THE EFFECT OF LASER ON THE ELECTRICAL CHARACTERISTICS OF CRYSTALLINE SILICON SOLAR CELLS

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1. ***ABSTRACT:*** *This study is aimed at to find changes that occur on electrical characteristics for monocrystalline silicon solar cells when exposed to laser light continuous wave mode (CW) at different time periods. Experimental results showed that most output values of the solar cell parameters were increased after irradiation for a period of 15 minutes, then began declining gradually increase when the irradiation of up to less than the value before irradiation values also the values of the internal parameters of the sample were increased according to the irradiation time, this increase also contributed to the decrease in the efficiency of the solar cell conversion. The increase in parameter values for the solar cell when irradiation went out for a period of 15 minutes, due to the short-term radiation exposure, while the values decreased to increase the period of exposure to radiation due to changes in crystal structure resulting from the defect and blemishes caused by prolonged exposure to radiation that.*

Keyword: laser light**,** solar cell**,** open circuit**,** power, irradiation

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2. INTRODUCTION:

The crystalline silicon solar cells are still the best options for photovoltaic solar energy systems, in the space or the land [1]. The electrical characteristics of silicon solar cells are affected by environment condition, they are exposed to radiation such as used in space systems and satellites [2]. They are exposed to radiation, such as: gamma rays, neutrons, charge particles, etc. These types of high-energy radiation lead to defects and damage of crystalline structure of silicon solar cells. These defects lead to the deterioration of the electrical characteristics of solar cells [3, 4].

Photo-voltaic means “light-electricity”. Photovoltaic (PV) consist of two terms “Photo” which comes from the Greek word “Phos” which means “Light” and “Volt” comes from the name of Alessandro Volta (1745-1827)[5]. The photovoltaic effect is the conversion of light energy into electricity using a device called a solar cell [6, 7, 8].

3. Theory:

The most important output parameters of the solar cell are [9]: short circuit current I_{sc} Open circuit voltage Voc, fill factor FF and efficiency. Figure (1), shows the relation among these quantities[10].

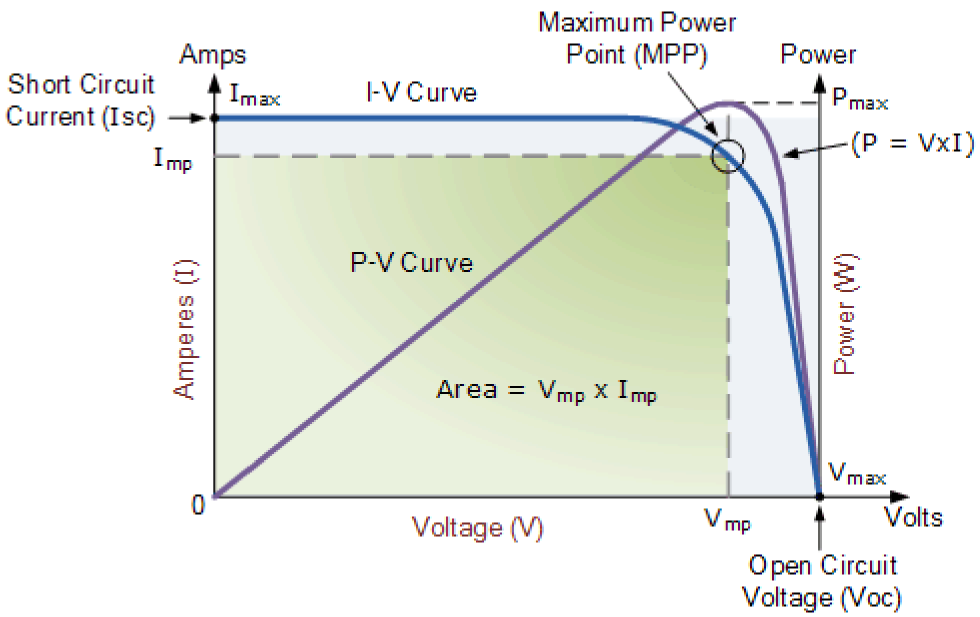

Figure (1) : Characteristic curve of the solar cell[11]

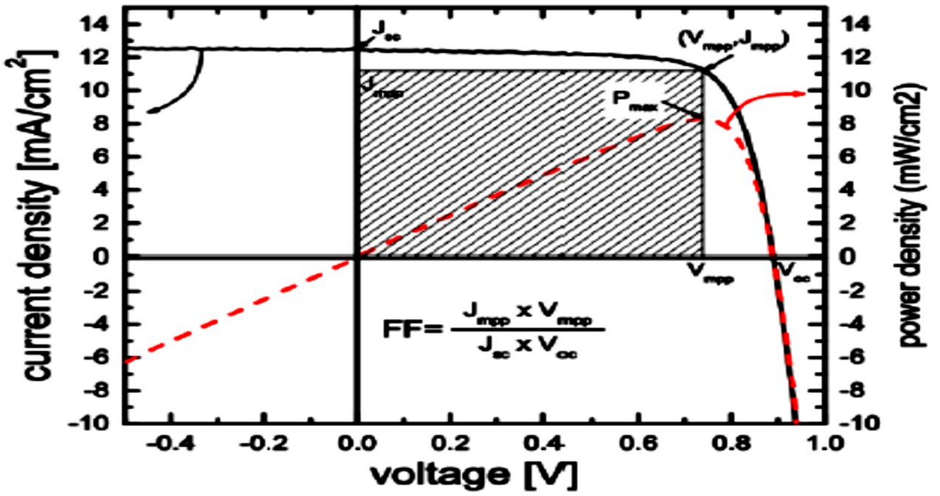

Figure (2): Effect of series resistance on I-V curve[16]

The maximum power P_{max} from the figure (3) can be calculated by the relations : $P_{max} = I_{mp}V_{mp}$.

The fill factor (FF) parameter for solar cells can be found from[12] :

$$FF = \frac{I_{max}V_{max}}{I_{sc}V_{ov}} \dots (1)$$

The efficiency (η) for a solar cell is given by[13] :

$$\eta = \frac{I_{sc}V_{oc}FF}{P_{in}} \dots (2)$$

Where :

P_{in} is the incident light power[14,15].

The effect of the series res
istance and shunt resistance on the I-V curve is shown in Figure (2)

4. Methods of Experiment:

In this research, we used one sample of mono-crystalline silicon solar cells pn-type and irradiated by laser light source CW with 532 ± 10 nm wavelength and 2000 mW output power. At different times (15, 30, 60, and 90) minutes. The cell sample put in front of the laser light beam in the appropriate distance, and the laser light covers about 75 to 80% of the cell are by using the diverged lens as shown in figure (3)..

We built solar laboratory system as illustrated in figure (4). The illuminated by tungsten lamp with lighting Intensity 100mW/cm^2 at room temperature.

Table (1) refers to the most important results achieved before and after the atatherer (I-V) and for multiple temporal periods to observe the variable load. Figure (5) refers to the wavelengths where amplitude can be increased to focus the light with a wavelength and thus increase efficiency Light cell

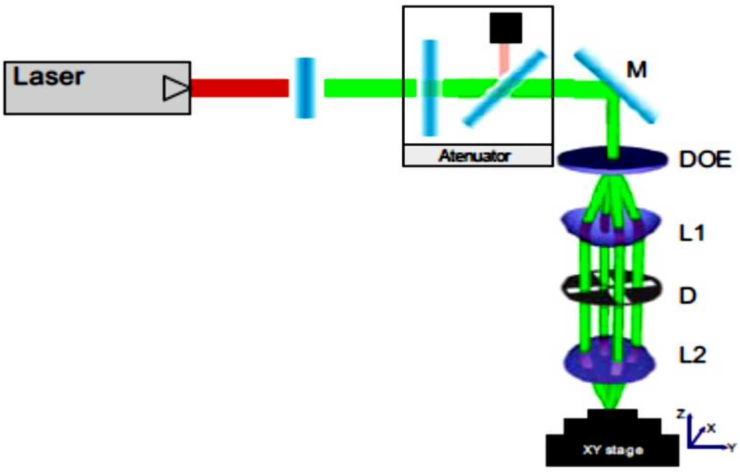

Figure (3) the laser light [17]

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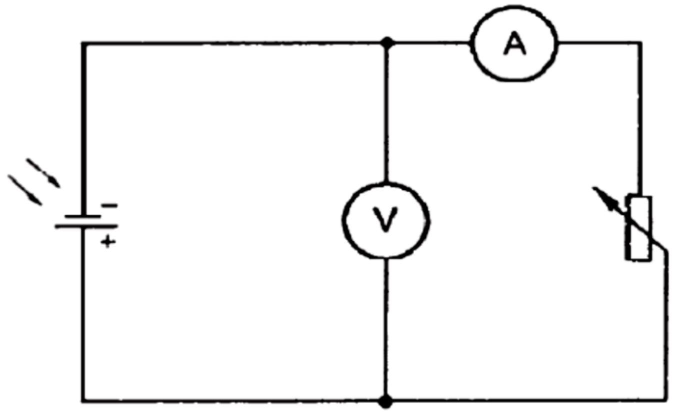

Figure (4) : Circuit for I-V characteristics of solar cell

Table (1) : represent the (I-V) characteristic in illumination state for cell sample before and after irradiation.

Time (m)	R_s (Ω)	R_{sh} (Ω)	I_{sc} (A)	V_{oc} (V)	P_{max} (W)	FF	η%
before	0.98	45.73	0.15	0.49	0.0385	0.5238	3.31
after 15	1.00	46.67	0.15	0.50	0.0448	0.5973	3.85
after 30	1.07	50.00	0.14	0.50	0.0432	0.6171	3.71
after 60	1.13	52.76	0.13	0.49	0.0380	0.5965	3.27
after 90	1.20	56.00	0.12	0.48	0.342	0.5937	2.94

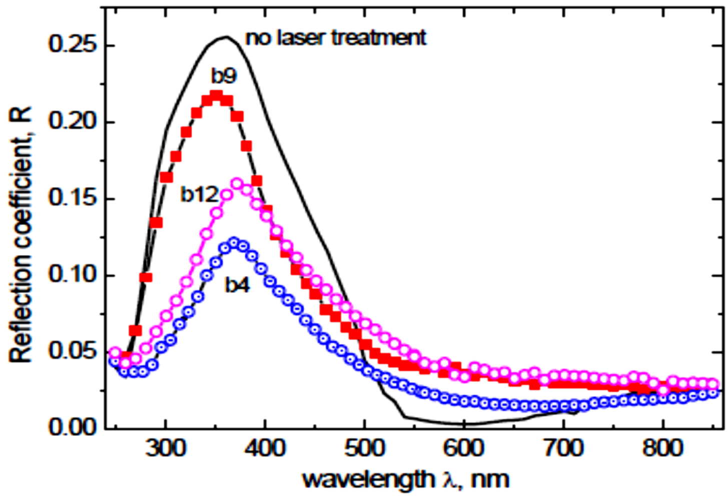

Figure (5) : presents the absorption and reflection spectra of laser-modified solar cells

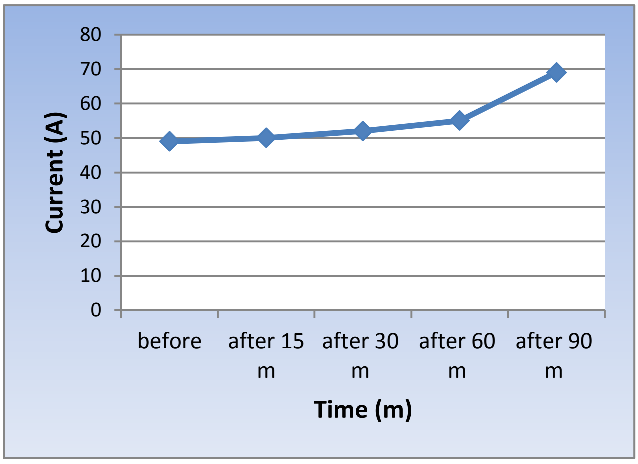

Figure (6): Short circuit current with the time of laser irradiation for the solar cell sample

4.1. Short circuit current (I_{sc})

Figure (6) shows the changes short-circuit current parameter with time of laser irradiation for solar cell sample.

The value of short circuit current increased in solar cell sample after period irradiation 15 minutes and decreases gradually when increased the time of irradiation, this mainly related to the minority carrier lifetime.

The minority carrier lifetime of solar cells, is the average time which a minority carrier can spend in an excited state after electron-hole generation before it recombines. The lifetime of minority carriers is sensitive to the radiation-induced defects that mostly act as recombination points.

4.2. Open circuit voltage (V_{oc})

Figure (7) shows the changes open circuit voltage parameter with time of laser irradiation for solar cell sample.

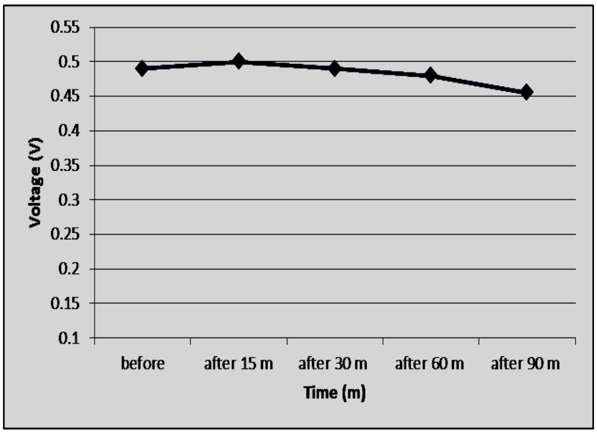

Figure (7): Open circuit voltage with a time of lase4r irradiation for solar cells sample

There is no significant difference in the value of open circuit voltage for the solar cell sample before and after irradiation for different time periods, only some of the cases showed a decrease in the open-circuit voltage values, due to the increase in the degree of solar cell temperature, due to the irradiation.

Like all other semiconductor devices, solar cells are sensitive to temperature; increases in temperature reduce the band gap of a semiconductor. The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material, lower energy is therefore needed to break the ond, in the bond model of a semiconductor band gap, reduction in the bond energy also reduces the band gap, therefore increasing the temperature reduces the band gap. In a solar cell the parameter most affected by an increase in temperature is the open-circuit voltage.

4.3. Maximum power :

Figure (8) shows the changes maximum power parameter with time of laser irradiation for solar cell sample.

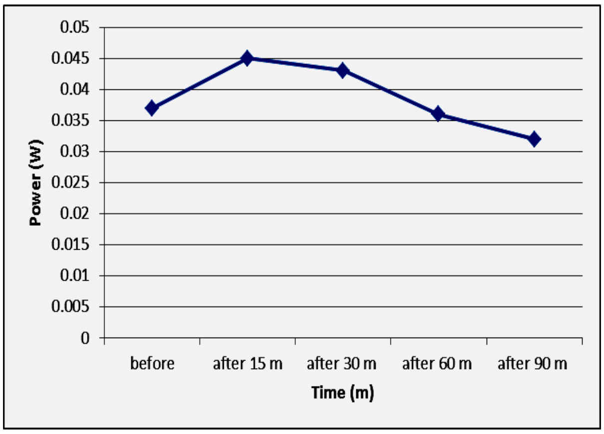

Figure (8): Maximum power with a time of laser irradiation for solar sample

The value of maximum power is increased in all samples after irradiation by laser light for a period of 15 minutes when the irradiation time is greater than 30 minutes, the value of maximum power gradually decreased in all solar cell sample to reach value less than its value before irradiation. This decrease is due to the adoption of maximum power on the current $P_{max} = I_{max}V_{max}$.

4.4. Fill factor (FF)

Figure (9) shows the changes fill factor parameter with time of laser irradiation for solar cell sample.

The value of fill factor increased with time irradiation increase. This is due to the increase in the degree of heat of the sample during laser light irradiation.

4.5.Efficiency

Figure (10) shows the changes efficiency with time of laser irradiation for solar cell sample.

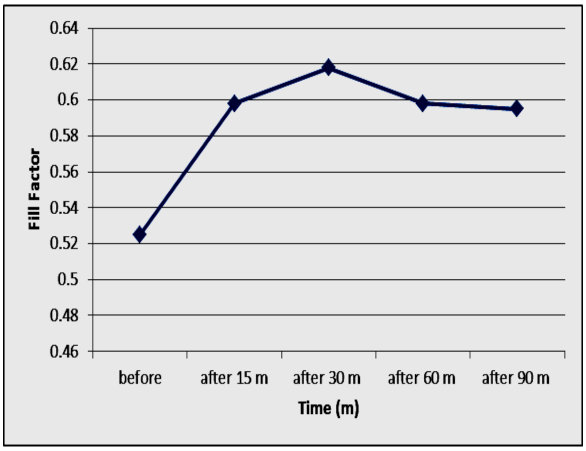

Figure (9) : Fill factor with a time of laser irradiation for solar cell sample.

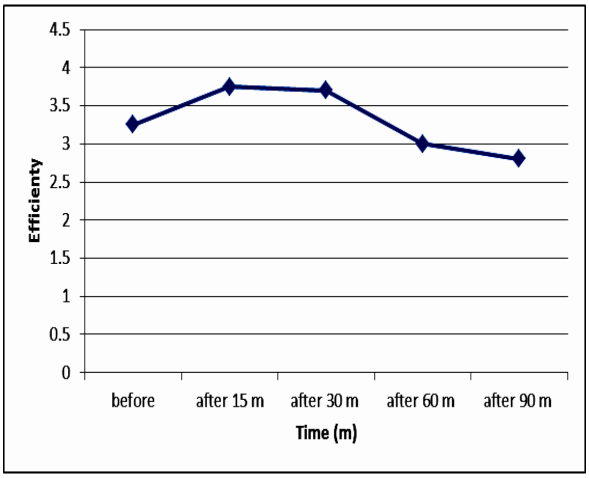

Figure (10): Efficiency with a time of laser irradiation for the solar cell sample

The efficiency of solar cells dependent on the values of each of the short circuit current (I_{sc}), open circuit voltage (V_{oc}), maximum power (P_{max}), and the fill factor (FF). Where affected by an increase or decrease values in parameters.

The efficiency increases relatively after irradiation period 15 minutes from their pre-irradiation, then begins to decrease gradually the greater the irradiation period of up to less than the value before irradiation.

4.6. The Internal parameters of a solar cell include series resistance (R_{se}) and Shunt resistance (R_{sh})

a- series resistance (R_{sc}): Figure (11) shows the series resistance with time of laser irradiation for solar cell sample. b- Shunt Resistance (R_{sh}): Figure (12) shows the series resistance with time of laser irradiation for solar cell sample.

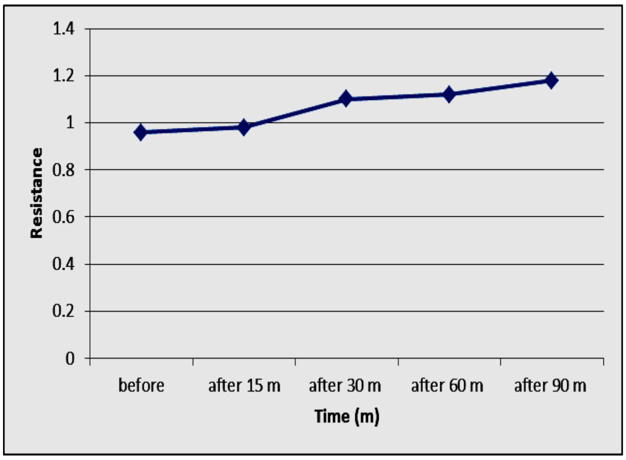

Figure (11) : Series resistance with a time of laser irradiation for solar cell sample

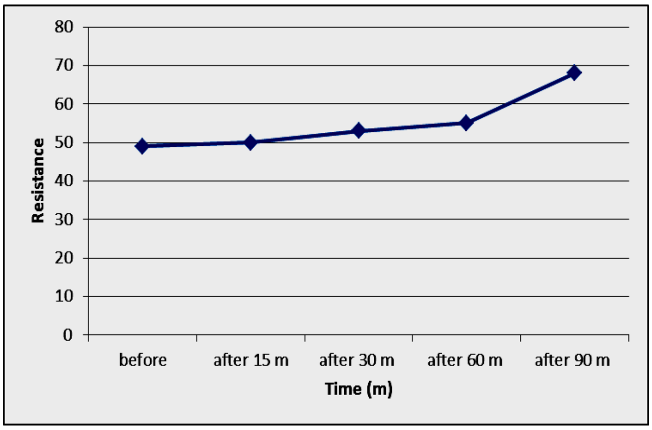

Figure (12): Shunt resistance with a time of laser irradiation for the solar cell sample

Decrease in the efficiency of the solar cells samples, is due to the increase I the value of series resistance and shunt resistance, and the significant increase of efficiency in most samples irradiation period of 15 minutes, offset by a decrease in the value of each of series resistance and shunt resistance at the same period of irradiation 15 minutes.

The decline in solar cells efficiency has to be overcome by series resistance, because of the main impact of series resistance in the maximum power point voltage, although excessively high values may also reduce the short-circuit current.

The effect of a shunt resistance is particularly severe at low light levels since there will be less light-generated current. The loss of this current to the shunt, therefore, has a larger impact. In addition, at lower voltages where the effective resistance of the solar cell is high, the impact of a resistance in parallel is large.

5. CONCLUSION:

Results show that all output parameters of solar cell, namely, short-circuit current (I_{se}), open-circuit voltage (V_{oe}), maximum power (P_{max}), fill factor (FF), and relative efficiency (η), were degraded after irradiation by laser doses in the periods time (30 - 60 and 90) minute. But in irradiation for a period 15 minutes, the sample it achieved an increase in output parameters of the solar cell.

The internal parameter for the sample of solar cells has increased with increasing period of irradiation, but this increase means a decrease in the efficiency of the solar cell.

The deterioration of output parameters in the solar cells sample under laser irradiation was observed influenced by increasing the period of irradiation.

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