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Performance Analysis of Solar Cell by Using Nano Coating

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***Abstract*— Solar cell is used for power generation and its efficiency is about 5-6%. In order to improve the performance of the solar panel MgO - TiO_2 is to be coated in the solar panel. Theoretical calculations such as the optimum refractive index, optimum thickness, transmissivity and reflectivity properties of the solar panel without coating were found using theoretical calculations. The coating material MgO - TiO_2 has high refractive index so it can be used for coating. The coating material is of nano size. The MgO - TiO_2 nano coating is to be applied on the solar panel. The experimental analysis shows that the MgO-TiO_2 PVD coating improves the efficiency of the solar cell by 1.74% and the power produced in the solar cell with and without coating gives the increases of power with 0.33W.**

***Index Terms*— Solar Cell, PVD Coating, Nano Coating, Solar Panel.**

I. INTRODUCTION

Fossil fuels like Coal, oil and natural gas are the three kinds of fossil fuels that we have mostly depended on for our energy needs, from home heating and electricity to fuel for our automobiles and mass transportation [2]. The problem is fossil fuels are non-renewable and make more harmful to the environment [1]. They are limited in supply and will one day be depleted. Fossil fuels formed from plants and animals that lived hundreds of millions of years ago.

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. These renewable energy sources create their own energy. The problem is to capture and harness their mechanical power and convert it to electricity in the most effective and productive manner possible [3-5]. There's more than enough renewable energy sources to supply all of the world's energy needs forever; however, the challenge is to develop the capability to effectively and economically capture, store and use the energy when needed.

Renewable energy contributed 19 percent to our global energy consumption and 22 percent to our electricity generation in 2012 and 2013, respectively [11-13]. This energy consumption is divided as 9% coming from traditional biomass, 4.2% as heat energy (non-biomass), 3.8% hydro electricity and 2% is electricity from wind, solar, geothermal, and biomass. Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. National renewable energy markets are projected to continue to grow strongly in the upcoming years [14].

II. THEORETICAL CALCULATION FOR SOLAR CELL

Refractive index of the coating material given by,

$$n_1=\sqrt{n_0 \times n_2}$$

Optimum thickness calculation of material to be coated

$$d_1=\frac{\lambda}{4n_1}$$

III. EXPERIMENTAL TESTING

MgO and TiO_2 pellets are formed from the powder with the help of the hydraulic press.

A. Physical Vapor Deposition (PVD) coating:

Physical vapor deposition is the method of thin film coating in the vacuum medium [7-10]. The process is carried by using physical means like heating or sputtering. PVD coating is used to produce thin film in the coating material.

The solar cell is cutted for the required dimension of 15.6cm×7.8cm by the use of the diamond cutter. The solar cell is then placed in the circular disc in the PVD coating machine. In the crucible the pellet of MgO and TiO_2 is placed inside the PVD machine. The crucible will withstand a temperature of 3000k.

MgO will be vaporized at a temperature of 2800k and TiO_2 will be vaporized in the temperature of 1700k. The crucible is placed inside the machine and the process is monitored and heating is controlled by the switches.

The working pressure is below 5×10^4Pa and the chamber is made up of stainless steel grade 304 and the holder is also made up of the same. The solar cell is placed in the substrate holder and the equipment is closed and the heating process is started. Before the coating is started the chamber must achieve the vacuum condition.

MgO is first coated in the solar cell and after that TiO_2 is coated by the use of the physical vapor deposition machine. After the coating of the MgO the equipment is allowed to cool down and after that only the TiO_2 coating is done. After the coatings are finished the chamber is allowed to cool down to reduce the temperature inside the chamber.

Fig 3.1 Physical Vapor Deposition Equipment

B. Solar Cell Testing:

The solar cell testing is carried out by the solar cell testing equipment. The equipment consists of probes which will touch the cell to measure the output parameters like voltage and current. The equipment is computerized and the readings are shown in the excel sheets.

The equipment consists of xenon flash tube, it flashes the light and the probes come in contact with the cell and give the output parameters. The intensity of the light is similar to that of sun. In some modern equipment xenon flash tube is replaced by the LED flashes.

Fig 3.2 solar cell testing equipment

IV. RESULTS AND DISCUSSION

A. XRD Analysis:

The 2θ and intensity peak is calculated for the coated material using XPERT-PRO system with copper anode.

The substrate is analyzed with the X-Ray Diffraction to verify the crystal quality. The XRD pattern of coated solar cell is shown in the fig 5.5 and the peaks are seen clearly.

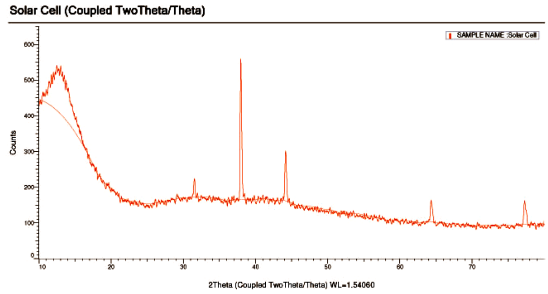

Fig 4.1 XRD graph

B. SEM Analysis:

The fig 5.6 shows the scanning electron microscope image of the coated solar cell with the magnification of 500 times and fig 5.7 has a magnification of 3000 times.

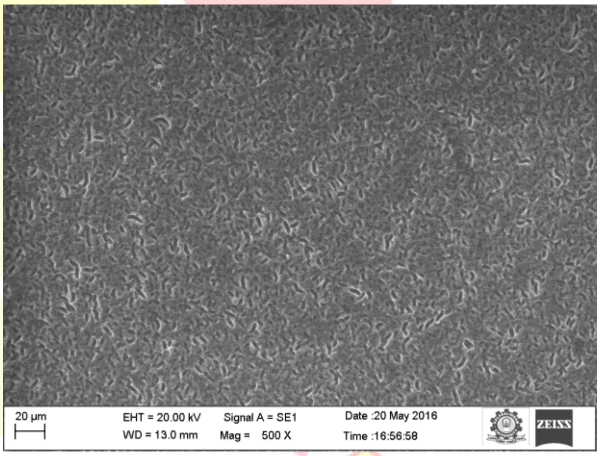

Fig 4.2 SEM image of coated solar cell (500X)

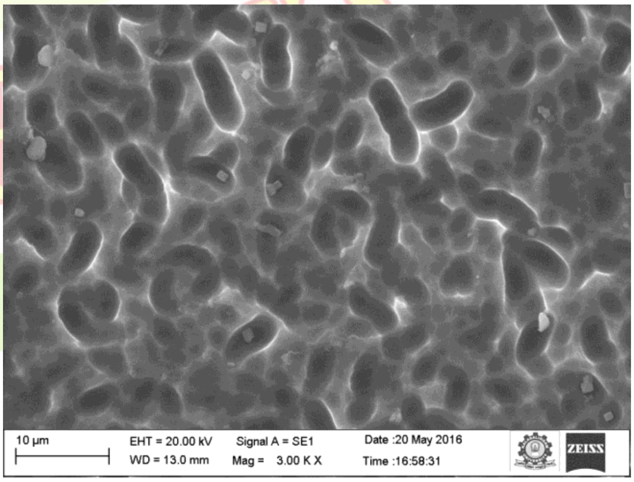

Fig 4.3 SEM image of coated solar cell (3000X)

The figs 4.4 show the variation of voltage with respect to current and voltage with respect to power for the panel without coating. As the voltage increases gradually current is constant for about 0.24V and there is an sudden drop and from there the current tends to decrease as the voltage increases. power increases for the point about 0.51V and reaches 0.6V.

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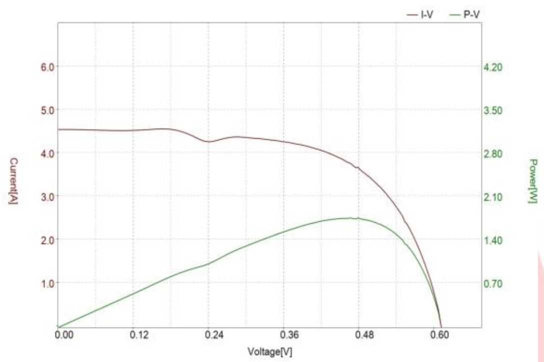

Fig 4.4 Variation of Voltage Current And Voltage Power For The Cell Without Coating

The fig 4.5 shows the variation of voltage with respect to current and voltage with respect to power for the panel with coating. As the voltage increases gradually current is approximately constant for about 0.36V and after that it decreases and increases and from there the current tends to decrease as the voltage increases. Voltage increases for the point about 0.51V and reaches 0.6V.

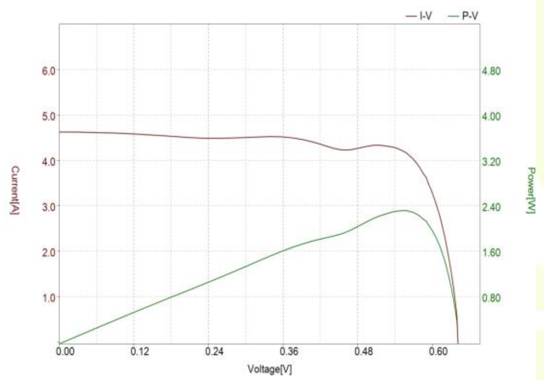

Fig 4.5 Variation Of Voltage Current And Voltage Power For The Cell With Coating

The fig 4.6 gives the variation of current with respect to voltage is shown for the solar cell with and without coating. The blue line indicates the solar cell without coating and the red line indicates the solar cell with coating. By comparing the values of solar panel with coating and without coating, the solar cell with coating gives current and voltage more than that of solar cell without coating.

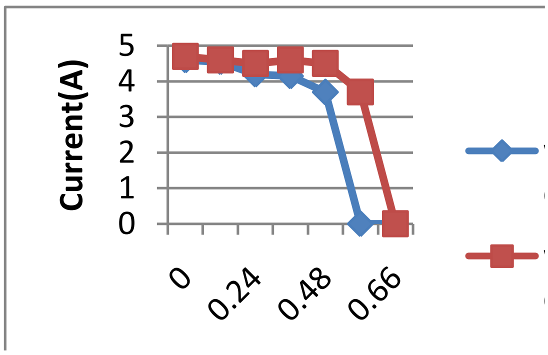

Fig 4.6 Variation of Voltage and Current for the Cell with and Without Coating

The fig 4.7 gives the variation of power with respect to voltage is shown for the solar cell with and without coating. The blue line indicates the solar cell without coating and the red line indicates the solar cell with coating. By comparing the values of solar panel with coating and without coating, the solar cell with coating gives power and voltage more than that of solar cell without coating.

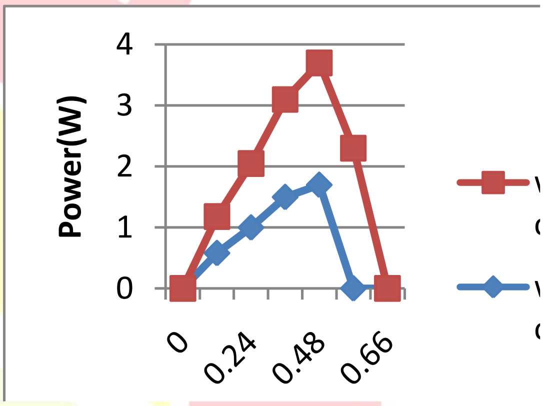

Fig 4.7 Variation of Voltage and Power for the Cell with and Without Coating

The refractive index of the coating material should have the refractive index of 1.85 for optimum transmission of light into the silicon material. For the calculated refractive index effective coating materials are identified.

- The efficiency of the solar panel is about 6-10% in the standard temperature and pressure
- Based on the optimum refractive index the material (MgO-TiO_2) is selected.
- The selected material is coated on the solar cell and experimental analysis is done.

From the tested sample the efficiency of the solar cell is increased by 1.74% with the results of without coating solar cell and the power is increased by 0.33W.

V. Conclusion

- Based on the theoretical calculations, the refractive index is 1.85.
- The optimum refractive index is used to select the material to be coated in the solar cell.
- Based on the optimum value the material the combination of material (MgO and TiO_2) is selected and coated.

The solar cell without coating only produces the power of 2.02W for the irradiation of 100 mW/cm^2 and the solar cell with coating produces a power of 2.35W, So that the coating enhances the efficiency of the solar cell. The coating material MgO-TiO_2 the tendency to absorb the light from the sun. The efficiency of the solar panel without coating 17.48% whereas the efficiency of solar panel with coating is 19.22%, the efficiency is increases by 1.74%.

REFERENCES

1. Bhattacharya J., Chakravarty N., Pattnaik S., Slafer W.D., Biswas R., Dalal V. (2012) 'Comparison of optical properties of periodic photonic–plasmonic and randomly textured back reflectors for nc-Si solar cells', vol. 358, pp 2313-2318
2. Das D., Banerjee A. (2015) 'Anti-reflection coatings for silicon solar cells from hydrogenated diamond like carbon', vol. 345, pp 204-215.
3. Ho W.J., Lee Y.Y., Lin C.H., Yeh C.W. (2015) 'Performance enhancement of plasmonics silicon solar cells using Al2O3/In NPs/TiO2 antireflective surface coating', vol. 161, pp 34-39.
4. Huang Q., Liu Y., Yang S., Zhao Y., Zhang X. (2012) 'Hydrogen mediated self-textured zincoxide films for silicon thin film solar cells', vol. 103, pp 134-139.
5. Hussain B., Ebong A., Ferguson I. (2015) 'Zinc oxide as an active n-layer and antireflection coating for silicon based hetero-junction solar cell', vol. 139, pp 95-100.
6. Li Z.X., Zhaon J., Ren L. (2012) 'Aqueous solution-chemical derived Ni–Al2O3 solar selective absorbing coatings',vol. 105, pp 90-95.
7. Lin A, Zhong Y.K., Fu S.M. (2014) 'Comparison of nano-structured solar cell anti-reflection coating based on graded-index or mode coupling approach', vol. 12, pp 493-500.
8. Mahadik D.B., R.V. Lakshmi, Harish, C. Barshilia (2015) 'High performance single layer nano-porous antireflection coatings on glass by sol–gel process for solar energy applications', vol. 140, pp 61-68.
9. Pakhuruddin M.Z., Y. Yusof, K. Ibrahim, A. Abdul Aziz (2013) 'Fabrication and characterization of zinc oxide anti-reflective coating on flexible thin film microcrystalline silicon solar cell', vol. 124, pp 5397-5400.
10. Raut H.K., Nair A.S., Dinachali S.S., Ganesh V.A., Walsh T.M., Ramakrishna S. (2013) 'Porous SiO2 anti-reflective coatings on large area substrates by electro spinning and their application to solar modules', vol. 111 pp 9-15.
11. Sali.S, M.Boumaour, M.Kechouane, S.Kermadi, F.Aitamar (2012) 'Nano-crystalline ZnO film deposited by ultrasonic spray on textured silicon substrate as an anti-reflection coating layer', vol. 407, pp 2626-2631.
12. Salman K.A., Omar K., Hassan Z. (2012) 'Effective conversion efficiency enhancement of solar cell using ZnO/PS antireflection coating layers', vol. 86, pp 541-547.
13. Suman S., Mohd, Khan K., Pathak M. (2015) 'Performance enhancement of solar collectors—A review', vol. 49, pp 192-210.
14. Wang B., Leu P.W. (2015) 'High index of refraction nano sphere coatings for light trapping in crystalline silicon thin film solar cells', vol. 13, pp 226-232.