Study The Effect of Temperature on The Efficiency of Silicon Solar Cell

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Abstract

It is important to know that the temperature is one of factors which have a great effect on the efficiency of the silicon solar cells .In this study ,the increasing in temperature over it's standard value(±27°C) caused decreasing in the silicone solar cell performance and reduced it's efficiency from η = 7% in 27ºC to η=6.94% , η=6.4% η =6.18% and η = 3.2% in the temperatures of 39.6ºC , 41 ºC , 46 ºC and 64 ºC respectively .

1. Introduction .

The problems with energy supply and use are related not only to global warming , but also to such environmental concerns as air pollution, acid precipitation , ozone depletion , forest destruction , and radioactive substance emissions . however ,to prevent these effects , the power generation with solar cells systems has received great attention in research because it appears to be one of the possible solutions to the environmental problems.

The solar energy may be used to produce electricity in photovoltaic modules Which is based on direct conversion of sunlight into electricity .The solar cells may be produced from various materials, but silicon still remains the most popular material and crystal silicon modules are most of them used. The generation efficiency of the (electron-hole) pairs inside Si p-n junction depends not only on the quality of crystal structure, but also on the temperature of the cell work ; temperature negatively affects the efficiency of photovoltaic (PV) conversion [1,2].

2 .Theory

When photons of light fall on the cell, they transfer their energy to the charge carriers . The electric field across the junction separates photo-generated positive charge carriers (holes) from their negative counterpart(electrons) in depletion zone and produce electromotive force [3].

Like all other semiconductor devices ,solar cells are sensitive to temperature , increases in temperature reduce the band gap of a semi-conductor.The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of electron in the material [4] .

3 . Temperature effect on characteristic of solar cells

The current-voltage (*I/V*) characteristic of the solar cell changes with incident light intensity *S(W/m* ^{2}*)* and Cell temperature *t(ºC).*

3.1 - Short circuit current(*I_{sc}* Short circuit current is the current flowing freely from a photovoltaic cell through an external circuit that has no load or resistance ; the maximum current possible[5].

The decrease of the energy band gap results in a decrease of the density of short – circuit current , but the short circuit current, I_{sc} ,increases slightly with temperature, since the band gap energy, E_G, decrease and more photons have enough energy to create (e-h) pairs. However, this is a small effect and the temperature dependence of the short circuit current from a silicon solar cell is[6]:

$$\frac{1}{I_{sc}}\frac{dI_{sc}}{dT} \approx 0.0006\, per^{\circ}\, C for Si$$

3.2 Open circuit voltage (V_{oc})

It is the maximum voltage possible across a photovoltaic cell or module ; the voltage across the cell in sunlight when no current is flowing

The temperature depends of the open circuit voltage V_{oc} is as follows [5,6] :

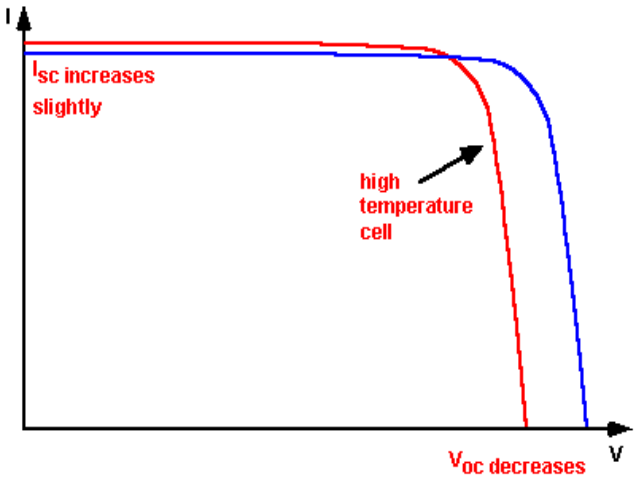
(1)

$$V_{oc}(T) = V_{oc}(300) - \left(\frac{Eg(0)}{q} - V_{oc}(T)\right)\left(\frac{T}{300} - 1\right) - \frac{3kT}{q}\ln\frac{T}{300}$$

The differentiation of Eq (2) gives:[5,6]

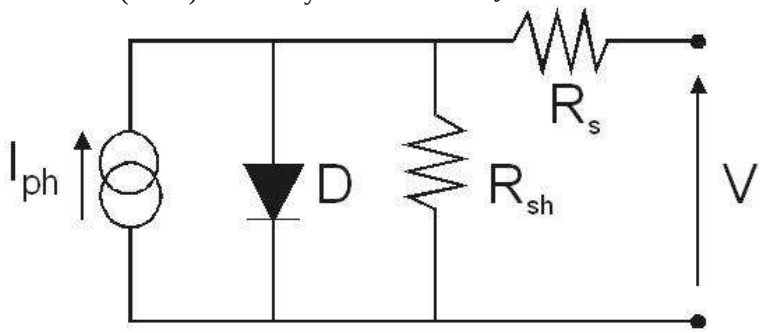
(2)

$$\frac{dV_{oc}}{dT} = \frac{\frac{E_g(0)}{q} + \frac{3kT}{q} - V_{oc}(300)}{T}$$



4. Expermental

Current /Voltage (I/V) characteristic were acquired indoor for a silicon p-type solar cell with (78.5 cm^2) area, (350µm) thickness and (0.5–3) resistivity. It supported from Al-Mansoure factory ,Iraq, under different temperatures. The indoor tests were taken by digital multimeter supported by Phywe company , Germany.



Figure(1): the circuit of solar cell measurement recorded

5. Measurements and results

Five I/V serieses were measured under different temperatures (table1). This kind of measuring is used to obtain efficiency as a function of cell temperature from which the temperature coefficient of efficiency is then determined [7].

table (1): measurements obtained for solar cell

	Temperature ºC	Irradiance mW/cm^2	Efficiency %η
Silicon Solar cell	27	100	7
	39.6	205	6.94
	41	216	6.4
	46	288	6.1
	64	478	3.2

The I/V curves of solar cell and it's efficiencies had taken in different temperatures by digital thermometer when the solar cell surrounded by three mirrors that form "triple mirrors concentrator". The value of falling irradiance intensity had been changed by using lenses of different refractive index . figer 2 shows The I/V curve of the solar cell characteristic in 27ºC and100 mW/cm^2 irradiance intensity

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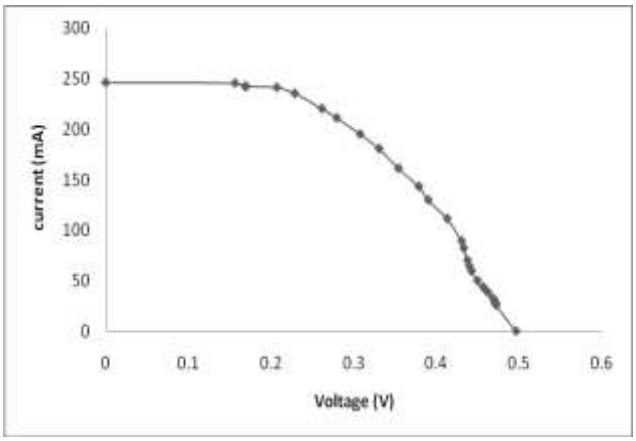

figure 2: The I/V curve of the solar cell in 27ºC and irradiance intensity 100 mW/cm^2 .

the efficiency of solar cell calculated by equation :

$$\eta = \frac{P_m}{P_{in} A_c} \quad (3)$$

η : efficiency of solar cell
P: maximam power of solar cell
$P_{in:}$ 100 mW/cm^2
Ac : the effective area of solar cell
The result of This equation , the solar cell efficiency is 7% in 27ºC. Figure 3 shows a decreasing in voltage of solar cell then reduce it's efficiency to 6.94% under 39.6ºC and 205 mW/cm^2.

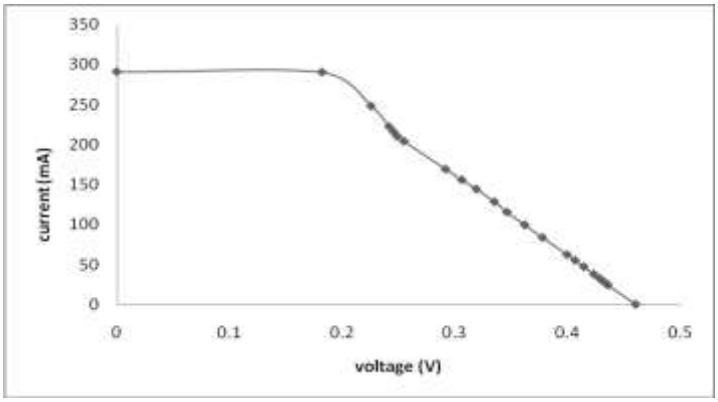

figure 3: I/V curve under 39.6ºC

The 4 , 5 and 6 declare The properties of solar cell under , 41 ºC , 46 ºC and 64 ºC and irradiance intensities of 216 mW/cm^2, 288mW/cm^2 and 478 mW/cm^2 .Hence the efficiencies were η=6.94% , η=6.4% η =6.18% and 3.2% respectively.

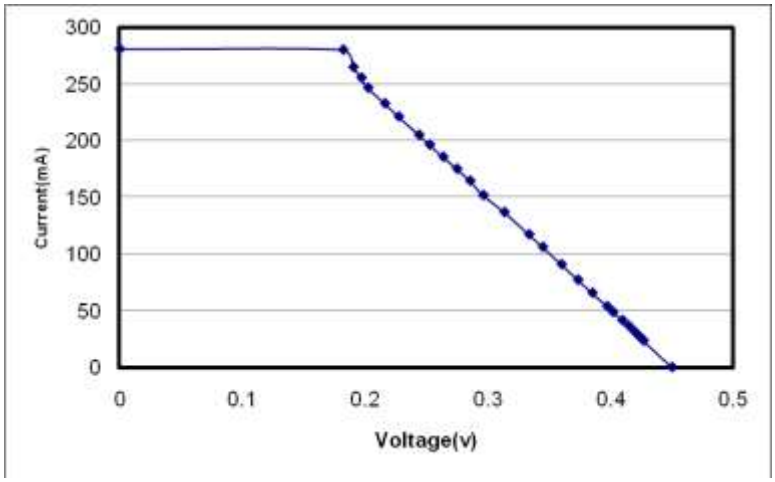

figure 4: I/V curve under 41ºC

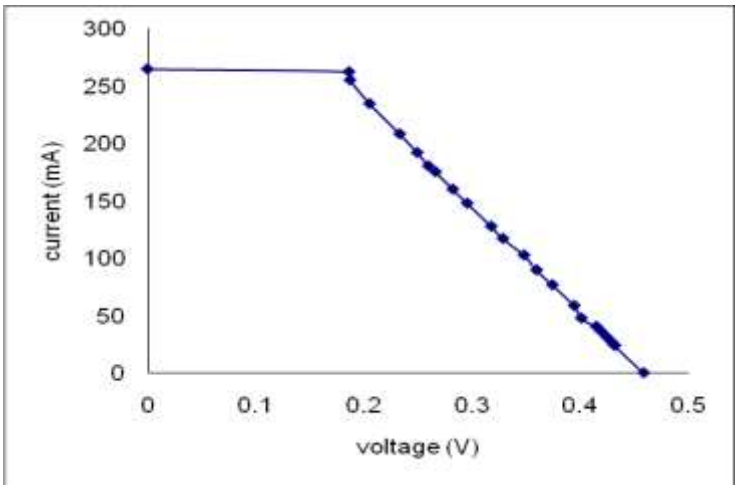

figure 5: I/V curve under 46ºC

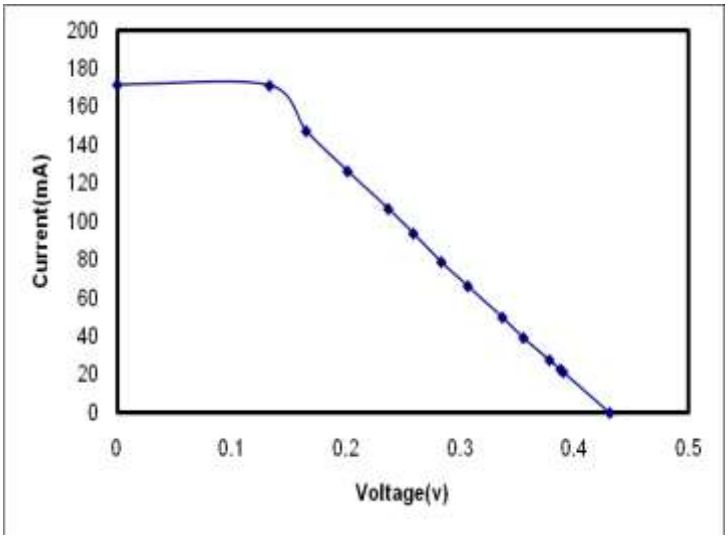

figure 6: I/V curve under 64ºC

Conclusion:

This paper declare that the increasing in temperature of solar cell over it's standard value(±27°C) caused a decrease in it's performance and reduce in the conversion efficiency.

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دراسة تأثير درجة الحرارة على كفاءة الخلية الشّمسية السّليكونية

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الملخص

من المهم معرفة أنّ درجة الحرارة تعدُّ من العوامل المهمة ذات التأثير الكبير على كفاءة الخلية الشّمسية السّليكونية .

في هذه الدّراسة لوحظ أنّ زيادة درجة الحرارة سببتْ انخفاضا في أداء الخلية الشّمسية ، وقللت من كفاءة التّحويل من η= 7% عند درجة الحرارة القياسية (27°C) إلى η=6.94% وη=6.4% و η =6.18% و η = 3.2% في درجات الحرارة 39.6ºC ، 41 ºC ، 46 ºC ، و 64 ºC .