ARPN Journal of Engineering and Applied Sciences

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ZnO ANTIREFLECTION COATING ON SOLAR CELL TO INCREASE THE EFFICIENCY BY ENHANCING OPTICAL PROPERTIES

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ABSTRACT

In today's world, solar cell efficiency is an important concern. Anti-Reflection Coating serves a critical function in increasing solar cell efficiency. The efficiency of a solar cell is influenced by a variety of factors. The key issue here is reflectivity. Antireflection coatings are used to minimise the solar cell's reflectivity. AR coating is done using semiconductor materials. Generally, the reflectance of solar cell can be reduced up to 3.2% by using Anti-reflection coating. In this experiment ZnO is employed as an antireflection coating on the solar cell using the spin coating process. After coating, the solar cell is allowed to cure at a rapid rate of evaporation to get a thin film. UV-Spectrophotometer and Solar Simulator are used to investigate the coated solar cell's optical and electrical features. When the results are compared to the efficiency of a bare silicon solar cell, the coated cell outperforms the unprotected solar cell by 4%.

Keywords: solar cell, AR coating, ZnO, reflectance, efficiency.

INTRODUCTION

Among all the renewable energy, the solar energy is most needful for human living because of its free source and its photovoltaic effect. The PV effect is converting the amount of captured photons or light energy into electrical energy through semiconductor materials. Generally, materials are three types; they are conductor, Semiconductor and Insulator. Semiconductor Materials has unique electrical properties. Material which conducts is called conductors which has no band gap between valance band and conduction band. Material which does not conduct is call insulators which has large bandgap between valence band and conduction band. Semiconductor is in between them. It is neither conductor nor an insulator. These materials need small amount of energy to make electrons flow. The basic semiconductor material is Silicon. It is mostly used in semiconductor industry and microelectronics industry. The band gap of silicon is 1.12ev [1]. A single silicon has high refractive index of about 3 or 5. But solar radiation about 35% reflected back to the surface [2]. Some photons from the solar radiation do not have sufficient energy to hit the electrons in the silicon photovoltaic cell. This reduces the efficiency of solar cells. To reduce the reflection of the photons, an antireflection coating or protective layer is needed. Antireflection coating is a layer applied or deposited on the solar cell or on the protective glass on the cell [3]. Materials like Zinc Oxide, Silicon Nitride, Titanium di oxide, silicon di oxide and boron nitride are commonly used as antireflection coating material [4]. These materials are high in strength, large bandgap and good optical and electrical properties. Hence in this paper discussed about effect of antireflection coating on solar cell and results of optical properties were shown with UV-Spectrophotometer analysis.

Methods of Coating

Antireflection Coating can be applied on solar cell by many methods. They are mainly classified into two types. Physical Vapour Deposition and Chemical Vapour Deposition. PVD means the material changed from Condensed state to vapour state, then it again reformed to condensed state in thin films [5]. Common types in PVD are thermal evaporation, Sputter Deposition and arc vapour Deposition. High operating temperature is needed to operate these types. CVD means the material is exposed to a precursor to convert to gaseous state and deposited as thin film [6]. This also classified as plasma enhanced CVD, Atomic layer CVD, and sol-gel process. When compared to all other methods sole gel process is simple and easy to operate for micro and Nano electronics. Sol-gel process is a technique to produce chemical solution from the material to be deposited [7]. Sol-gel process also having many types depends on the application like dip coating, spraying and spin coating. Here for this application, spin coating is suitable for making antireflection coating on the solar cell. Spin coating is technique for applying thin films uniformly on the substrate by using centrifugal force [8]. It is economically low in cost and easy to operate in micro or Nano size substrate. The spin coating consists of four processes. They are Depositing, Spin up, Spin Down and Evaporating.

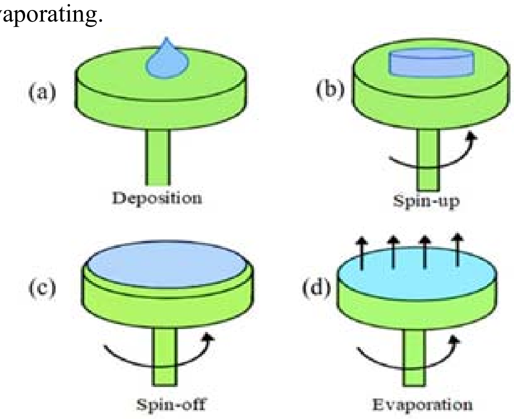

Figure-1. Process of spin coating [9].

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In deposition, Solution is deposited through pipette in the centre of the substrate. In Spin up process, the substrate is made to rotate to spread the solution uniformly. In Spin off process, the substrate made to stop after coated. Final process is the important, which is Evaporation. In this the coated Substrate is dried in oven to obtain thin film on the solar cell. Evaporation is the important stage to get desired thickness of the coated film.

ZnO Solution Preparation

ZnO is mainly used for antireflection coating for solar cells [10]. It has good optical and electrical properties like scattering light, good refractive index and absorption of photons. For preparing Zinc Oxide solution, Ethanol, Zinc acetate dehydrate and distilled water is used. 5 ml of ethanol is needed to dissolve 0.5g of Zinc Acetate Dehydrate. It was stirred with temperature about 65 deg Celsius for 100 minutes. To get stable solution for three months, 10 ml of distilled water is added and stirred at temperature of 100 deg Celsius for 180 minutes. In this experimental analysis, the solar panel with size of 50 mm x 60 mm is used.

Testing on Spin Coater

The solar cell substrate is placed in the Spin coater where annealing process is also inbuilt with it. Then, using a pipette, 0.5 microliter of produced ZnO is injected into the device's centre hole. The device is then set to revolve at 1500 rpm for 10 seconds while continually evaporating the substrate in a 420K oven, according to the technique.

Figure-2. Spin coater device [12].

The coating is evenly distributed throughout the substrate, as seen by the SEM study. Figure-3 depicts the crystallisation of the components and the homogeneity of the solution, as well as the availability of Zinc on the substrate, with yellow dots indicating Zinc on the solar cell. The crystal formation grows rough as the temperature of evaporation rises.

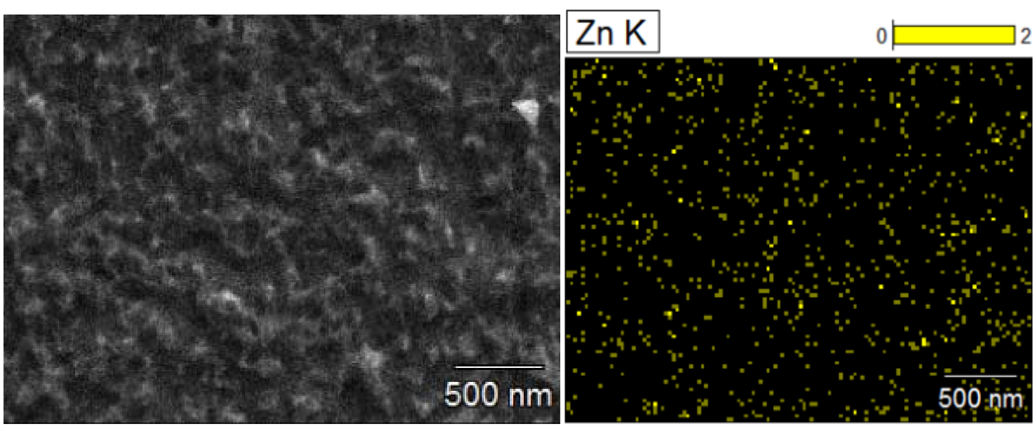

Figure-3. SEM image for coated solar cell.

RESULTS AND DISCUSSIONS

UV - Spectrophotometer is used to analyse the optical properties for ZnO coated layer of solar cell. Optical properties are absorbance, transmittance and reflectance [13]. The results are compared with bare silicon solar cell which means without antireflection coating and coated solar cell.

ISSN 1819-6608

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Figure-4. Optical properties of coated solar cell a) Absorbance b) Transmittance c) Reflectance.

The graph clearly depicts the absorbance, transmittance, and reflectance values. The amount of photons caught by a substance is referred to as absorbance. The absorbance value is enhanced after coating ZnO. The highest conducting wavelength for Zinc Oxide is 320nm to 370nm. The graph 4a shows a modest increase in

 ISSN 1819-6608

ARPN Journal of Engineering and Applied Sciences

wavelength from 330 to 350 nm. Photons transmitted to the deep layer are referred to as transmittance. The transmittance of the coated solar cell is greater than that of the uncoated solar cell, as shown in graph 4b. The amount of photons reflected back to the surface is referred to as reflectance. This is due to photons having insufficient energy to penetrate through the silicon material. Antireflection coating corrects this. Insufficient photons are absorbed by ZnO, which reduces reflectance [14]. The reflectance in the coated cell is lowered, as seen in graph c.

Solar simulators are artificial sunlight for laboratories. They are used to measure the parameters of open circuit voltage, short-circuit current and efficiency. Open circuit voltage means the value of maximum voltage at zero current in the cell. Short circuit current is the value of maximum current at zero potential voltage across the cell. Efficiency is the ratio of output energy to input energy.

Figure-5. Solar Simulator [13].

Table-1. Electrical properties of solar cell.

AR Coating	J_{sc}(mA./cm^2)	V_{oc}(v)	η (%)
Bare solar cell	20.50	0.5615	8.32
Trial 1 with AR	22.82	0.5671	9.50
Trial 2 with AR	25.93	0.5768	10.95
Trial 3 with AR	29.32	0.5812	12.72

From this table, the efficiency of the Zinc Oxide antireflection coating applied solar has increased by 4 % when compared to bare solar cell. From this, it is clearly shown; the antireflection coating increases the absorbance by reducing the reflectance.

CONCLUSIONS

The findings of this experiment are compared to those of a naked solar cell, which is an uncoated solar cell. Weak photons are also absorbed when an antireflective coating is applied to a solar cell. The efficiency and quality of the solar cell are improved by lowering the reflectance. The coated cell's voltage is boosted from 0.58v to 0.58v. Antireflection coating, like protective glass, is required. The efficiency of single layer antireflection, double layer, and triple layer antireflection coatings is excellent. Antireflection coating for semiconductor integrated circuits is a cost-effective process in the semiconductor industry. Due to its low cost and ease of use, spin coater technology is suited for all micro and Nano electronics integrated circuits.

REFERENCES

[1] Jeremy J. Low, Michael L. Kreider, Drew P. Pulsifer Andrew S. Jones. et al. 2008. Band Gap Energy in Silicon. American Journal of Undergraduate Research. 7(1).

[2] V Semenova, V A Yuzova, N Patrushev, F FMerkushev. 2014. Antireflection and protective films for silicon solar cells. Materials Science and Engineering. 2: 66.

[3] Vikas. 2015. Anti-Reflection coatings for highly efficient solar cells. National Conference on Photonics and Material Science.

[4] Natarajan Shanmugam, Rishi Pugazhendhi, Narottam Das. 2020. Anti-Reflective Coating Materials: A Holistic Review from PV Perspective. Energies. 13: 1362.

[5] Andresa Baptisa, Francisco Silva, Jacobo Porteiro. 2018. Sputtering Physical Vapour Deposition (PVD) Coatings: A Critical Review on Process Improvement and Market Trend Demands. Coatings. 8(11).

[6] Manikandan N., Shanthi B. and Muruganand S. 2013. Construction of spin coating machine controlled by arm processor for physical studies of PVA. International Journal of Electronics and Electrical Engineering. 3(4): 318-322.

[7] Sadegh-Cheri M. 2019. Design, Fabrication, and Optical Characterization of a Low-Cost and Open-Source Spin Coater, ACS Publications. 1268-1272.

[8] Gurucharan V. Karnad, R. N. Ninad and V. Venkataraman. 2017. Design of an inexpensive spin coater (with a touch-screen interface). Materials Research. 3(7): 51-59.

[9] Siddhant. B. Patel, Jignasa. V. Gohel. 2018. Optimization of sol-gel spin coated CU2 ZnSnS4

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(CZTS) thin film control parameters by RSM method to enhance the solar cell performance. Journal of material science. 53(17): 71-79.

[10] Lintao He, Hao Gu, Xiaolong Liu, Penswei Li. et al. 2020. Efficient anti solvent - free spin coated and printed Sn-Perovskite solar cells with crystal - Based pre cursor solutions. Matter. 2(1): 167-180.

[11] Yofentina I, Vista I. V, Hikam. M, Bam bang. S et al. 2012. Optimization of rotational speed in the growing of the thin film using Sol-gel method which is prepared with spin coating. Journal of Material Science Engineering. 1(3): 100113-100119.

[12] Halin. D. S. C, I. A. Talib, A. R. Daud, M. A. A. Hamid. 2014. Characterization of cuprous oxide thin films prepared by Sol-Gel spin coating technique with different additives for the photo electro chemical solar cell. International Journal of Photo energy. 2014(1): 1-6.

[13] Fujishima A, Honda K. 1972. Photo electrolysis of water using semiconducting TiO2 crystals. Nature. 37(238).

[14] C. M. Firdaus. 2012. Characterization of ZnO and ZnO: TiO2 Thin Films Prepared by Sol Gel Spray-Spin Coating Technique. International Symposium on Robotics and Intelligent Sensors, (IRIS 2012).