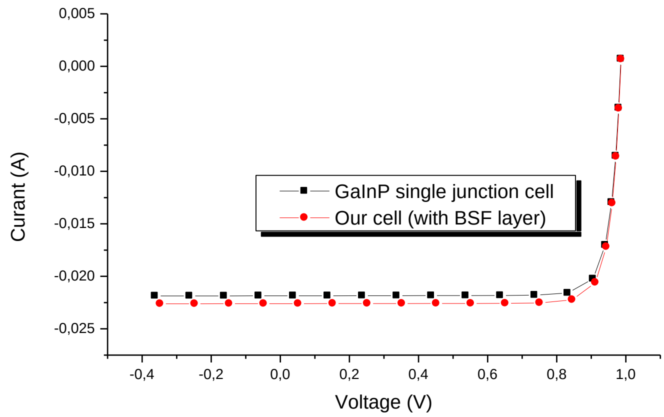

Fig. 4: I-V curve for the optimized two cells

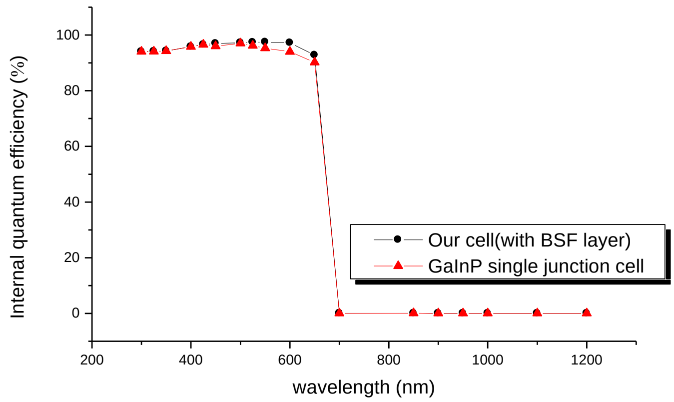

Fig.5: Internal Quantum Efficiency for the two cells

III. SUMMARY

We have found the technological parameters of a BSF GaInP solar cell leading to its optimized performance (η=19% and FF=85.2%). We have, also, compared these cell performances with those of an optimized GaInP single junction solar cell to show the BSF layer improvement. The results presented here are not necessarily precise due to the uncertainty of some of the parameters used in simulation, but they reflect the correct trend. As a future prospect, we are going to put this cell on an optimized GaAs solar cell in order to optimize the tandem structure performances

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