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Effect of Temperature on the Electric Power of Si, InAs and GaAs Based Solar Cells

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ABSTRACT

The electrical power is a nominal quantity which indicates the performance of the solar panels. It depends on the sunshine and also on the properties of the material used.

In this work we are interested in the properties of materials to study the evolution of electrical power as a function of the temperature of the following cells based on (Si silicon, InAs indium arsenide and GaAs gallium arsenide).

KEYWORDS: *Power, Photo voltage, vertical junction solar cell, temperature*

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I. INTRODUCTION

When solar panels are exposed to the sun, they build up heat. It is important to find materials that adapt better to the increase in heat. In this article we study the evolution of the electric power of solar cells based on: silicon Si, gallium arsenide GaAs, Indium arsenide InAs.

All three cells are identical and are parallel vertical junction solar cells used in the same solar lighting condition. This solar panel is an improvement of solar panels. It is manufactured in such a way that the radiation which arrives simultaneously touches the emitter, the base and the junction [1]. This facilitates the collection of electrons.

II. THEORETICAL BACKGROUND

The vertical junction solar panel is represented by Fig. 1, [1, 2].

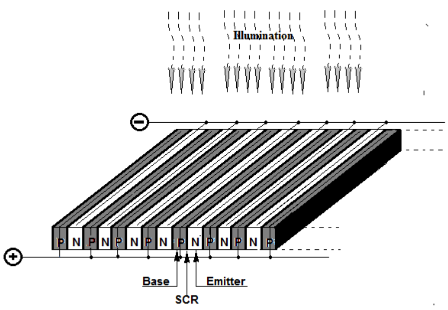

Fig. 1: Parallel vertical junction solar cell

The base region plays a very majority role in the generation of electrons. It is represented by fig.2.

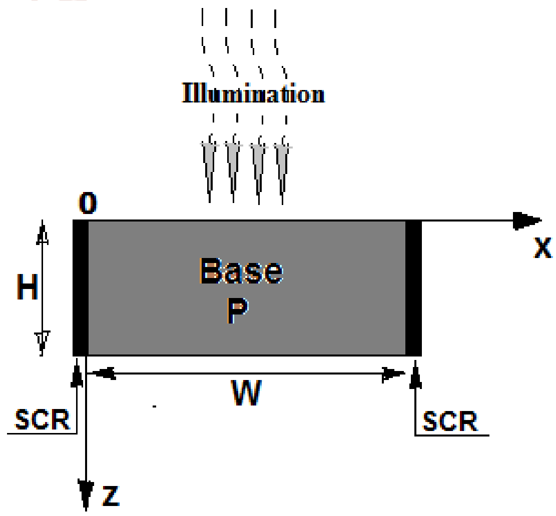

Fig. 2: Solar cell unit

1. Diffusion-recombination equation

Taking into account the generation, recombination and diffusion phenomena in the base, the equation, governing the variation of the electrons in static regime can be written as [1, 2].

$$\frac{\partial^2 n(x)}{\partial x^2} - \frac{n(x)}{L^2} = -\frac{G_n}{D} \qquad (1)$$

n(x) and L are respectively the electrons density, diffusion length.

D is the diffusion constant and μ the mobility [2, 3]

$$D = \mu \cdot \frac{K}{q} . T \qquad (2)$$

with q the elementary charge, k the Boltzmann constant and T the temperature.

Gn= g(z)+gth is the carrier generation rate.
g(z) is the carrier generation rate at the thickness z in the base and can be written as:

$$g(z) = \sum a_i e^{-biz} \qquad (3)$$

a_i and b_i are obtained from the tabulated values of AM1.5 solar illumination spectrum and the dependence of the absorption coefficient of silicon with illumination wavelength.

gth is the thermal generation rate. But in the absence of temperature gradient gth is uniformity compensated by the thermal recombination rate [4]
It is given by:

$$g_{th} = c.n_i^2 \qquad (4)$$

With

$$n_i = A_n . T^{\frac{3}{2}} . \exp\left(\frac{Eg}{2KT}\right) \qquad (5)$$

n_i refers to the intrinsic concentration of minority carriers in the base, A_n is a specific constant of the material, Eg is the energy gap

N_B is the base doping concentration in impurity atoms and C is the proportionality coefficient and τ lifetime

$$\tau = \frac{1}{C . N_B} \qquad (6)$$

The energy gap is given by:

$$Eg = Eg_0 - \frac{a.T^2}{b+T} \qquad (7)$$

2. Electrons density

The solution of equation (1) is:

$$n(x) = A \sinh\left(\frac{x}{L}\right) + B \cosh\left(\frac{x}{L}\right) + \sum \frac{a_i}{D} L^2 e^{-biz} + \qquad (8)$$

$$\frac{L^2}{D} C.A_n.T^3.\exp\left(\frac{Eg}{KT}\right)$$

Coefficients A and B are determined through the following boundary conditions

Boundary conditions:

- at the junction (x=0):

$$\left.\frac{\partial n(x)}{\partial x}\right|_{x=0} = \frac{S_f}{D} n(0) \qquad (9)$$

- in the middle of the base (x=W/2) :

$$\left.\frac{\partial n(x)}{\partial x}\right|_{x=\frac{w}{2}} = 0 \qquad (10)$$

The photocurrent Iph is given by

$$I_{ph} = qD \left.\frac{\partial n(x)}{\partial x}\right|_{x=0} \qquad (11)$$

2.1. Photo-voltage

The photo-voltage derives from the Boltzmann relation:

$$V_{ph} = \frac{k.T}{q} \cdot \ln\left(N_B \cdot \frac{n(0)}{n_i^2} + 1\right) \qquad (12)$$

2.2. Electric power

The electric power is given by

$$P_{ph} = I_{ph} . V_{ph} \qquad (13)$$

III. RESULTS AND DISCUSSION

The variation of the electric power according to the junction recombination velocity is illustrated by the fig. 3:

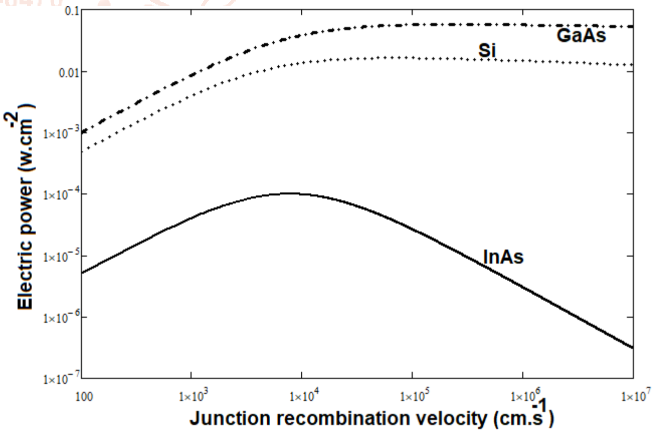

Fig.3: Electric power versus junction recombination velocity

This fig. 3 shows that there is a value of the Electric power versus junction recombination velocity.

($Sf \approx 10^5 cm.s^{-1}$) where the electric power is maximum.

Indeed, a high recombination reduces the storage of electrons. Therefore the power decreases. This reduction is all the more important as the width of the bandgap is low.

- The evolutions of the electric power according to the temperature are illustrated by the fig. 4

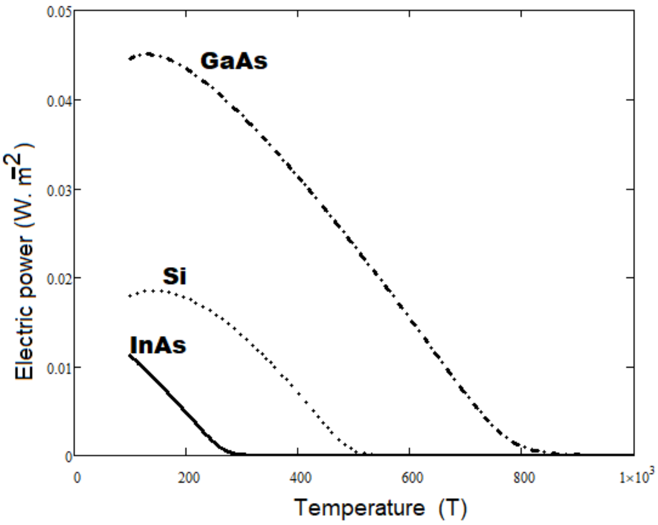

Fig. 4 –Electric power versus temperature

This fig.4 shows that the electrical power decreases when the temperature increases [4]. This decrease is all the more important as the width of the forbidden band is small. Strong heat in the materials decreases the electric power of the solar cells. It is therefore necessary to find materials which have a wide forbidden band to better resist the negative effect of temperature [5].

I. CONCLUSION

We can therefore retain from this study that a high heat in the materials and a junction recombination velocity strongly contribute to the decrease in the electric power of solar cells. The best materials that are capable of producing in sufficient quantity are those that have a wide bandgap. This work can be deepened by making a comparative study of the diffusion capacity of different solar cells made from different materials.

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