Dependence of solar cell characteristics and performance on secondary light source

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Abstract - Focusing a light of a particular wavelength on the PV cell in addition to the sunlight will result in an increase in the no of electron-hole pair produced due to the fact that the A particle need only have greater energy than that of the band gap in order to excite an electron from the valence band into the conduction band. And there is a fair possibility that our PV cell will have at least one electron having the same energy requirement to break its covalent bond as provided by the additional secondary source.

This paper presents a qualitative approach on the above stated effect and studies the effect on maximum power output and open circuit voltage by illuminating a PV cell with secondary light source of a particular wavelength and tries to provide an alternative for increasing the power output of existing solar cells and open the gates for further research on this never before explored sector and in the end provide a viable path for implementing the above theory which may prove as a viable solution for the Present energy crisis.

I. INTRODUCTION

Generating electrical power from a solar cell is most promising alternative to the conventional power producing methods. There are currently many research groups active in the field of photovoltaic in universities and research institutions around the world. This research can be divided into three areas: making current technology solar cells cheaper and more efficient to effectively compete with other energy sources; developing new technologies based on new solar cell architectural designs; and developing new materials to serve as light absorbers and charge carriers.

At present, solar produced electricity is most often fed into the electricity grid using inverters (grid-connected photovoltaic systems); in stand-alone systems, batteries are used to store the energy that is not needed immediately. Solar panels can be used to power or recharge portable devices.

But after some time, we will need a system where solar power is sufficient alone to power the whole region without the help of any power produced by conventional sources.at that time maximum power produced by a solar panel will be the most important and judging criteria.

Till date many experiments and research are done on increasing the power output and efficiency of a solar panel focusing on the characteristic of material used temperature and other factors. But no efforts are made to study the effect of secondary light source on a PV cell primarily because lighting a secondary source will itself consume power decreasing the efficiency of PV cell.

But with improved efficiency of the lighting sources and the fast growing field of producing small amount of power from every imaginable and unimaginable source of energy ranging from sunlight, wind power to piezoelectric and body thermal heat, which can be collectively used to harness enough power to light a secondary light source; it becomes necessary to study this parameter and its effect on the maximum power output of the solar cell.

This paper will provide a qualitative report on the effect of wavelength and intensity of a secondary light source kept in front of a solar panel illuminating it in addition to the sunlight, on the maximum base power output and the open circuit voltage.

It will try to establish the fact that by illuminating a PV cell with a secondary source of light in addition to the sunlight we can increase the power output of the given cell by a considerable factor.

II. EXPERIMENT PERFORMED AND THE THEORY BEHIND IT

- A simulation of commonly used solar cell.
- Keeping all the parameters same we have one by one introduced a secondary light source of changing wavelength and intensity and recorded the maximum base power output and the open circuit voltage in each case.
- Below is tabular record of the results obtained, analyzed later in the paper.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.448	1.509	1.537	1.555
Open circuit Vb (volt)	0.5942	0.5947	0.5952	0.5955

Table-1 Secondary light source of constant intensity and a monochrome wavelength of 100 to 100 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.589	1.639	1.707	1.745
Open circuit Vb (volt)	0.5962	0.5971	0.5980	0.5986

Table-2 Secondary light source of constant intensity and a monochrome wavelength of 200 to 200 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.771	1.791	1.864	1.934
Open circuit Vb (volt)	0.5981	0.5994	0.6007	0.6015

Table-3 Secondary light source of constant intensity and a monochrome wavelength of 300 to 300 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	2.310	2.819	2.986	3.047
Open circuit Vb (volt)	0.6067	0.6094	0.6118	0.6132

Table-4 Secondary light source of constant intensity and a monochrome wavelength of 400 to 400 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	2.925	3.090	3.186	3.233
Open circuit Vb (volt)	0.6138	0.6173	0.6203	0.6221

Table-5 Secondary light source of constant intensity and a monochrome wavelength of 500 to 500 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	3.983	3.199	3.276	3.316
Open circuit Vb (volt)	0.6171	0.6208	0.6240	0.6259

Table-6 Secondary light source of constant intensity and a monochrome wavelength of 600 to 600 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	3.166	3.264	3.333	3.369
Open circuit Vb (volt)	0.6195	0.6234	0.6268	0.6288

Table-7 Secondary light source of constant intensity and a monochrome wavelength of 700 to 700 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	3.215	3.305	3.369	3404
Open circuit Vb (volt)	0.6213	0.6253	0.6288	0.6303

Table-8 Secondary light source of constant intensity and a monochrome wavelength of 800 to 800 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	3.223	3.312	3.375	3.409
Open circuit Vb (volt)	0.6216	0.6256	0.6291	0.6312

Table-9 Secondary light source of constant intensity and a monochrome wavelength of 900 to 900 nm.

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.589	1.639	1.707	1.745
Open circuit Vb (volt)	0.5962	0.5971	0.5980	0.5986

Table-10 Secondary light source of constant intensity and a monochrome wavelength of 1000 to 1000 nm.

.Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.589	1.639	1.707	1.745
Open circuit Vb (volt)	0.5962	0.5971	0.5980	0.5986

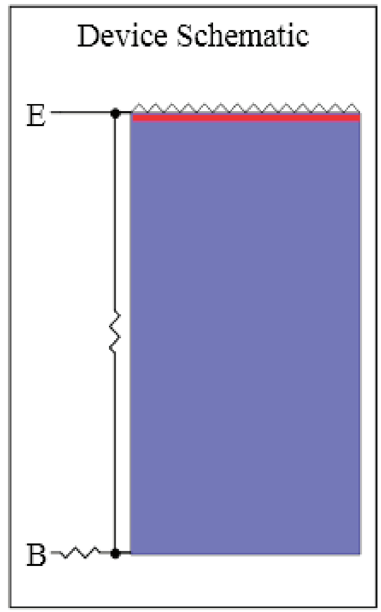
Table-11 Secondary light source of constant intensity and a monochrome wavelength of 1200 to 1200 nm

Intensity	0.12 w/cm2	0.15 w/cm2	0.18 w/cm2	0.2 w/cm2
Max_base power (watt)	1.589	1.639	1.707	1.745
Open circuit Vb (volt)	0.5962	0.5971	0.5980	0.5986

Table-12 Secondary light source of constant intensity and a monochrome wavelength of 1300 to 1300 nm.

Below is a screen shot of one of the simulation profile during one of the simulation.

File: C:\Users\PrAchI\Desktop\PC1D5\t1--b..prm
This is a PC1D test problem. It is a 100-cm2 silicon solar cell with parameters typical of low-cost commercial products, including series resistance and shunt conductance. It has a shallow diffused emitter that has been pyramidally textured. The front reflectance is 10% across the solar spectrum. The file scans the one-sun I-V curve of the cell.



DEVICE
Device area: 100 cm^2
Front surface texture depth: 3 µm
No surface charge
Exterior Front Reflectance: 10%
No Exterior Rear Reflectance
Internal optical reflectance enabled
Front surface optically rough
Emitter contact enabled
Base contact: 0.015 Ω
Internal conductor: 0.3 S
REGION 1
Thickness: 300 µm
Material from si.mat
Carrier mobilities from internal model
Dielectric constant: 11.9
Band gap: 1.124 eV
Intrinsic conc. at 300 K: 1×10^{10} cm^{-3}
Refractive index from si.inr
Absorption coeff. from si300.abs
Free carrier absorption enabled
P-type background doping: 1.513×10^{16} cm^{-3}
1st front diff.: N-type, 2.87×10^{20} cm^{-3} peak
No 2nd front diffusion
No rear diffusion
Bulk recombination: $\tau_n = \tau_p = 7.208$ µs
Front-surface recom.: S model, $S_n = S_p = 1\times10^6$ cm/s
Rear-surface recom.: S model, $S_n = S_p = 1\times10^5$ cm/s
EXCITATION
Excitation modified from one-sun.exc
Excitation mode: Transient, 16 timesteps
Temperature: 25°C
Base circuit: Sweep from -0.8 to 0.8 V
Collector circuit: Zero
Primary light source enabled
Constant intensity: 0.1 W cm^{-2}
Spectrum from am15g.spc
Secondary light source enabled
Constant intensity: 0.12 W cm^{-2}
Monochrome, wavelength from 500 to 500 nm
RESULTS

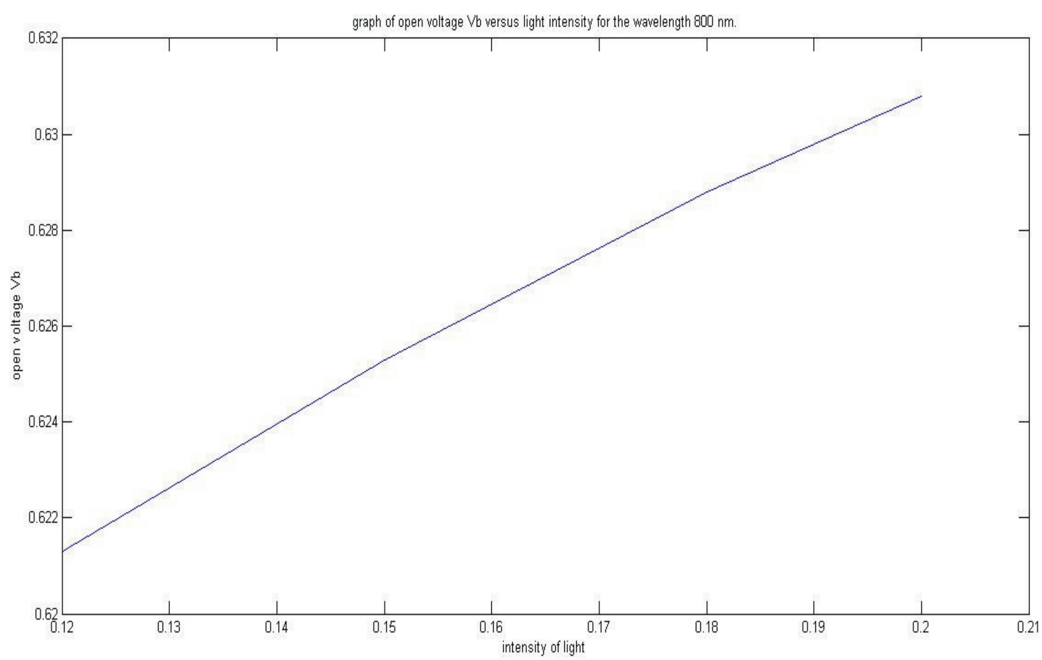
Max base power out: 2.925 watts
Open-circuit Vb: 0.6138 volts

III. ANALYSIS

Before analyzing the data collected let us ponder on the reason that why did it happen?

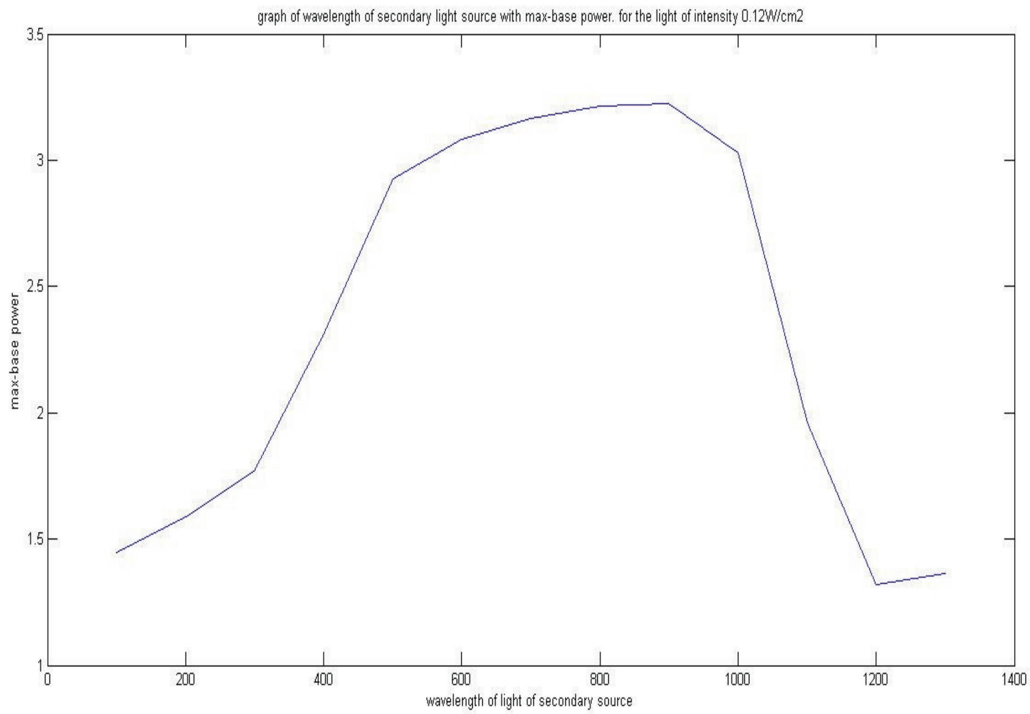
- Maximum base power may increase with increasing wavelength because a particular wavelength may provide the particular energy to a set of electrons that require that energy to break their bond. This way focusing a light of particular wavelength may generate additional pairs of charge carriers more effectively thus increasing the maximum power.
- Maximum base power increases with the increasing wavelength may be because a light with higher wavelength will be able to provide enough energy to break the bonds in electrons which can be broken by lower wavelength electron plus additional extra bonds.
- Same may be reason with increasing intensity because increasing intensity means more effective action.

All the above reasons are based on hypothetical assumption and need further research and study for a fully formulated reason.



Graph-1

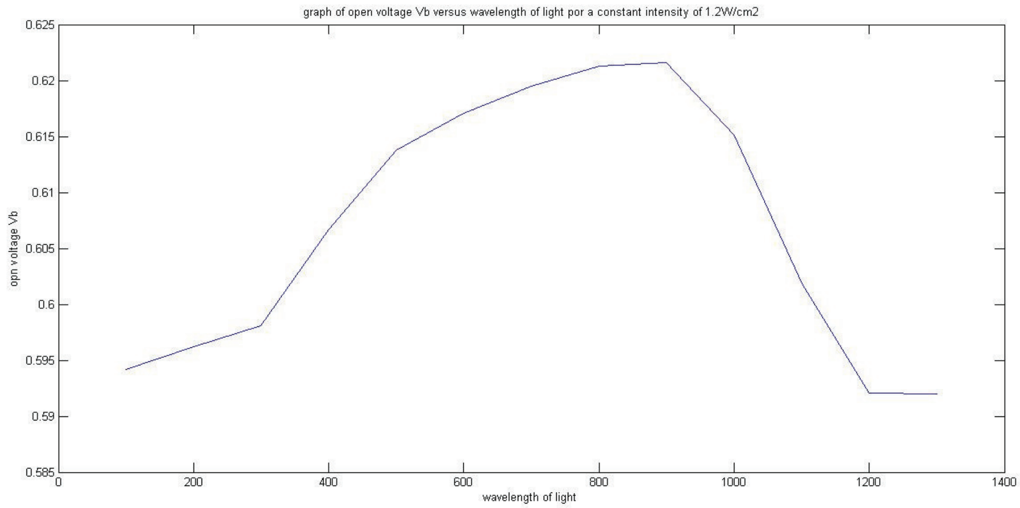
This is a graph of open source voltage versus intensity of light for a random wavelength of light 800 nm. In this we observe that as intensity increase open source voltage increase almost linearly



Graph-2

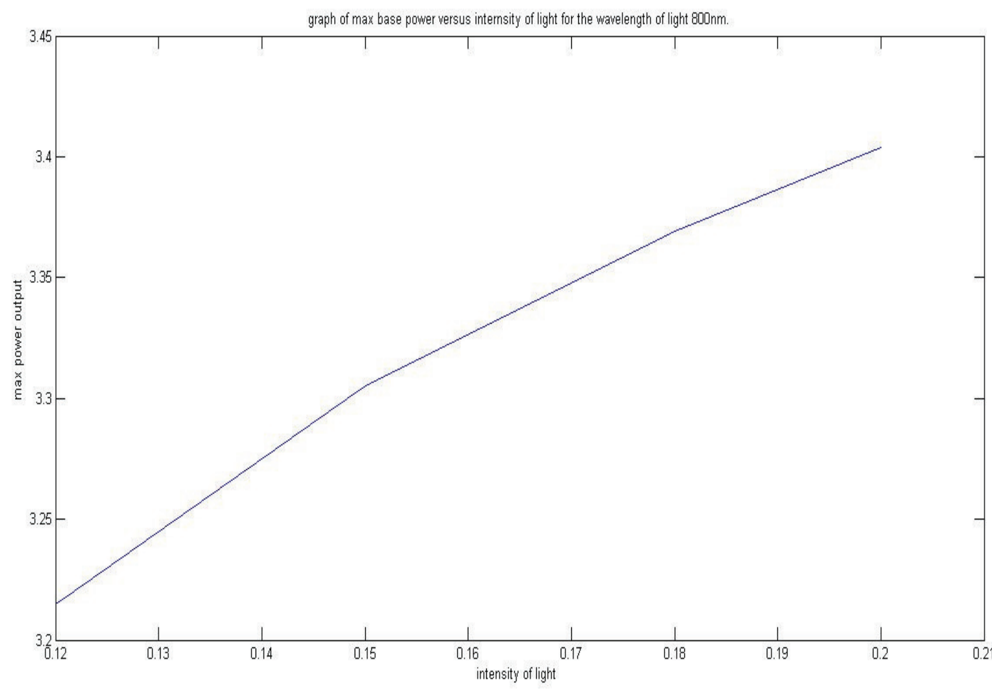
This is a graph of maximum base power versus wavelength of secondary light source for a random intensity of 0.12 W/cm2. It clearly shows that maximum base power first increase rapidly for the initial wavelength then saturation comes and then it starts decreasing.

Below are some similar graph based on the above data collected



Graph-3

Graph of open voltage versus wavelength of light at a random intensity of 0.12W/cm2 following the same pattern as maximum base power first rapid increase, then saturation and then decrease.



Graph-4

Graph of maximum base power to the intensity of light for a wavelength of 800nm, following an almost linear curve.

IV. FUTURE SCOPE OF WORK AND RESEARCH

Right now we are doing research and work on finding a reason behind this phenomenon, a quantitative analysis of the above data, and planning a practical scheme for using this phenomenon. If developed this result can be used with wireless transfer for a completely new design of homes and industries with increased solar power efficiency and thus increased dependence on solar energy. This result can be used anywhere wherever increased efficiency of solar panels is required or a solar panel is need to be driven by external light source like in case of solar powered equipment used in home can be charged by light sources present at home. The above data can be used in designing the future arrangements of solar panel driven by a secondary source beside primary source i.e sunlight.

V. CONCLUSION

Qualitatively analyzed the effect of secondary light source on the performance of a PV cell and developed a method to increase the efficiency of existing solar panel without replacing the solar panel.

Analyzed and presented data which can be futuristically developed in an energy efficient model.

REFRENCES

[1] Solar photovoltaics-A lab training manual by Chetan S.Solanki.,Brij M.Arora,Juzer Vasi,Mahesh B.Patil

[2] PC1D version 5.9 software.