Series Resistance of $SnO_2/SiO_2/Si(n)$ Solar Cells

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Abstract. The aim of this work is to determine the series resistance (R_s) of solar cells with a transparent SnO_2 conductor thin film, which affects directly the conversion efficiency, this is for different oxide thicknesses (d). In this kind of solar cell there is no shadow effect, so we do not need any grid as the transparent conductor oxide acts as a conducting layer.
Our modelization results are :

- d= 0 Å(R_S=5 Ohms), efficiency= 13.28%
- d = 10 Å (10 Ohms), efficiency= 18.76%
- d = 24 Å (20 Ohms) efficiency= 21.61%

Key words: solar cell, conversion efficiency, series resistance.

1. Introduction

The series resistance is a parasitic resistance which is detrimental to solar cell performance because it reduces the device power output [1]. The series resistance R_S of a photovoltaic (PV) module represents the resistances in cell solder bonds, emitter and base region, cell metallization, cell-interconnect busbars, and resistances in junction-box terminals [2].
As a practical matter it is generally found that the series resistance in a cell should be no more than a few tenths of an Ohm for each square centimeter of illuminated cell area under one sun conditions [3]. If this is exceeded the cell loads itself down with internal resistance [4]. The series resistance becomes more effective at high generated photocurrents [5].

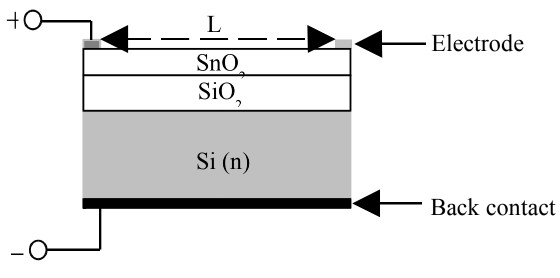


Fig.1 SnO_2-SiO_2-Si (n) structure of solar cell.

In this paper we shall study the SnO_2-SiO_2-Si(n) solar cells (fig.1), in which thin film SnO_2 has the quality of having high electrical conductivity and transparency at least in the visible region of solar spectrum. Its refractive index lies in between 1.9 and 2.0 [6] and hence it can be used as a low resistance top contact to the junction and also as an anti-reflection coating for the active substrate. Since SnO_2 is highly transparent it acts as a window for the transmission of solar Radiation falling directly on the active substrate.

2. Behavior of SnO_2-SiO_2-Si(n) structure under solar concentration

The conversion efficiency under solar concentration can be expressed as:

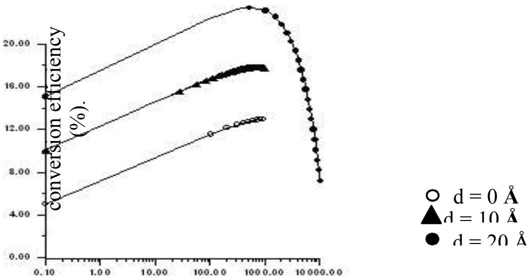
$$\eta(C)_{Rs} = \eta(1)\left[1 + \frac{nKT}{qV_{CO1}} Log(C) - \frac{R_S C^2 I_{CC}^2}{CPi}\right] \quad (1)$$

where:
$\eta(1)$ is the conversion efficiency for radiation not concentrated,
C is the solar concentration,
R_s is the series resistance,
P_i is the incident power,
I_{CC} is the short-circuit current,
V_{CO1} is the open-circuit voltage under one sun,

n is the ideality factor,

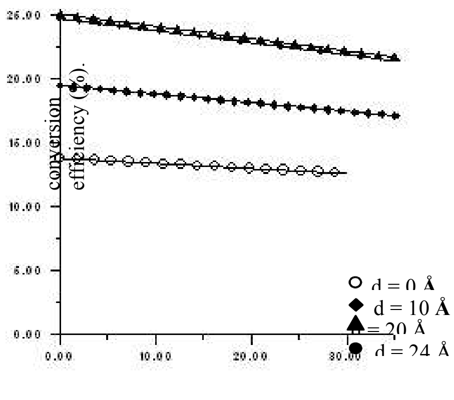
and $\frac{kT}{q}$ is the thermal voltage (=0.026 eV at 300°K).

Fig.2 shows the variation of the conversion efficiency versus the solar concentration calculated for different oxide thicknesses d.
Fig.3 shows the variation of conversion efficiency versus the series resistance calculated for different oxide thicknesses.



solar concentration.

Fig.2 Variation of conversion efficiency versus the solar concentration.



series resistance (Ω)

Fig.3 Variation of conversion efficiency versus the series resistance

We summarize the values of conversion efficiency in Table I.

Table1: Values of conversion efficiency versus series resistance for different oxide thickness.

R_s (Ω) / η(%)	0	5	10	20	30
d= 0 Å	13.33	13.28	13.24	13.15	13.06
d = 10 Å	19.16	18.96	18.76	18.36	17.96
d = 20 Å	24.02	23.35	22.69	21.36	20.03
d = 24 Å	24.51	23.42	22.91	21.61	20.25

3. Discussion and suggestions

For a thickness equals 20 Å (Fig.2) and in the range [0.1, 500] suns, the efficiency increases to reach its maximum (23%), beyond this value there is an obvious fall of efficiency.
For 10 Å thickness, the efficiency reaches its maximum (17%) for 970 suns, afterwards it decreases versus the concentration.
When the oxide thickness is canceled (Schottky structure), the efficiency increases, till its maximum 12.2% where there is a remarkable efficiency decrease.
The behavior of the cell towards efficiency-series resistance variations, when the concentration is fixed (1000 suns) -as shown in Fig.3- appears to have a remarkable linear decrease. The rate of this decrease is clearly proportional to the oxide thickness.

4. Summury

It is clear from this study that the series resistance becomes important because of the spreading resistance in the surface sheet.
We sum up by saying at definite concentration range and in comparison with cells having metallic grid, the SnO_2-SiO_2-Si(n) solar cells have an efficiency which is good but improvable. But over this range they become fewer performers towards their efficiency, which decreases due to the series resistance.
These observations presented here strongly suggest that the conversion efficiency of solar cells can be improved, if an appropriate technology is applied to establish a compromise between the shadow effect and the series resistance effect.

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