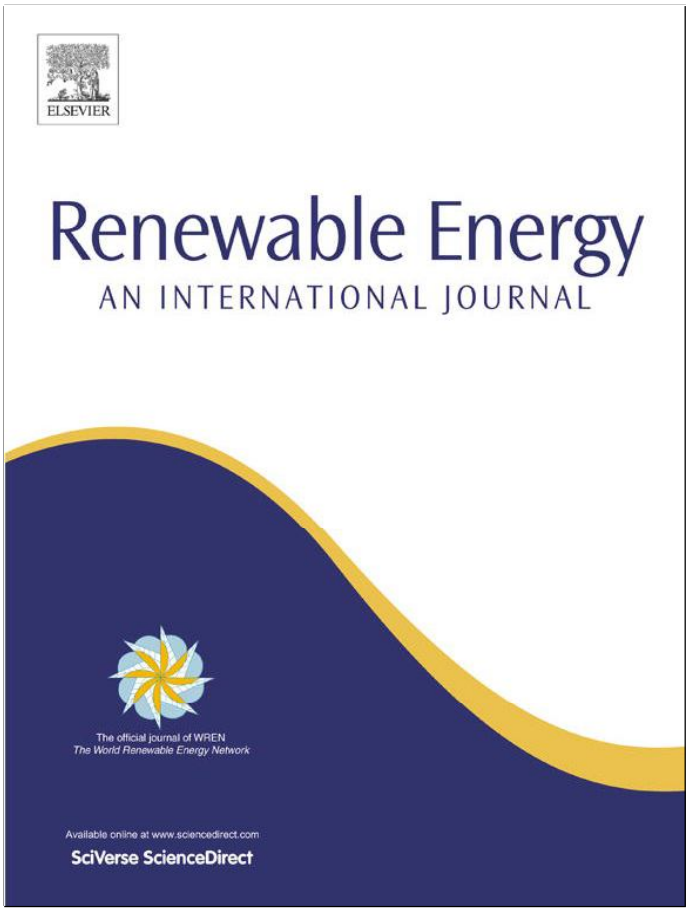

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Analytical expression of the physical parameters of an illuminated solar cell using explicit *J–V* model

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ABSTRACT

The *J–V* characteristics of an illuminated solar cell can be represented as a simple explicit form of $v^{\eta}+j^{\xi}=1$, here the normalized voltage, v and normalized current density j can be represented as $v=V/V_{oc}$ and $j=J/J_{sc}$ respectively, where V_{oc} is the open circuit voltage and J_{sc} is the short circuit current density. Here η and ξ are the shape parameters of the *J–V* curve which can be obtained from the experimental data. In this paper it is shown that the model parameters, η and ξ can be used for the analytical representation of the single exponential model parameters of an illuminated solar cell, namely ideality factor n, parasitic series resistance R_s, parasitic shunt resistance R_{sh}, dark-current density J_0, and photo-generated current density J_{ph}. The simple measurement of voltage (V) and corresponding current density (J) of an illuminated solar cell experimentally determines the parameters η and ξ, with which the physical parameters of the illuminated solar cells can be determined. The proposed analytical expression is used to determine the physical parameters for wide variety of solar cells and gives satisfactory results.

1. Introduction

A simple analytical representation of experimental data is sometimes good practice to choose the simplest mathematical expression which can adequately represent the data. Recently [1], it is shown that the voltage (V) and corresponding current density (J) of an illuminated solar cell can be represented as,

$$v^{\eta}+j^{\xi}=1 \tag{1}$$

where $v=V/V_{oc}$ can be represented as the normalized voltage and $j=J/J_{sc}$ can be represented as normalized current density. Here J_{sc} is the short circuit current density and V_{oc} is the open circuit voltage. The model parameters η and ξ are the shape parameters of the *J–V* characteristics of solar cell to satisfy the experimental data.

For an illuminated solar cell having parasitic series and shunt resistances, the simplest of the current density-voltage (*J–V*) equations called the Single Exponential Model (SEM), has an implicit form

$$J=J_{ph}-J_0\left\{\exp\left(\frac{V+JR_s}{nV_t}\right)-1\right\}-\frac{V+JR_s}{R_{sh}} \tag{2}$$

Here the physical parameters are as follows: J_{ph} is the photo-generated current density, J_0 is the dark-current density, n is the ideality factor, R_s is the unit area parasitic series resistance, and R_{sh} is the unit area parasitic shunt resistance. The parameter V_t, which is not a physical parameter of the solar cell, but depends on the temperature T, is known as Thermal voltage. The knowledge of these physical parameters of a fabricated solar cell is required for process optimization as well as for the simulation of solar cell array. In Ref. [1], it is shown that the Equation (1) is equivalent to Equation (2) with proper choice of the shape parameters η and ξ and this simple analytical representation (1) gives an easy way to calculate the maximum power point and the fill-factor of solar cell using the shape parameters, η and ξ as [1],

$$v_{mpp}=\frac{V_{mpp}}{V_{oc}}=\left(\frac{\xi}{\eta+\xi}\right)^{\frac{1}{\eta}} \tag{3}$$

where v_{mpp} can be regarded as the normalized maximum power point, which can be defined as $v_{mpp}=V_{mpp}/V_{oc}$ where V_{mpp} is the maximum power point; and the fill-factor (FF) as,

$$FF=\left(\frac{\xi}{\eta+\xi}\right)^{\frac{1}{\eta}}\left(\frac{\eta}{\eta+\xi}\right)^{\frac{1}{\xi}} \tag{4}$$

Though the parameters η and ξ of solar cell depends on *J–V* characteristics, these parameters can be related with the physical parameters of the solar cell as [2]

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