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RESEARCH ARTICLE

STUDY OF THE EXTERNAL QUANTUM EFFICIENCY AND THE SPECTRAL RESPONSE FOR THE SCREEN-PRINTED FRONT CONTACT SOLAR CELL UNDER DIFFERENT LIGHT SOURCES

Papa Touty Traore[1*], Moussa Dieng[1], Mor Ndiaye[1] and Issa Diagne[1]

[1]Department of Physics, Cheikh Anta Diop University, Dakar Senegal; [2]Informatics Practitioner, Central Java, Indonesia

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ABSTRACT

The external quantum efficiency EQE(λ) is the fraction of photons incident on the solar cell that create electron-hole pairs in the absorber, which are successfully collected. It is wavelength dependent and is usually measured by illuminating the solar cell with monochromatic light of wavelength λ and measuring the photocurrent Iph through the solar cell. The aim in this work is to show the external quantum efficiency and the spectral response for the screen-printed solar cell under different illumination. The photocurrent delivered by the solar cell is highlight for each illumination. The work environment is the power simulation softward PV Lighthouse.

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INTRODUCTION

Screen-printed solar cells were first developed in the 1970's. As such, they are the best established, most mature solar cell fabrication technology, and screen-printed solar cells currently dominate the market for terrestrial photovoltaic modules. The key advantage of screen-printing is the relative simplicity of the process. There are a variety of processes for manufacturing screen-printed solar cells. Screen-printed solar cells typically use a simple homogeneous diffusion to form the emitter where the doping is the same beneath the metal contacts and between the fingers. To maintain low contact resistance, a high surface concentration of phosphorus is required below the screen-printed contact. However, the high surface concentration of phosphorus produces a "dead layer" that reduces the cell blue response. Newer cell designs can contact shallower emitters, thus improving the cell blue response. Selective emitters with higher doping below the metal contacts have also been proposed [1],[2] - and are being introduced into commercial production. The quantum efficiency may be given either as a function of wavelength or of energy. If all photons of a certain wavelength are absorbed and the resulting minority carriers [3] are collected, then the quantum efficiency at that wavelength is unity. The quantum efficiency for photons with energy below the band gap is zero. The quantum efficiency can be viewed as the collection probability due the generation profile of a single wavelength, integrated over the device thickness and normalized to the incident number of photons at that wavelength. The spectral response [4] is conceptually like the quantum efficiency. The quantum efficiency gives the number of electrons output by the solar cell compared to the number of photons incident [5] on the device, while the spectral response is the ratio of the current generated by the solar cell to the power incident on the solar cell.

MATERIALS AND METHODS

Materials

The instrumen that used in this study are:

1. Unscaled xenon lam with aescusoft Sol Sim Single Xe lamp
2. Unscaled Sunlight with AM1.5g. [Gue95] model
3. Screen-printedfront contact for external quantum efficicencysolar cell with aescusoft modeln,[6]
4. Under standard test conditions

The model is applied under the powerful softward calculator pvlighthouse developed by Keith McIntosh, Malcolm Abb Ben Sudbury and many contributors from the PV industry.[7]

The external quantum efficiency is given by [6]

$$EQE = \frac{I_{ph}(\lambda)}{q\,\Psi_{ph,\lambda}} \quad (1)$$

where q is the elementary charge and Ψph, λ is the spectral photon flow incident on the solar cell. Since Iph is dependent on the bias voltage, the bias voltage must be fixed during measurement. The photon flow is usually determined by measuring the EQE of a calibrated photo diode under the same light source. The spectral response uses the power of the light at each wavelength whereas the quantum efficiency uses the photon flux. Converting QE to SR is done with the following formula:

$$SR = \frac{q\lambda}{hc}EQE \qquad (2)$$

Where SR is the spectral response, EQE the external quantum efficient, q is the elementary charge, h plank constant and c speed of light.

RESULT AND DISCUSSION

First we show the spectral response and the external quantum efficiency of the screen-printed front contact solar cell illuminated by the unscaled sunlight [8]. The figure 2 and table 1 above show the results.

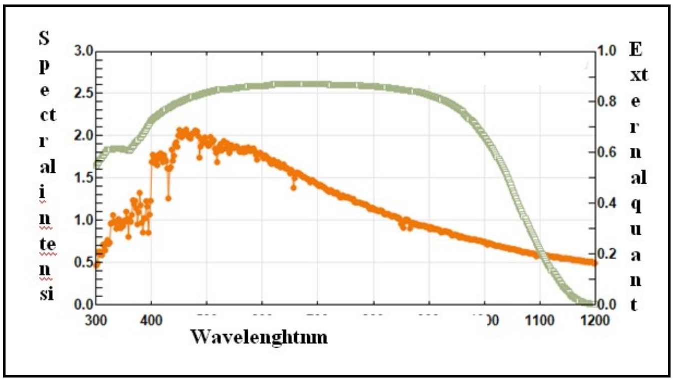

Fig. 1. Spectral intensity and external quantum efficiency versus sunlight wave length

Over the range of 300nm-450nm the spectral intensity increases and reach the maximum. The growth response is due to front surface recombinason. for more than 500 nm the spectral response decreases. The reduced response is due to rear surface recombinaison. But that decay is approximatively linear. That means the spectral response of the screen-printed front contact solar cell is more important over the range 350nm-490nm when it is illuminated by unscaled sunlight. The external quantum efficiency is quasi static over the range of 500 nm and 900 nm. In that range EQE reach its maximum value approximately 0.85. The table below shows the intensity, the photo current and the short-circuit current of the solar cell. Table 1 Spectral outputs over the range of 300nm-to 1200nm of wavelength for unscaled sunlight. Second, we show the spectral response and the external quantum efficiency of the screen-printed front contact solar cell illuminated by the unscaled xenon lamp.

The figure 3 and table 2 above show the results.

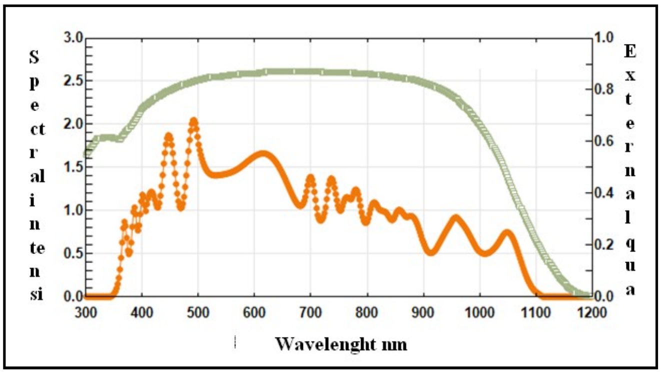

Fig. 2. Spectral intensity and external quantum efficiency versus Led wave length

Over the range of 300nm-490nm the spectral intensity increases like an exponential growth function and reach the maximum approximatively at 495nm. for more than 500 nm the spectral response decreases. But that decay is not linear. That means the spectral response of the screen-printed front contact solar cell is more important over the range 350nm-490nm when it is illuminated by unscaled xenon lamp. The external quantum efficiency is quasi static over the range of 500 nm and 900 nm. In that range EQE reach its maximum value approximately 0.85.

The table 2 below shows the intensity, the photo current and the short-circuit current of the solar cell.

	Xenon lamp spectrum
Intensity (mw/cm^2)	83.21
Photon current (mA/cm^2)	49.06
Short-circuit current density (mA/cm^2)	34.05

End, we show the spectral response and the external quantum efficiency of the screen-printed front contact solar cellilluminated by the Led. The Table 2 above show the results.

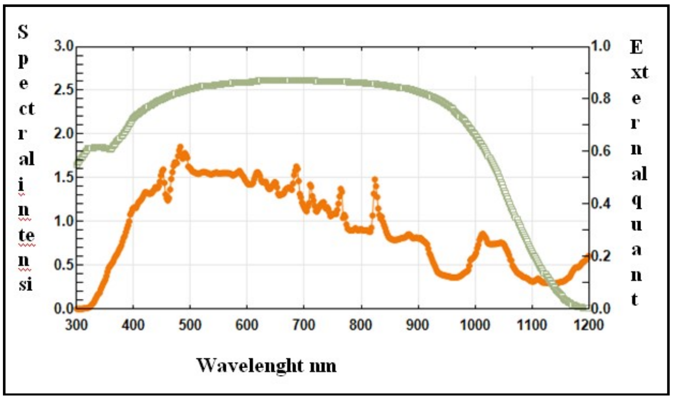

Fig. 3. Spectral intensity and external quantum efficiency versus Xenon lamp wavelength

Over the range of 300nm-450nm the spectral intensity increases and reach the maximum. But the growth is not exponential for some wavelength in that range the spectral intensity decreases. For more than 500 nm the spectral response decreases. But that decay is approximatively linear. That means the spectral response of the screen-printed front contact solar cell is more important over the range 350nm-490nm when it is illuminated by unscaled sunlight. The external quantum efficiency is quasi static over the range of 500 nm and 900 nm. In that range EQE reach its maximum value approximately 0.85.

Table 3 Spectral outputs over the range of 300nm-to 1200nm of wavelength for Led.

	Sunlight spectrum
Intensity (mw/cm^2)	78.94
Photon current (mA/cm^2)	42.82
Short-circuit current density (mA/cm^2)	34.25

Maximums external quantum efficiency reached by the screen-printed solar cell for is approximately the same for each light source 0.85. Nevertheless, the photocurrent is more important for the sunlight (57.83 mA/cm^2) compared to the xenon lamp and the Led. The last one has 42.82mA/cm^2.

CONCLUSION

In this study different spectral responses are shown for a screen-printed solar front contact solar cell with their external quantum efficiency. The EQE are totally different foralllight sources studied, unscaled sunlight, unscaled xenon lamp and Led. The photocurrent delivered by the solar cell under sunlight illumination is more important than the photocurrent delivered but unscaled xenon lamp and led. Nevertheless, the maximum external quantum efficiency reach by the solar cell is the same for all sources of light.

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