SIMULATION OF POLYCRYSTALLINE SILICON SOLAR CELL USING GPVDM SOFTWARE

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Abstract *:* Electricity is playing a vital role in our daily life. Solar energy is an alternative source to produce electricity. Different types of solar cells are available to convert solar energy into electrical energy. In this paper, polycrystalline silicon solar cell is simulated using GPVDM software. Solar cell and GPVDM software are slightly explained first. Then, how the efficiency of solar cell is changed with respect to the change in thickness of different layers of a polycrystalline silicon solar cell is simulated and the outputs are represented in the form of graph. Finally, this paper concludes that the variation in the thickness of base layer causes notable change in efficiency when compared to other layers.

***Keywords* - Solar cell, Polycrystalline silicon solar cell, GPVDM simulation software.**

INTRODUCTION

A solar cell or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell whose electrical characteristics such as current, voltage or resistance vary, when exposed to light. Solar cells are photovoltaic, irrespective of whether the source is sunlight or an artificial light. Individual solar cell devices are combined to form modules, otherwise known as solar panels.

Types of solar cells:

Different types of solar cells are

- Amorphous Silicon solar cell (a-Si)
- Biohybrid solar cell
- Cadmium telluride solar cell (CdTe)
- Crystalline silicon solar cell (c-Si)
- Dye-sensitized solar cell (DSSC)
- Hybrid solar cell
- Luminescent solar concentrator cell (LSC)
- Micromorph (tandem-cell using a-Si/μc-Si)
- Monocrystalline solar cell (mono-Si)
- Multi-junction solar cell (MJ)
- Nanocrystal solar cell
- Organic solar cell (OPV)
- Perovskite solar cell
- Photoelectrochemical cell (PEC)
- Plasmonic solar cell
- Polycrystalline solar cell (multi-Si)
- Quantum dot solar cell
- Solid-state solar cell
- Thin-film solar cell (TFSC)
- Wafer solar cell, or wafer-based solar cell crystalline.

In this paper, polycrystalline silicon solar cell is simulated using GPVDM simulation software.

POLYCRYSTALLINE SILICON SOLAR CELL

Like monocrystalline silicon solar cells, Polycrystalline solar cells are also made from silicon. But, instead of using a single crystal of silicon, manufacturers melt many fragments of silicon together to form the wafers for the panel. Polycrystalline solar panels are also referred to as “multi-crystalline,” or many-crystal silicon, because there are many crystals in each cell.

The polycrystalline silicon cell from a solar panel is shown in Fig.1.

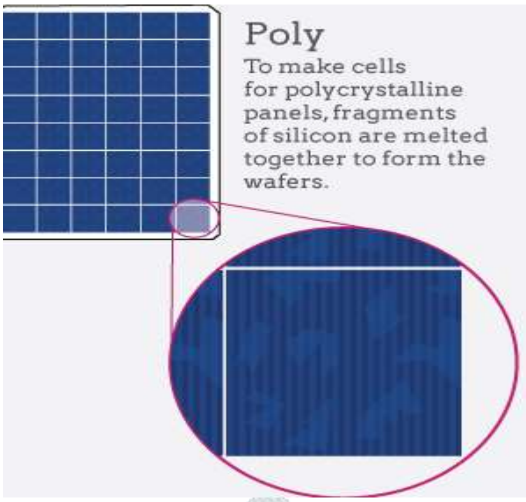


Fig.1. Polycrystalline silicon solar cell from a solar panel.

GPVDM SIMULATION SOFTWARE

General - purpose Photovoltaic Device Model – GPVDM is a free general – purpose tool for the simulation of opto – electronic devices. It was originally written to simulate organic solar cells, but it has now been extended to simulate other classes of device, including OLEDs, OFETs and many other types of 1st, 2nd and 3rd generation solar cells. The types of devices available in GPVDM software are Organic solar cell, Amorphous Si solar cell, Organic bi-layer device, CIGS solar cell, OFET, Organic LED, Perovskite solar cell, Polycrystalline Silicon solar cell, Tandem solar cell etc.

In this paper, Polycrystalline silicon solar cell is simulated. The structure of polycrystalline silicon solar cell available in GPVDM simulation software is shown in Fig.2.

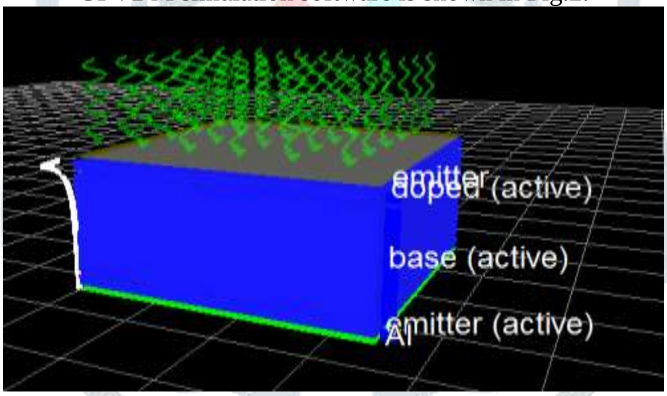
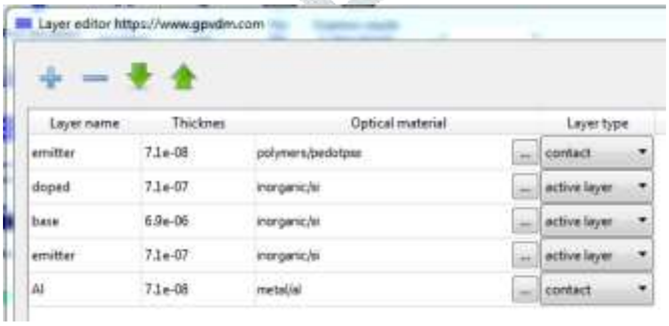


Fig.2. The structure of polycrystalline silicon solar cell available in GPVDM simulation software.

SIMULATION METHODOLOGY

The layer editor table for polycrystalline silicon solar cell available in GPVDM software is shown in Fig.3.


Layer editor https://www.gpvdm.com

Layer name	Thicknes	Optical material	Layer type
emitter	7.1e-08	polymers/pedotpss	contact
doped	7.1e-07	inorganic/si	active layer
base	6.9e-06	inorganic/si	active layer
emitter	7.1e-07	inorganic/si	active layer
Al	7.1e-08	metal/al	contact

Fig.3. The layer editor table for polycrystalline silicon solar cell available in GPVDM software.

Using this table, we can add or remove any of these layers. Also the thickness, material and layer type can also be changed according to the analysis. In this paper, the thickness of the layers are changed one by one and the corresponding efficiency are noted and plotted.

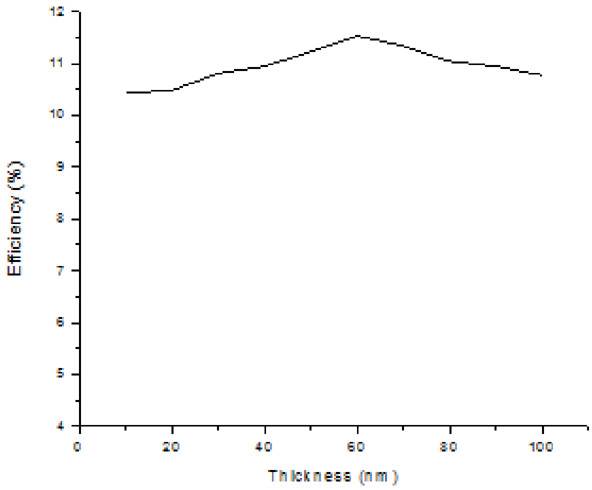
RESULTS AND DISCUSSIONS

1st emitter layer polymers/pedotpss:

Initially, the thickness of the 1st emitter layer is varied from 10 to 100nm and their corresponding efficiencies are noted and plotted. The thickness vs efficiency plot for 1st emitter layer is shown in Graph.1.

Graph.1 shows that there is not much variation in the efficiency when the thickness of the 1st emitter layer is changed from 10 to 100nm. So, the thickness of this 1st emitter layer can be fixed according to the needs. For example, if the thickness of the solar cell is to be reduced, then the minimum thickness is to be chosen or if the solar cell is to be designed with maximum efficiency, then the thickness at which the efficiency is maximum is to be chosen.

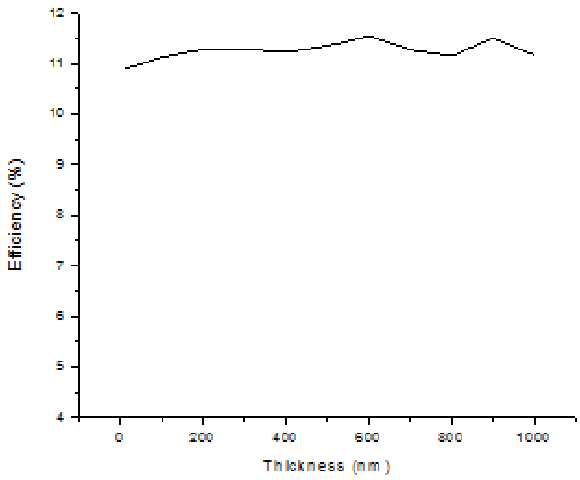
In this paper, the thickness at which the efficiency is maximum is considered. Hence, the thickness of 60nm at which the efficiency is 11.53504% is chosen and fixed for the analysis of 2nd layer.



Graph.1. The thickness vs efficiency plot for 1st emitter layer.

2nd doped layer inorganic/Si:

Fixing the 1st emitter layer as 60nm, the thickness of the 2nd doped layer is varied from 100 to 1000nm and the corresponding efficiencies are noted and plotted as shown in Graph.2.



Graph.2. The thickness vs efficiency plot for 2nd doped layer.

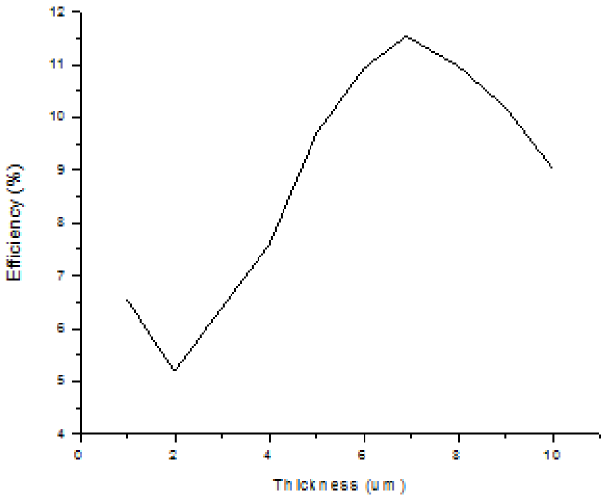
The thickness of this 2nd layer also didn't cause much variation in efficiency. Here, the thickness of 600 nm at which the efficiency is 11.55071% is fixed for the analysis of 3rd layer.

3rd base layer inorganic/Si:

Fixing the thickness of 1st and 2nd layers as 60nm and 600nm respectively, the thickness of 3rd base layer is varied from 1 to 10µm and the corresponding efficiencies are noted and plotted as shown in Graph.3.

The thickness of this 3rd layer has more effect on efficiency when compared to 1st and 2nd layers. Each one µm of this layer cause some notable change in efficiency. Hence, the graph is plotted and the thickness at which the maximum efficiency is obtained is noted.

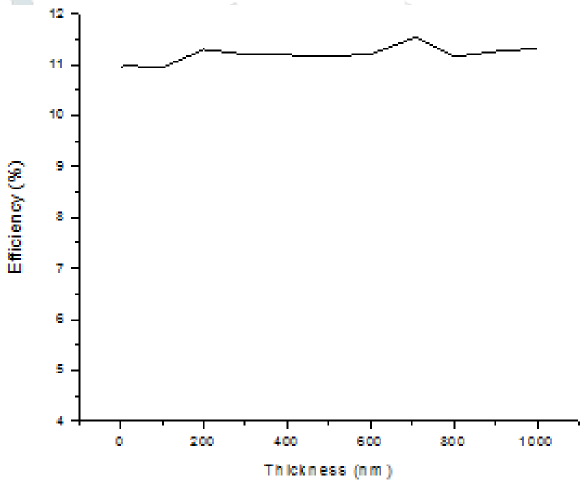
Here, the maximum efficiency of 11.55071% is obtained for the thickness of 6.9 µm. In addition to 1st and 2nd layers, the third layer is fixed at 6.9 µm for the analysis of 4th layer.



Graph.3. The thickness vs efficiency plot for 3rd base layer.

4th emitter layer inorganic/Si:

Fixing the thickness of first three layers, the thickness of the fourth emitter layer is varied from 100 to 1000nm and the corresponding efficiencies are noted and plotted as shown in Graph.4.



Graph.4. The thickness vs efficiency plot for 4th emitter layer.

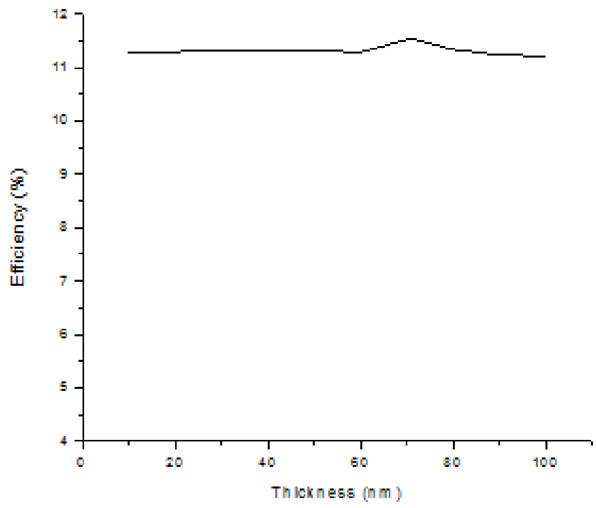
This graph also shows that there is not much difference in efficiency when the thickness of the 4th layer is changed from 100 to 1000nm. Then, to analyse the thickness of 5th Al layer, the 4th emitter layer is fixed as 710nm at which maximum efficiency of 11.55071 is obtained.

5th Al layer metal/Al:

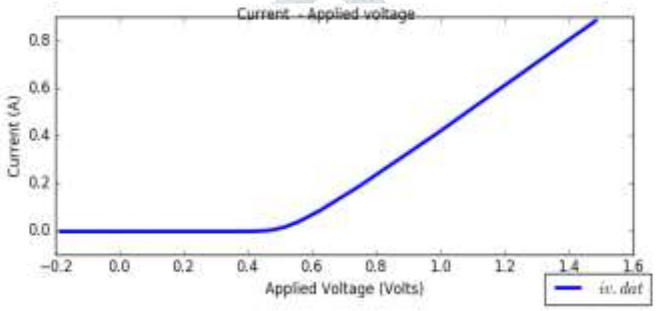
Fixing the thickness of first four layers as discussed above, the thickness of the 5th Al layer is varied from 10 to 100nm and the corresponding efficiencies are noted and plotted as shown in Graph.5.

The graph shows that there is not much difference in efficiency when the thickness of the 5th layer is changed from 10 to 100nm. Finally, the thickness of the 5th Al layer is fixed as 71nm at which the maximum efficiency of 11.55071 is obtained.

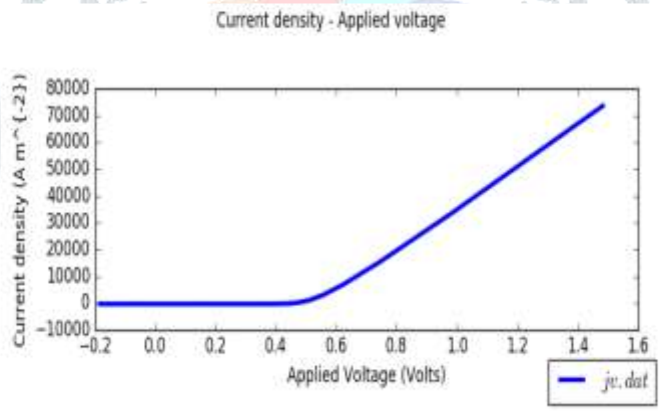
Other plots are also available in the plot file. After fixing the thickness of five layers as discussed above, the iv and jv characteristics of the polycrystalline silicon solar cell available in the plot file are represented in Graph.6 and graph.7 respectively.



Graph.5. The thickness vs efficiency plot for 5th Al layer.



Graph.6. Current – Voltage characteristic curve (i-v).



Graph.7. Current density – Voltage characteristic curve (j-v).

CONCLUSION

In this paper, the thickness of five layers of a polycrystalline silicon solar cell is varied one by one and the corresponding efficiencies are noted and plotted. This analysis shows that the thickness of all the layers does not have much effect on efficiency. Only, the variation in the thickness of 3rd layer causes a notable change in efficiency. Likewise, the material for these layers can also be changed. Here, only the thickness of the layers are changed and the materials are kept unchanged. The material used are mentioned in Fig.3. But, they can also be changed for further analysis.

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