International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-15 Issue-9, August 2026

Study of the Parallel Vertical-Junction Silicon Solar Cell Under External Electrical Bias: Determination of Dark Capacitance and Diffusion Potential

Marcel Sitor Diouf, Oulimata Mballo, Moustapha Thiame

Abstract: ***This study presents a theoretical analysis of a parallel vertical-junction silicon solar cell under external electrical bias. The focus is on the influence of a biasing electric field on the solar cell's performance under constant multispectral illumination at steady state. The analytical solution of the continuity equation, incorporating the quasi-neutral base approximation and boundary conditions that account for the recombination velocity at each junction, has enabled the derivation of an expression for the density of photogenerated minority charge carriers in the base. Consequently, expressions for photocurrent, photovoltage, electrical power, and capacitance have been derived and analysed as functions of the electric field and the minority-charge-carrier recombination velocity at the junction. Analysis of the results shows that applying an external electric field enhances the movement of minority charge carriers toward the junctions, thereby reducing recombination losses and promoting photocurrent generation by improving carrier collection. This movement of a large number of minority charge carriers toward the junctions under the influence of the electric field increases their density near the junctions. Consequently, the short-circuit photocurrent, open-circuit photovoltage, junction capacitance near open circuit, and maximum electrical power delivered by the solar cell all increase. The study also reveals a decrease in the diffusion potential as the electric field increases. Finally, the capacitance-photovoltage characteristic enables determination of the dark capacitance and the diffusion potential of the solar cell. The results show a relatively small increase in open-circuit voltage (Voc), from 0.58613 V at E = 0 V/cm to 0.58619 V at E = 6 V/cm. Short-circuit current density (Jsc) increases from 0.1032 A/cm² at E = 0 to 0.4168 A/cm² at E = 6 V/cm, representing a significant change. The diffusion potential (V_D) decreases from 0.73 V to 0.42 V. The maximum power (Pmax) increases from 0.0507 W to 0.2348 W. Applying an external electric field to the parallel vertical-junction silicon solar cell is therefore an effective way to improve its electrical performance, which may prove useful for optimisation purposes. This work will be extended to include an experimental study of these phenomena and an analysis of the simultaneous influence of the electric field and temperature on the solar cell's electrical parameters.***

Keywords: Silicon Solar Cell, Photocurrent, Photovoltage, Capacitance.

Nomenclature:
Voc: Open Circuit Voltage
Jsc: Short-circuit Photocurrent
Co: Dark Capacitance
Pmax: Maximum Power
V_D: Diffusion Potential

I. INTRODUCTION

Improving the performance of silicon solar cells remains a major challenge in renewable energy. A solar cell's performance depends primarily on its ability to efficiently generate, transport, and collect photogenerated minority charge carriers while minimizing recombination within the bulk material and at interfaces. A better understanding of carrier transport mechanisms is therefore a key factor in optimizing the efficiency of photovoltaic devices.

With this in mind, numerous theoretical and experimental studies have focused on several solar cell architectures:

- The polycrystalline silicon solar cells, in which the influence of the electromagnetic field on their electrical parameters is studied [1].
- Bifacial silicon solar cells operating in the frequency-dependent dynamic regime are studied under the influence of a constant magnetic field [2]. The optimal base thickness is determined and then analyzed as a function of frequency [3].
- Concentrator multi-junction solar cells for which general electrical parameters [4] are investigated. Research has also focused on series resistance and recombination velocity [5].

Among the various solar cell architectures, the vertical parallel-junction silicon solar cell is of particular interest due to its geometric configuration. In this structure, the base is flanked by two identical junctions that simultaneously contribute to the collection of photogenerated carriers. This configuration promotes a more uniform distribution of minority charge carriers within the base, making the study of their behaviour under an external electric field particularly relevant.

This work presents a theoretical analysis of the influence of a biasing electric field on a parallel vertical-junction silicon solar cell under

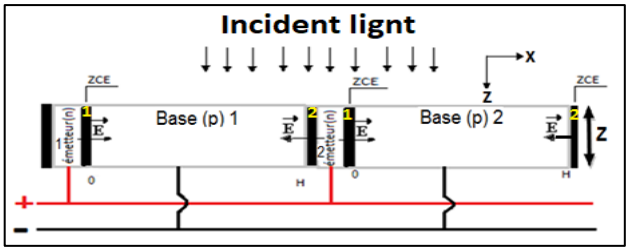
Manuscript received on 28 July 2026 | First Revised Manuscript received on 01 August 2026 | Second Revised Manuscript received on 08 August 2026 | Manuscript Accepted on 15 August 2026 | Manuscript published on 30 August 2026.
**Correspondence Author(s)*
Marcel Sitor Diouf*, Department of Physics, Cheikh Anta Diop University of Dakar (UCAD), Dakar, Senegal. ID: marceldiouf39@yahoo.fr. Orcid ID: 0009-0006-2806-3128
Oulimata Mballo, Department of Physics, Cheikh Anta Diop University of Dakar (UCAD), Dakar, Senegal, ID: oulimatamballo@gmail.com
Moustapha Thiame, Department of Physics, Assane Seck University of Ziguinchor (UAS), Senegal, ID: mthiame@univ-zig.sn, Orcid ID: 0009-0000-1760-2997

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

constant multispectral illumination at steady state. Solving the minority-charge-carrier continuity equation in the base allows determination of the carrier density, which in turn leads to expressions for the solar cell's photocurrent, photovoltage, electrical power, and capacitance. The study then highlights the effect of the electric field on the behaviour of these electrical parameters. Finally, a graphical analysis enables the determination of dark capacitance and diffusion potential, two fundamental parameters for the electrical characterisation of the solar cell.

II. THEORY

We consider a parallel-vertical-junction silicon solar cell under an electric bias and constant polychromatic illumination, as shown in Figure 1.



[Fig.1: Structure of a Parallel Vertical Junction Solar Cell Under Electric Bias]

Under the quasi-neutral base (QNB) approximation, the continuity equation obeyed by the minority charge carriers in the base under steady-state conditions is given by:

$$G(z) + D_n \cdot \frac{\partial^2 \delta(x)}{\partial x^2} + \mu \cdot E \cdot \frac{\partial \delta(x)}{\partial x} - R(x) = 0 \qquad (1)$$

where D_n is the diffusion coefficient of the minority charge carriers; *G(z)* is the carrier generation rate at depth z [6];

$$G(z) = \sum_{i=1}^{3} a_i e^{-b_i z}$$

R(x) is the carrier recombination rate at position x [7];

$$R(x) = \frac{\delta(x)}{\tau}$$

Moreover, *δ(x)* is the density of the minority carriers photogenerated at position x in the base. The solution of Equation (1) has the form:

$$\delta(x,z) = e^{\beta x}[\mathrm{Ach}(\alpha \cdot x) + \mathrm{Bsh}(\alpha \cdot x)] + \sum_{i=1}^{3} C_i e^{-b_i z} \quad (2)$$

With

$$\alpha = \frac{(L^2{}_E + 4 \cdot L^2{}_n)^{\frac{1}{2}}}{2 \cdot L^2{}_n} \quad \beta = \frac{-L_E}{2 \cdot L_n^2} \quad C_i = a_i \cdot \frac{L_n^2}{D_n}$$

Where *Ln* is the diffusion length, and L_E is a constant introduced to simplify the calculations [7]. The constants A and B in Equation (2) are determined by applying the boundary conditions [8]: at the emitter–base junction (x = 0):

$$D_n \cdot \left.\frac{\partial \delta(x,z)}{\partial x}\right|_{x=0} = Sf \cdot \delta(x,z)|_{x=0}$$

and at the middle of the base (x = H/2) [8]:

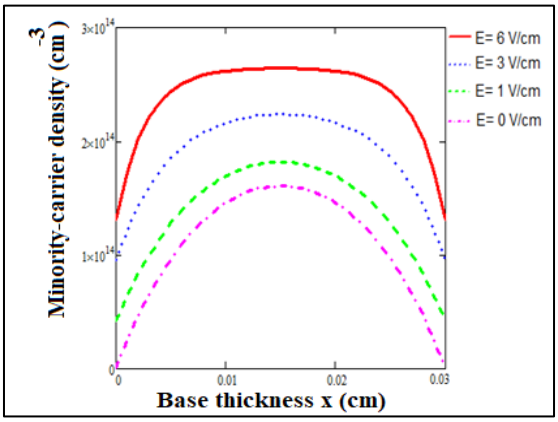
$$\left.\frac{\partial \delta(x,z)}{\partial x}\right|_{x=\frac{H}{2}} = 0$$

where *Sf* is the recombination velocity at the junction.

III. RESULTS AND DISCUSSION

A. Minority-Carrier Density

Figure 2 shows the variation of the minority-carrier density as a function of the base thickness x, for different values of the electric field, near short-circuit conditions.



[Fig.2: Minority-Carrier Density Profile as a Function of the Base Thickness X, for Different Values of the Electric Field E Under Short-Circuit Conditions (Z = 0.0008 cm; Sf = 10^5 cm·s^{-1}; D = 26 cm^2·s^{-1}; L = 0.01 cm)]

Figure 2 shows that the various minority-carrier density curves are symmetric about the middle of the base (x = H/2). This is because our solar cell model has a parallel vertical junction configuration, so the base under study lies between two junctions that contribute equally.

In base region 1, between x = 0 and x = H/2, the carrier gradient is positive: the electrons located in this region can cross junction 1 and contribute to carrier collection.

At the middle of the base (x = H/2), the minority charge carriers, under the action of the two electric fields, are driven back toward junctions 1 and 2.

Between x = H/2 and x = H, the carrier gradient is likewise positive with respect to emitter 2, so that all carriers located in this part of the curve can be driven toward junction 2 to contribute to the photocurrent.

When an external electric bias is applied, we observe an increase in the carrier density and a shift of its maximum toward the junctions. Indeed, the application of an external electric field increases the drift force acting on the photogenerated minority carriers. This force adds to the diffusion mechanism and promotes carrier transport toward the junctions. The resulting decrease in recombination within the bulk of the base increases the carrier concentration near the junctions, which explains the rise in density observed as the electric field increases.

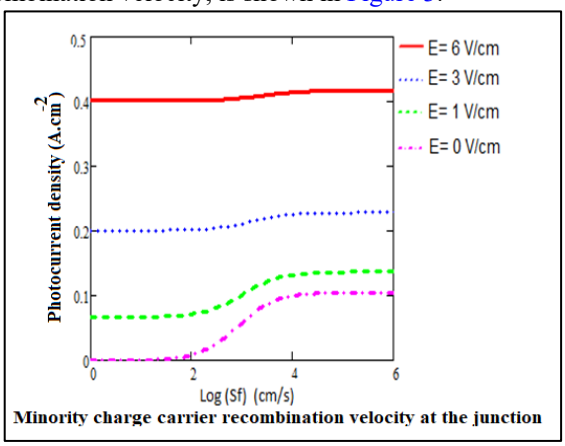
B. Photocurrent

The photocurrent of a solar cell under external electric bias is given by:

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

$$J_{ph} = 2 \cdot q \left[D_n \frac{\partial \delta(x,z)}{\partial x}\Big|_{x=0} + \mu \cdot E \cdot \delta(0,z) \right] \quad (3)$$

With q the elementary electron charge, and Jph = 2 × (J_D + J_C). Indeed, the photocurrent is the sum of the diffusion current (J_D), due to the carrier concentration gradient, and the conduction current (J_C), due to the electric field [7]. The influence of the electric field on the photocurrent density, plotted as a function of the logarithm of the junction recombination velocity, is shown in Figure 3.



[Fig.3: Photocurrent Profile as a Function of the Logarithm of the Recombination Velocity, for Different Values of the Electric Field E (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

Figure 3 shows two characteristic plateaus: a first plateau at low values of the junction recombination velocity (Sf), corresponding to open-circuit operation of the solar cell at this level, the minority charge carriers are stored at the junction, resulting in a zero photocurrent in the absence of external bias; and a second plateau at high values of the junction recombination velocity, corresponding to short-circuit conditions at this level, the minority charge carriers succeed in crossing junctions 1 and 2 and contribute to the photocurrent.

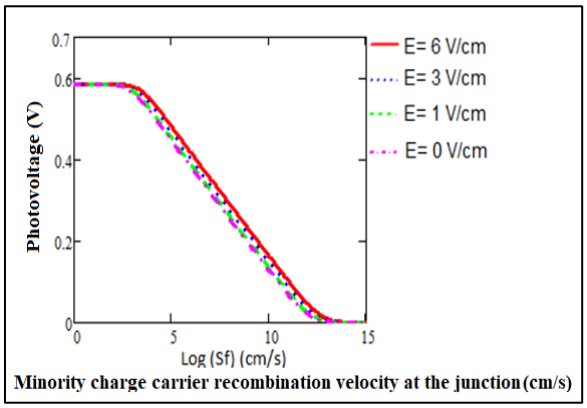
In the presence of an electric field, an increase in the photocurrent is observed, especially at low values of the recombination velocity. Indeed, near open circuit, the external bias increases the mobility of the charge carriers and drives them across the junctions, contributing to the photocurrent. An increase in the short-circuit photocurrent (Jsc) is also observed. Indeed, in addition to the minority carriers that cross the junctions due to junction recombination, the electric field further reinforces their motion toward the junctions. The nearly monotonic increase in the short-circuit photocurrent with the electric field thus shows that carrier collection becomes increasingly efficient. Consequently, a growing number of carriers reach the junctions before recombining, thereby directly improving the solar cell's collection efficiency.

C. Photovoltage

The Boltzmann relation gives the photovoltage of the solar cell:

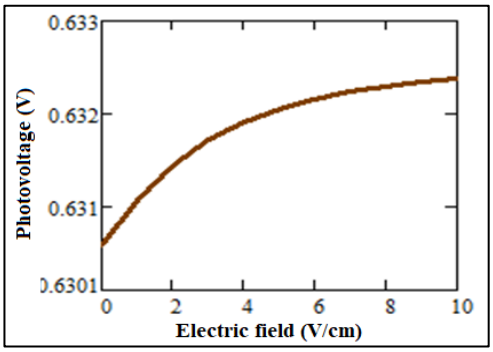
$$V_{ph} = V_T \cdot \left[\ln\left(\frac{N_B}{n_i^2} \cdot \delta(0,z) \right) + 1 \right] \quad (4)$$

With V_T the thermal voltage: V_T = kT/q; N_B the base doping concentration; ni² the intrinsic carrier concentration; k the Boltzmann constant; T the temperature; and q the electron charge. Figure 4 shows the photovoltage profile as a function of the recombination velocity at the junction for different electric-field values.



[Fig.4: Photovoltage Profile as a Function of the Logarithm of the Recombination Velocity, for Different Values of the Electric Field (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

Figure 4 shows that the photovoltage is maximal at the open-circuit voltage (Voc) for low junction recombination velocity (Sf), and then decreases toward zero for high Sf. Indeed, for low values of the junction recombination velocity, the carriers are confined at the junction, so the photovoltage is at its maximum. As this velocity increases, the minority charge carriers cross the junctions, and the photovoltage decreases, becoming zero near short-circuit conditions. To further illustrate the effect of the electric bias on the photovoltage, Figure 5 shows the evolution of the open-circuit voltage as a function of the electric field generated by the applied bias to the solar cell.



[Fig.5: Open-Circuit Photovoltage as a Function of the Electric Field (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

Figure 5 shows an increase in the open-circuit voltage (Voc) when an electric bias is applied to the solar cell. This increase reflects a greater accumulation of charge on either side of the junction. The electric field promotes the transport of photogenerated minority carriers toward the charge-separation regions, thereby strengthening the electrochemical potential of the junction and increasing the open-circuit voltage.

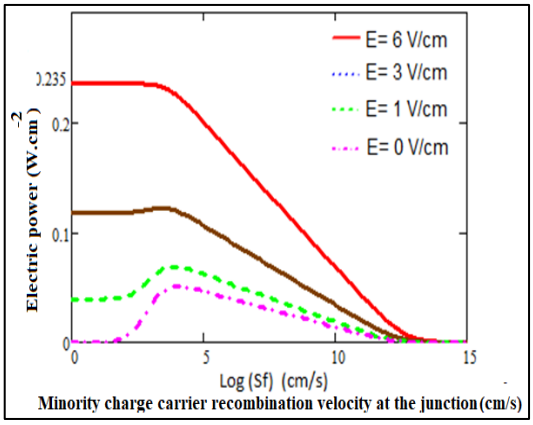
D. Electric Power

The following equation gives the power delivered by an illuminated solar cell:

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

$$P = Jph \times Vph \quad (5)$$

Figure 6 below shows the electric power profile as a function of the junction recombination velocity, for different values of the electric field.



[Fig.6. Electric Power Profile as a Function of the Logarithm of the Junction Recombination Velocity, for Different Values of the Electric Field E (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

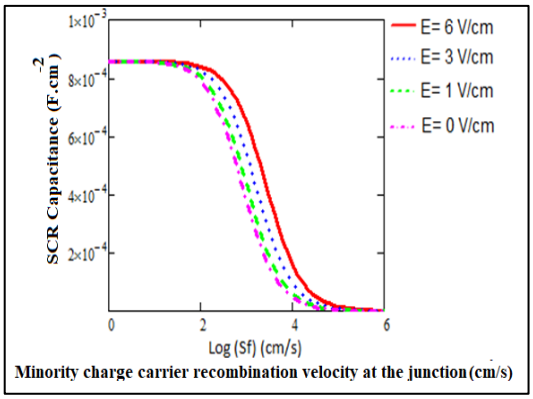
In the absence of an electric field, Figure 6 shows a low electric power in the vicinity of the open-circuit and short-circuit. However, the power reaches a maximum, indicating an optimal operating point that represents the best compromise between current and voltage. Applying an external electric bias to the solar cell produces a substantial electric power near open circuit, which increases considerably with the electric field. Indeed, the electric bias drives a large flow of charge carriers to the junction. As the electric field increases, the optimal operating point shifts toward higher power values, indicating improved energy performance of the solar cell due to more efficient collection of minority charge carriers.

E. Capacitance

The capacitance of the solar cell under polychromatic illumination is given by the following expression [8]:

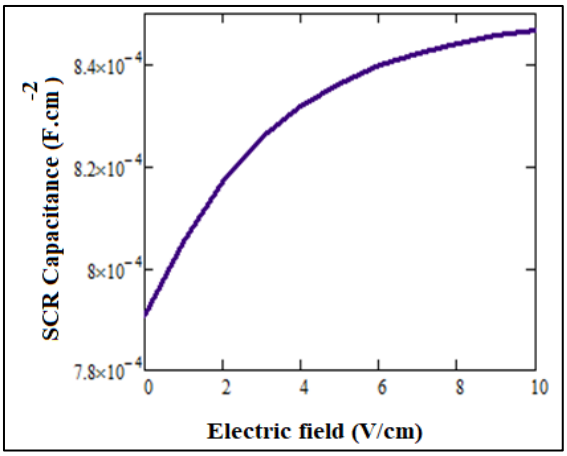
$$C = C_0 + q \cdot \frac{\delta(0,z)}{V_T} \quad (6)$$

Where VT is the thermal voltage, and C_0 is the dark capacitance. Figure 7 below shows the capacitance profile of the solar cell as a function of the logarithm of the junction recombination velocity, for different values of the electric field E.



[Fig.7: Capacitance Profile as a Function of the Logarithm of the Recombination Velocity, for Different Values of the Electric Field (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

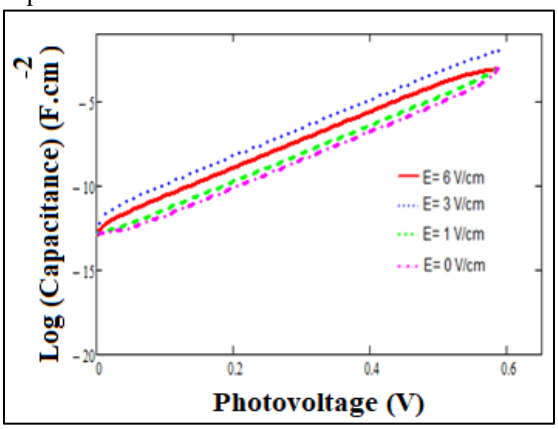
Figure 7 shows that the capacitance is maximal near the open circuit. Indeed, at low junction recombination velocities, a large number of minority charge carriers are stored at the junction, increasing the open-circuit voltage and, consequently, the capacitance. As the recombination velocity increases, away from open circuit, charge carriers cross the junction, and the capacitance decreases, becoming nearly zero near short-circuit conditions. Applying an electric bias to the solar cell increases charge accumulation at the junction near open circuit, which raises the open-circuit voltage and, consequently, the capacitance. Figure 8 illustrates this phenomenon.



[Fig.8: Capacitance as a Function of the Electric Field Near Open Circuit (Z = 0.0008 cm; D = 26 cm²·s⁻¹; L = 0.01 cm)]

F. Determination of the Dark Capacitance

The dark capacitance is determined graphically by plotting the logarithm of the capacitance as a function of the photovoltage. The dark capacitance corresponds to the y-intercept of these curves.



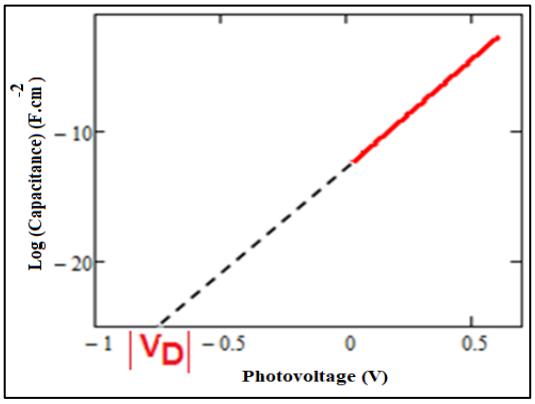
[Fig.9: Logarithm of the Capacitance as a Function of the Photovoltage (E = 6 V/cm; Z = 0.0008 cm)]

The curves of the logarithm of the capacitance versus the photovoltage are straight lines, whose y-intercept gives the dark capacitance. We obtain: Log(C0) = −12.815 F/cm², which gives C0 = 2.72×10⁻⁶ F/cm². Thus, the capacitance of the illuminated solar cell, C(Sf), is the sum of its dark capacitance, C0, and the capacitance due to illumination, C1(Sf): C(Sf) = C0 + C1(Sf) [8].

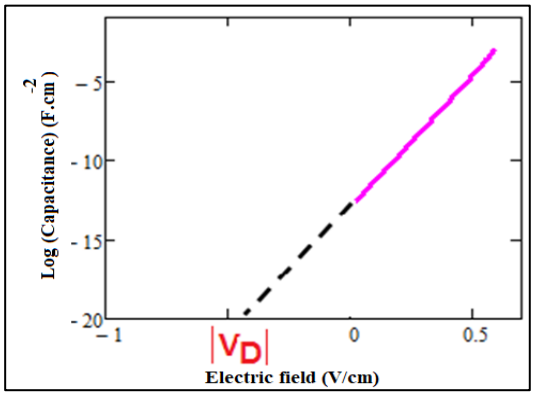
Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

G. Determination of the Diffusion Potential

Graphically, the diffusion potential of the solar cell corresponds to the point where the curve of the logarithm of the capacitance versus the photovoltage intersects the horizontal axis. Figures 10 and 11 show, respectively, the curve of the logarithm of the capacitance versus the photovoltage for a zero electric field and for an electric field of 6 V/cm.



[Fig.10: Logarithm of the Capacitance as a Function of the Photovoltage (E = 0 V/cm; Z = 0.0008 cm; V_D = 0.73 V)]



[Fig.11: Logarithm of the Capacitance as a Function of the Photovoltage (E = 6 V/cm; Z = 0.0008 cm; V_D = 0.42 V)]

Extrapolating the curve to the horizontal axis gives the value of the diffusion potential. We find V_D = 0.73 V for E = 0 V/cm and V_D = 0.42 V for E = 6 V/cm. The diffusion potential decreases when an external electric bias is applied. This decrease as the external field increases indicates that the applied field partially compensates the internal field of the junction. The potential barrier decreases, facilitating the passage of carriers across the junction and improving their collection.

H. Summary of results

E (V/cm)	V_{OC} (V)	J_{SC} (A/cm²)	C_0 (F/cm²)	V_D (V)	Pmax (W)
6	0.58619	0.4168	2.72×10^{-6}	0.42	0.2348
3	0.58617	0.2272	2.72×10^{-6}	0.58	0.1222
1	0.58614	0.1355	2.72×10^{-6}	0.67	0.0679
0	0.58613	0.1032	2.72×10^{-6}	0.73	0.0507

IV. CONCLUSION

In this work, we have theoretically studied the influence of an external electric bias field on the performance of a parallel vertical-junction silicon solar cell under constant multispectral illumination at steady state. Solving the continuity equation for the minority carriers in the base made it possible to determine their density and then to establish the expressions for the photocurrent, photovoltage, electric power, and capacitance of the solar cell as functions of the bias electric field and of the junction recombination velocity.

The results show that applying an external electric field significantly improves the transport of minority carriers toward the junctions by reinforcing the drift mechanism. This action limits recombination phenomena in the base and increases the concentration of collected carriers. It results in an increase in the minority-carrier density, the short-circuit photocurrent, the open-circuit photovoltage, and the maximum electric power delivered by the solar cell. These observations highlight the beneficial effect of the electric field on the electrical performance and potential efficiency of the photovoltaic device.

The study of the capacitance showed that it is maximal near open circuit, owing to the storage of charge carriers at the junction, and that it decreases progressively as the recombination velocity increases. Graphical analysis of the logarithmic capacitance–photovoltage characteristic enabled determination of the solar cell's dark capacitance, while extrapolation of this characteristic yielded the diffusion potential. The results show that the diffusion potential decreases as the external electric field increases, reflecting a modification of the junction potential barrier under the effect of the bias.

Ultimately, this study highlights the decisive role of the external electric field in enhancing the performance of a parallel vertical-junction solar cell. The results obtained contribute to the understanding of carrier transport mechanisms in silicon photovoltaic cells and can serve as a basis for optimizing their design. Future work could be devoted to the experimental study of these phenomena, as well as to the analysis of the simultaneous influence of electric field, temperature, illumination, and frequency effects on the performance of photovoltaic cells.

ACKNOWLEDGMENT

The author would like to thank the members of the Laboratory of Semiconductors and Solar Energy, Department of Physics, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD), Senegal, for facilitating access to the laboratory. The author is also grateful to the Heads of the Department of Physics at Cheikh Anta Diop University of Dakar and at Assane Seck University of Ziguinchor, Senegal, for their valuable contributions and advice.

DECLARATION STATEMENT

As the corresponding author, I confirm the accuracy of the following information on behalf of all co-authors.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

- **Conflicts of Interest:** To the best of my knowledge, this article presents no conflicts of interest**.**
- **Funding/Grants/Financial Support:** This article did not benefit from any funding from organisations or agencies...
- **Ethical Approval and Consent to Participate**: The content of this article does not require any ethical approval or consent to participate...
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contribution:** Authorship of this article is attributed equally to all participating individuals.

REFERENCES

1. **Ouedraogo, A., Soro, B., Konate, R., Oumarou, F.A., Bathiebo, D.J. (2021).** Investigation of the Polycrystalline Silicon PV Cell Efficiency in 3D Approximation versus Electromagnetic Field under Monochromatic Illumination. International Journal of Photoenergy, Vol. 2021. DOI: 10.1155/2021/5171351
2. **Diao, A., Thiaw, B., Boiro, M., Mbodji, S., Sissoko, G. (2021).** A Junction Electric Field Détermination of a Bifacial Silicon Solar Cell under a Constant Magnetic Field Effect by Using the Photoconductivity Method. Journal of Modern Physics, 12(5), 635-645. DOI: 10.4236/jmp.2021.125041
3. **Sall M., Diarisso D., Fall M.F.M., Diop G., Ndiaye M., Loum K., Sissoko G. (2021).** Back Illuminated N/P/P+ Bifacial Silicon Solar Cell under Modulated Short-Wavelength: Détermination of Base Optimum Thickness—Journal of Electromagnetic Analysis and Applications, Vol. 13. https://www.scirp.org/journal/paperinformation?paperid=109616
4. **Wang, Z., Zhang, H., Dou, B., Zhang, G., Wu, W. (2022).** Theoretical and experimental evaluation on the electrical properties of multi-junction solar cells in a reflective concentration photovoltaic system. Energy Reports, Vol. 8, pp. 820–831. DOI : 10.1016/j.egyr.2021.12.018
5. **Khalis, M., Masrour, R. (2021).** Predominant Range of Serial Resistance and Recombination Velocity at Different Concentration Levels: Vertical Multijunction Cell. Silicon, 14, 6107–6112. DOI: 10.1007/s12633-021-01374-z
6. **Diatta L., Thiame M., Traore S., Camara M. (2025).** Optimization of a Highly Doped Silicon Vertical Junction Silicon Solar Cell: Cross-effects of Base Thickness and Magnetic Field Inclination Angle. American Journal of Energy Engineering, 13(4), 171-178. DOI: 10.11648/j.ajee.20251304.12
7. **Zouma, B., Barro, F.I., Honadia, P.A.A. (2021).** Silicon Solar Cell Space Charge Region and Capacitance Behaviour under Electric Field. Energy and Power Engineering, 13, 41-50. DOI: 10.4236/epe.2021.131003
8. **Boiro M., Dione B., Toure I., Ndiaye A., Diao A. (2022).** Influence of the Magnetic Field on the Diffusion Capacitance of a Serial Vertical Junction Silicon Solar Cell in Frequency Modulation—American Journal of Modern Physics, Vol. 11, Issue 1. DOI: 10.11648/j.ajmp.20221101.11

AUTHOR'S PROFILE



Dr Marcel Sitor Diouf holds a PhD in Physics and Applications, specializing in solar energy systems and materials, from Cheikh Anta Diop University in Dakar, Senegal (2015). His research focuses primarily on the physical modelling of silicon photovoltaic cells and on improving energy conversion efficiency. He has served as an adjunct lecturer and researcher since 2014. He is a member of the Semiconductor and Solar Energy Laboratory within the Physics Department of the Faculty of Science and Technology at the same university. Additionally, he has been a physics and chemistry teacher and laboratory manager at Saint Pierre College in Dakar since 2013. He has authored or co-authored 33 international scientific publications and regularly supervises Master's theses and serves on thesis defence panels.



Dr Oulimata Mballo holds a PhD in Physics and Applications, specializing in materials and systems for solar energy, awarded in 2017 by Cheikh Anta Diop University in Dakar, Senegal. She has eleven years of experience as a high school physics and chemistry teacher and currently serves as a specialised inspector in physics and chemistry at the Faculty of Science and Technology of Education and Training (FASTEF) at the same university; she is also a member of the Semiconductor and Solar Energy Laboratory. Her research primarily focuses on characterising solar cells under various operating conditions and illumination modes. She has authored or co-authored ten international scientific publications and regularly supervises Master's students.



Moustapha Thiame is a lecturer and researcher at Assane Seck University of Ziguinchor in Senegal, specializing in semiconductor physics and solar energy. His research primarily focuses on optimising photovoltaic (PV) cells for various environments and studying the reliability and degradation of PV systems under real-world conditions. A Senior Lecturer (CAMES), he serves as Head of the Physics Department. He is a member of the Laboratory for the Chemistry and Physics of Materials (LCPM) at the same university. He has authored numerous scientific publications, currently supervises several doctoral theses and master's dissertations, and has served on various thesis defence panels at universities across the country.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the Publisher /Journal and/or the editor(s). The Publisher /Journal and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

© Copyright: All rights reserved.