SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online)
Year: 2025 Issue: 11 Volume: 151
Received: 17.10.2025
Accepted/Published: 30.11.2025
https://T-Science.org
Issue Article

Nfally Dieme
Cheikh Anta Diop University
Laboratory of Semiconductors and Solar Energy, Department of Physics, Faculty of Science and Technology,
Dakar, Senegal
nfallydieme@yahoo.fr

Moustapha Sane
Cheikh Anta Diop University
Laboratory of Semiconductors and Solar Energy, Department of Physics, Faculty of Science and Technology,
Dakar, Senegal
moustaphasane2003@yahoo.fr

Idrissa Fabe Barro
Cheikh Anta Diop University
Laboratory of Semiconductors and Solar Energy, Department of Physics, Faculty of Science and Technology,
Dakar, Senegal
fabebarro@gmail.com

COMPARATIVE STUDY OF THE ELECTRICAL CAPACITY OF PHOTOVOLTAIC SOLAR CELLS

Abstract: *The study of the performance of solar panels necessarily requires the mastery of the electrical parameters of the solar cell such as its electrical capacity and the energy gap of the materials used. This parameter is neglected in the studies but it is a good indicator of the performance of solar cells.*

In this work we make a theoretical study of the electrical capacity as a function of the gap energy for solar cells made of silicon (Si), indium arsenide (InAs) and gallium arsenide (GaAs).

Key words: *Capacity, temperature, charge carrier's collection velocity, gap energy.*
Language: *English*
Citation: Dieme, N., Sane, M., & Barro, F.I. (2025). Comparative study of the electrical capacity of photovoltaic solar cells. *ISJ Theoretical & Applied Science, 11 (151)*, 13-17.
Soi: https://s-o-i.org/1.1/TAS-11-151-3 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2025.11.151.3
Scopus ASCC: *3100.*

I. Introduction

In this increasingly digital world, all professional and economic activities will depend on electricity. Taking into account the forms of energy use by the users (lighting, heating, and household appliances) the habits of life (professional and social, economic) the average daily electricity consumption per person will be around 6.8KWh. In the year a person would need 6.8x365d= 2482kWh.

This seems enormous and unsustainable if we do not take the lead to ensure an energy transition. That is, the time has come to take advantage of the sun's free, non-polluting energy that it sends to the earth's surface. The conversion of solar energy into electrical energy is provided by solar panels.

II. Theory

II.1. The structuring around NP junction

The structure around the PN junction is identical to that of a capacitor of capacity C and whose armatures are the two *semi-conductors of type N (with an excess of electron) and type P with an excess of holes (positive charges)

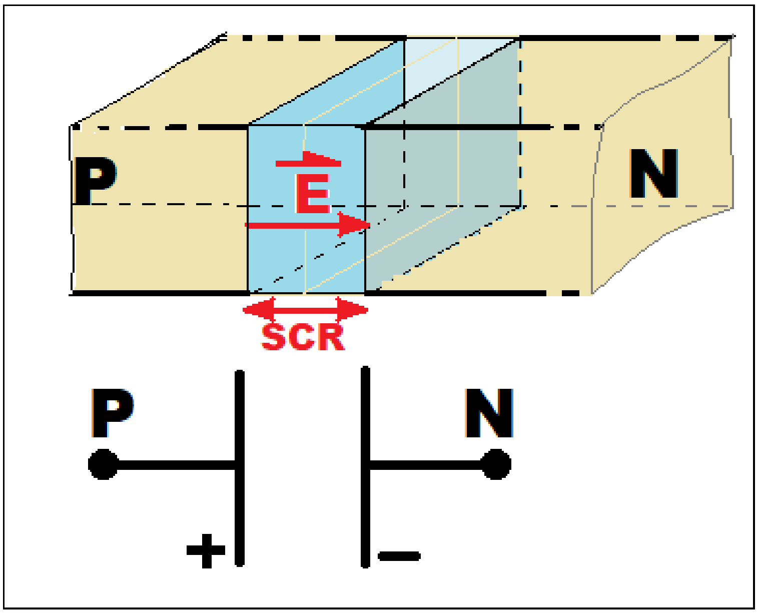

Fig.1: The structuring around NP junction

II.2. Determining the expression of capacity

Capacity derives from the electron density obtained from the solution of the continuity equation below **[1].**

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

n(x) and L are respectively the electrons density, diffusion length,
D is the diffusion constant.
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**:** [1]; [2]; [3]

$$g(z) = \sum a_i e^{-biz} \quad (2)$$

gth is the thermal generation rate. It is given by:`

$$g_{th} = c.n_i^2 \quad (3)$$

with

$$n_i = A_n.T^{\frac{3}{2}}.\exp(\frac{Eg}{2KT}) \quad (4)$$

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

The energy gap is given by: [3]; [4]

$$Eg = Eg_0 - \frac{a.T^2}{b+T} \quad (5)$$

Solar cell Capacity is :

$$C = q\left.\frac{\partial n(z)}{\partial V}\right|_{z=0} \quad (6)$$

And de voltage is given by: [2]; [5]

$$V = \frac{KT}{q}.\ln\left(\frac{n(z).N_B}{n_i^2} + 1\right) \quad (7)$$

N_B is the base doping concentration in impurity atoms

III. Results and discussion

The following curve is that of the energy of the gap of different semiconductor materials versus temperature.

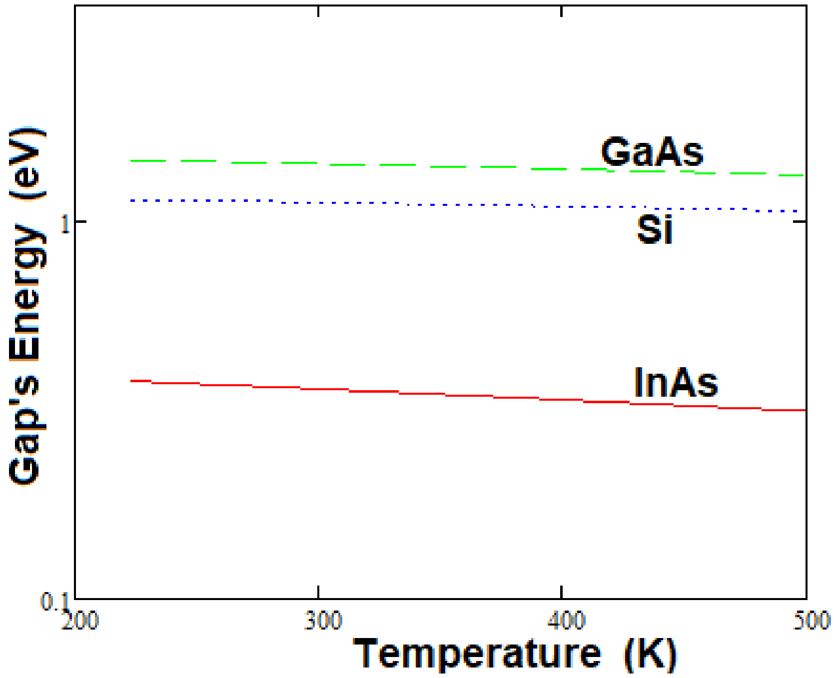

Fig.2: Gap Energy versus temperature.

To make the electron pass from the valence band to the conduction band it is necessary to provide it with a certain amount of energy called gap energy. This energy depends on the material used. That is, each material can be characterized by its own gap energy.

The Eg versus temperature curve shows that the gap energy decreases with temperature. This decrease is all the more important as the width of the forbidden band is low. Galium arsenide has a higher gap energy followed by silicon and indium arsenide.

The profile of the electrical capacity of the solar cell versus the velocity of the charge collection (recombination) is given by the following graph.

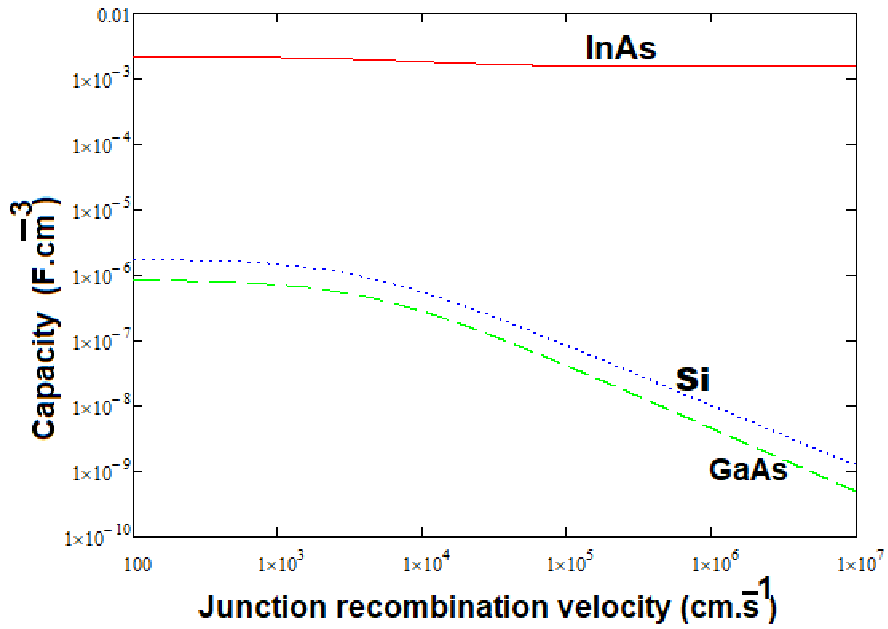

Fig. 3: Electrical solar cell Capacity versus junction recombination velocity

And on the other hand the curve of the electric voltage of the solar cell as a function of the junction recombination velocity of the charge carriers is as follows.

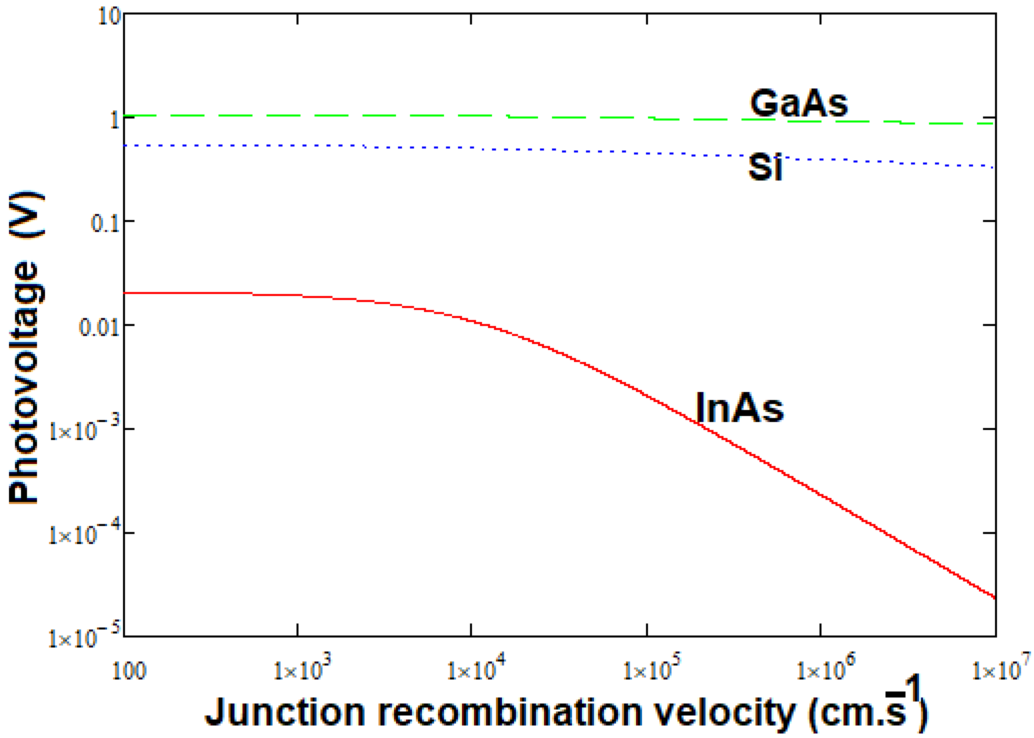

Fig. 4: Electrical solar cell voltage versus junction recombination velocity

The analysis of the figures (Fig.3 et Fig.4) shows that electric Capacity and electric Voltage are inversely proportional.

The capacitance is strongly related to the amount of electricity stored at the junction of the solar cell. Electron generation is much easier in materials with short band gaps. [5]

We find that the capacitance decreases as a function of the junction recombination velocity. This decrease is all the more important as the gap energy is large.

Both electrical capacity and electrical voltage; strong recombinations at the junction weaken the performance of solar cells.

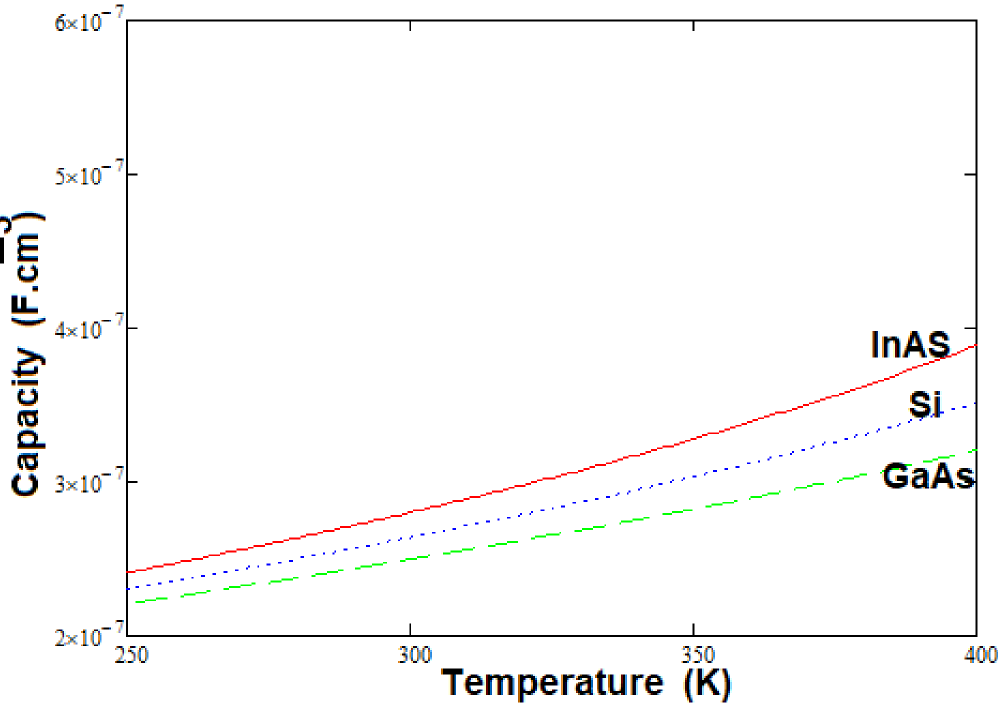

Fig. 5: Electrical solar cell Capacity versus temperature

This figure shows that the capacity increases with temperature. Indeed in the absence of illumination the temperature can cause a generation of charge carriers in the base: this is the thermogeneration.

This curve confirms the inverted proportionality of the electric capacity and the electric voltage of a solar cell. Because unlike the electric voltage, the electric capacity increases as a function of the temperature. This increase is as much greater as the energy of the gap is high.

Conclusion

This comparative study of the electrical capacity of solar cells of these different materials shows that solar cells weakly store charge carriers.

The solar panels must then be connected with the electrical batteries for the best storage the charge carriers.

It is difficult to comment on the performance of the solar cell by limiting itself only to the electrical capacity.

References:

1. Dieme, N., Sane, M., & Barro, I.F. (2015). Photocurrent and photovoltage under influence of the solar cell thickness. *ISJ Theoretical & Applied Science* 07 (27): 1-6.
2. Dieme, N., Sane, M., & Barro, I.F. (2015) effect of the doping rate on the shunt and series resistances of a silicon solar cell. *ISJ Theoretical & Applied Science* 09 (29): 162-168.
3. Dieme, Nf. (2015). “Study of the Electrons Density in the Base of the Parallel Vertical Junction Solar Cell under the Influence of the Temperature”, *American Journal of Optics and Photonics*. Vol. 3, 1, 2015, pp. 13-16.
4. Dieme, Nf. (2015). “study of the performance of a parallel vertical junction Silicon solar cell under thermal influence”, *Asian Academic Research Journal of Multidisciplinary*, vol.2, 1, 2015, pp. 8-16.
5. Dieme, Nf., & Sane, M. (2016). “Impact of Parasitic Resistances on the Output Power of a Parallel Vertical Junction Silicon Solar Cell”, *Energy and Power Engineering*, 8, 2016, pp. 130-136.