MIT World Peace University

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Characteristics of a Solar Cell

Experiment No. 7

Prepared By

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Pledge

I solemnly affirm that I am presenting this journal based on my own experimental work. I have neither copied the observations, calculations, graphs and results from others nor given it to others for copying.

Signature of the student

1 Aim

To plot I-V characteristics of solar cell, to determine its fill factor and corresponding optimum load

2 Apparatus

1. Solar cell/solar panel
2. Current and voltmeters (OR DMM)
3. Variable load and source of light

3 Significance of the Experiment

Solar cell is a specially designed PN junction which converts light in to electrical power. The ability of the solar cell to deliver optimum power to the optimized load is signified in terms of its fill factor. The present experiment aims at calculation of the fill factor and corresponding optimum load for a given solar cell.

4 Theory

Solar cell is a specially designed PN junction diode that converts light into electrical power. This conversion occurs in three stages. When the PN junction is exposed to light, electron hole pairs are generated in P and N regions. These are then separated across opposite electrodes due to emf at the junction. (refer Fig.7.1). The separated carriers accumulate across the metal contacts and thus generate a potential difference (p.d). This p.d. can drive the optically excited minority carriers in circuit. Thus solar cell, when exposed to light, behaves as a battery that can deliver power to a load. The typical voltage and current from one junction is around 0.6 volts and a few micoramp, however this can be increased by cascading the solar cells in series and parallel (solar panels). Solar cells generate electricity from inexhaustible, freely available sunlight and without pollution, without accidents and need less maintenance. Further, an option of decentralized production can decrease transmission losses. However the low efficiency (10high production cost and dependence on sunlight limit its applications to remote areas (such as satellites and villages in deserts, forests) and low power accessories (such as calculators, wrist watches, street lights and solar water pumps). If efficiency is improved, solar power may find uses in solar automobiles, solar houses and many other areas.

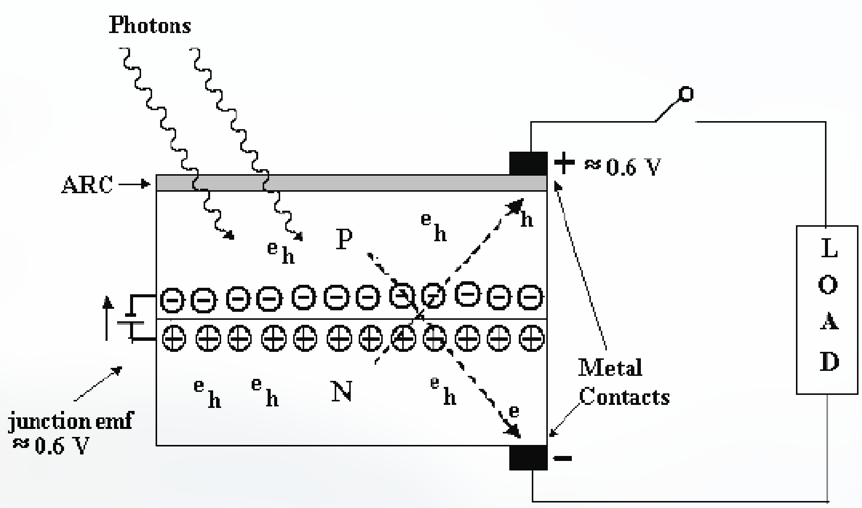


Fig. (7.1): Solar cell and its working

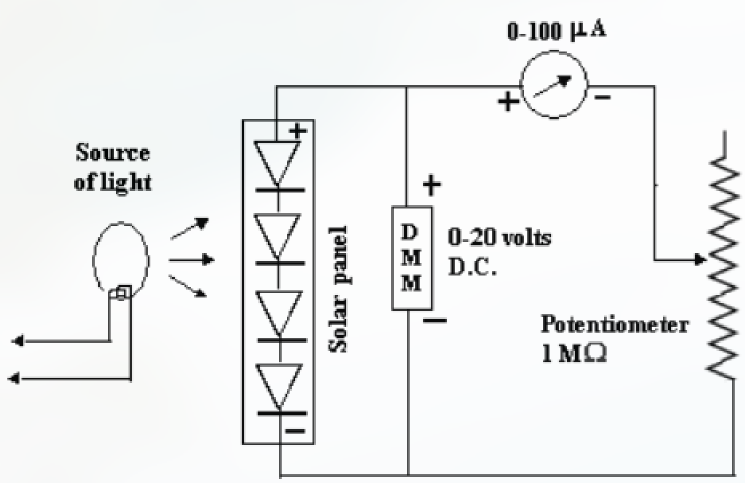


Figure (7.2): Circuit diagram

5 Procedure

1. Connect the circuit as shown in the diagram (Fig.8.2) and get it checked. Connect DMM as a 0-20 voltmeter in parallel and DMM and $0-200\mu$A in series across the 1MΩ variable load.

2. Make the light source ON and keep it to optimum intensity.

3. Take as many as possible current and voltage readings by varying the load. The readings corresponding to minimum and maximum load must be taken. Tabulate your observations as per table 8.1

4. Plot the graph of current Vs voltage. This represents characteristics of solar cell (refer Fig 8.3)

5. Extrapolate the graph on current and voltage axis. While extrapolating the curve keep the slope same. Calculate I_{SC} (Short circuit current) and V_{OC} (Open circuit voltage) from the intercept of the curve on current and voltage axis respectively. Draw perpendiculars at I_{SC} and V_{OC}. Intersection of these two lines defines a point $P_I\left(I_{SC,}, V_{OC}\right)$. The product $P_I = I_{SC} \times V_{OC}$ signifies ideal but unachievable power (refer Fig.8.3). The ideal power is unachievable because short circuit condition and open circuit condition cannot be obtained simultaneously.

6. An intersection of a line joining origin $(0,0)$ to $P_I(I_{SC}, V_{OC})$ on the curve gives a point, $P_W(I_W, V_W)$, where current and voltage are simultaneously optimum. The product $P_W = I_W \times V_W$ thus signifies the optimum and realizable and hence workable power. Measure I_W and V_W and calculate workable power (P_W)

7. Calculate the fill factor $\left(f = \frac{P_W}{P_I} \times 100\%\right)$. The fill factor signifies the extent to which workable power is close to ideal power. Alternatively, it signifies the extent to which workable power rectangle 'fills' the ideal power rectangle.

8. Calculate the workable load $R_W = \frac{V_W}{I_W}$.R_W signifies the workable load at which solar cell can deliver optimum/workable power.

9. Tabulate your calculations and results as per the table (8.2)

6 Observations

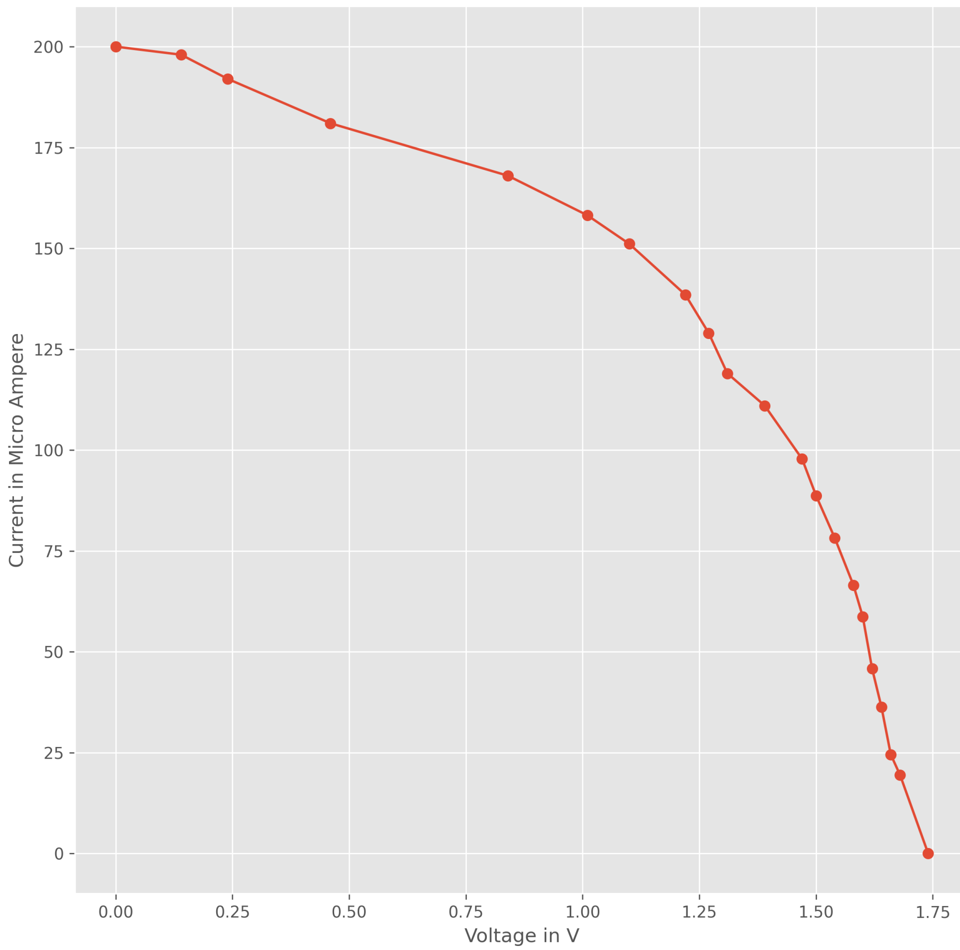
Sr. No.	Current (µA)	Voltage (volts)
1	(Minimum)	(Maximum)
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		

7 Calculations

Sr. No.	Quantity	Symbol and Formula	Value	Unit
1	Short circuit current	I_{SC}		μA
2	Open circuit voltage	V_{OC}		Volts
3	Ideal power	$P_I = I_{SC} \times V_{OC}$		μW
4	Workable current	I_W		μA
5	Workable voltage	V_W		Volts
6	Workable power	$P_W = I_W \times V_W$		μW
7	Fill factor	$F = \frac{P_W}{P_I} \times 100\ \%$		%
8	Workable load	$R_W = \frac{V_W}{I_W \times 10^{-6}} \Omega = \cdots k\Omega$		kΩ

8 Graphs

8.1 Plot between Volts and Current in Micro Amperes



9 My Understanding of the Experiment

A solar cell is a special pn junction diode that converts light into electrical power. As photons hit the cell, it excites their electrons, thereby producing electricity. In the process, some energy is wasted. An extent of how much power is wasted is given by the cell's Fill factor. As the working power is less than the ideal power. It is that fill factor that we wish to calculate in this experiment. If this fill factor is improved, and if the efficiency of the cell also improves significantly, solar cells are a very promising candidate in renewable energy.