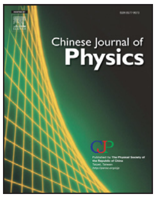
Chinese Journal of Physics 000 (2016) 1–8

Contents lists available at ScienceDirect

Chinese Journal of Physics

journal homepage: www.elsevier.com/locate/cjph



Performance of conversion efficiency of a bifacial silicon solar cell with particle irradiation

Gökhan Sahin[a,*], Fabe Idrissa Barro[b], Moustapha Sané[b],
Prince Abdoul Aziz Honadia[b], Adem Kocyigit[a], Genber Kerimli[a]

[a] *Electric and Electronic Engineering Department, IĞDIR University, Iğdır 76000, Turkey*
[b] *Department of Physics, Semiconductors and Solar Energy Laboratory, Faculty of Science and Technique, Cheikh Anta Diop University, Dakar BP5005, Senegal*

ARTICLE INFO

Article history:
Received 27 June 2016
Revised 21 September 2016
Accepted 14 October 2016
Available online xxx

Keywords:
Bifaciality
Conversion efficiency
Solar cell
Irradiation
Fluence

ABSTRACT

This paper investigates theoretically the performance of conversion efficiency of a bifacial silicon solar cell with particle irradiation. The bifaciality coefficient and the conversion efficiency are calculated for various rear side illumination conditions and electron fluence, taking into account the diffusion length related damage coefficient. The main purpose of the work is to show that irradiation could significantly degrade both the bifaciality coefficient and then the conversion efficiency of the bifacial solar cell and to exhibit the role of the fluence and rear side illumination condition level in the performance of the bifacial silicon solar cell.

1. Introduction

Bifacial solar cells, that is, semiconductor devices that are able of direct conversion of light into electricity from both sides were introduced since 1960 [1]. The main advantage when using bifacial solar cells instead of monofaciale solar cells is the generation of additional energy resulting from the conversion of the radiation collected by the rear side of the solar cell. Since their introduction bifacial solar cells continue to be improved to minimize both optical and electrical losses leading to a significant increase of their conversion efficiency [1–4] and their applications increased. Initially pioneered by space industry, essentially because solar energy is one of the main power sources for satellites, bifacial solar cells have made it to industrial PV arena.

During their operation on satellites bifacial solar cells are subjected to large temperature variations, space dust, and various types of irradiating particles that can be grouped into three major categories [5–7]: photons (x-rays and gammas), charged particles (electrons, protons, alpha particles, and heavy ions), and neutrons. Since these irradiating particles can damage the semiconductor structure [8–10], the performance of the solar cell under radiation exposure could be degraded significantly. It is then of major interest to investigate on solar cell parameters dependencies on radiation parameters.

The aim of the present work is to show how irradiation (particle fluency, damage coefficient) could influence the performance of a bifacial silicon solar cell, especially its conversion efficiency and bifaciality coefficient. The performance of the bifacial silicon solar cell under irradiation is evaluated taking into account the illumination level of the rear side of the cell.

---

[*] Corresponding author.
E-mail addresses: g.sahin38@hotmail.fr, konyakayseri@hotmail.com (G. Sahin).

http://dx.doi.org/10.1016/j.cjph.2016.10.018

Please cite this article as: G. Sahin et al., Performance of conversion efficiency of a bifacial silicon solar cell with particle irradiation, Chinese Journal of Physics (2016), http://dx.doi.org/10.1016/j.cjph.2016.10.018

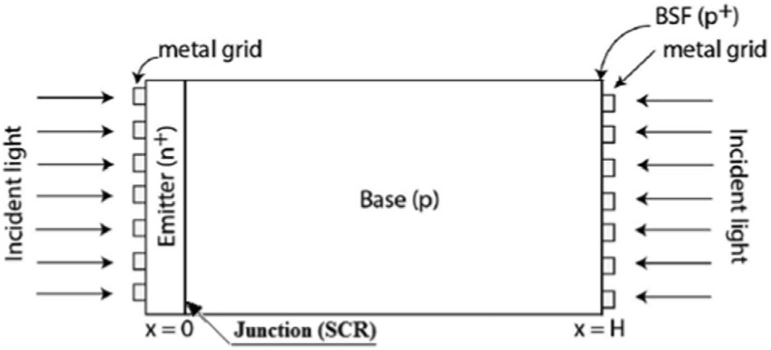


Fig. 1. Bifacial silicon solar cell.

2. Theory and model

This study is based on a bifacial silicon solar cell with an n+-p-p+ structure (Fig. 1). Given 20 that the base has a greater contribution to photocurrent, the following analyses have been conducted only in this region. A solar cell is actually a large area diode; here it is n-type -p- p+with a structure presented below.

We assume a quasi-neutral p-type base (QNB), low injection condition and no lateral effect; the principal transport mechanism then remains a one-dimension diffusion of minority carriers (electrons). Carrier generation, recombination and drift/diffusion are the three major phenomena that occur inside the solar cell under illumination; in steady state the transport equation can be written as [11,12]**:**

It may be noted three main parts which are the emitter (field n) or the front face, the branch around a space charge zone and the base (p region). The issuer is the doped portion with an impurity atom concentration of from 10^{17} to 10^{19} atomes cm^{-3}; its thickness is smaller (generally less than 1 μm). The base is lightly doped with a concentration of impurity atoms from 10^{15} to 10^{17} atomes cm^{-3}, but a much larger thickness up to 400 μm; since the base is p-type minority carriers are electrons.

We then the junction at the emitter-base interface called area space charge with a high electric field allowing separation of electron-hole pairs photo created arriving at the junction. The overdoping (P +) at the rear face ensures the creation of a field electric or BSF (Back Surface Field) for returning to the junction carriers generated in the vicinity of this rear face. To ensure the electrical connections to any external circuit, has electrical contacts deposited as metal gates [13]. In the remainder of this study, contribution of the transmitter as well as the field lens that exists within the base have been neglected [14]. The solar cell is discussed in one dimension with the original axis taken at of the junction.

When the solar cell is illuminated, different processes occur in the database: it is the generation, recombination and diffusion of carrier's minority in excess. All of these processes can result in called continuity equation that has the form in static mode:

$$\frac{\partial^2 \delta_\alpha(x)}{\partial x^2} - \frac{\delta_\alpha(x)}{L^2} = -\frac{G_\alpha(x)}{D} \tag{1}$$

With,

G_α (x) denotes the generation rate of carriers under illumination for multispectral x depth in the base. [8,15,16]**.**

L is the diffusion length and D is diffusion coefficient, δ_α(x) is the density of electrons generated in the base and the index α used to designate the surface through which the solar cell is illuminated:

Illumination from the front: $\alpha =$ front
Illumination from the back side: $\alpha =$ rear
Simultaneous illumination of both sides: $\alpha =$ bifacial

The diffusion length L (after irradiation) is related to the particle fluence φ and the diffusion length damage coefficient K_L by the following relation [6,10]**:**

$$L(K_L, \phi) = \frac{1}{\sqrt{\left(\frac{1}{L_0^2} + K_L.\phi\right)}}. \tag{2}$$

The damage coefficient K_L is related to both particle type and energy; L_0 is the minority carrier diffusion length prior to particle irradiation. That is, excess minority carrier diffusion length decrease with irradiation. This diffusion length decrease, directly associated to a corresponding lifetime decrease, produces a degradation of the performance of the cell like conversion efficiency and electrical parameters. The diffusion length L_0 (before irradiation) is associated to the base doping density

Please cite this article as: G. Sahin et al., Performance of conversion efficiency of a bifacial silicon solar cell with particle irradiation, Chinese Journal of Physics (2016), http://dx.doi.org/10.1016/j.cjph.2016.10.018