iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** VII **Month of publication:** July 2016

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Effect of Silicon Nitride coating on the absorptivity Of Mono-Crystalline & Solar Grade Crystalline Silicon Wafers

Apurv Yadav[1], Bidyut Barman[2], Abhishek Verma[3], V. K. Jain[4]
Amity Institute of Renewable and Alternate Energy, Amity University Noida

Abstract—* Industrialization of modern world generates a need for alternative energy. Researches are going on to tap many sources of renewable energy but still increasing the efficiency of these resources remains a challenge. This work presents the effect of absorptivity of silicon wafers by varying the colours of coating. Efficiency of silicon solar cells is considerably affected by the absorption of light and charge collection area. As absorption increases, photocurrent and efficiency increases. To create various colours, silicon wafer were coated with different composition of silicon nitride. This test was conducted in the production line of Indosolar Ltd., Greater Noida. Experiments were performed during the two stages of production, the screen printing process and Plasma Enhanced Chemical Vapour Deposition (PECVD) stage on the equipment manufactured by Schmid Gmbh, Germany. The relation of short circuit current (ISC), open circuit voltage (VOC) and efficiency (η) is analysed with respect to the collection area of the silicon solar cell. A Bruker Alpha - E Spectrometer is used to test the absorption of different surface texture of silicon wafers.

***Keywords*—Silicon wafers; plasma coating; absorption spectrum; anti-reflective coating; silicon nitride.**

I. INTRODUCTION

Energy generation by solar cell is increasing worldwide nowadays. It is the most promising technique of alternative energy generation. It works on PV effect which was discovered by Becquerel in 1839. Fritts built the first solar cell in 1883. But solar cells have become successful only recently. The cause of this is its low efficiency and high cost per kW h of energy. Silicon solar cells have a low efficiency of around 20% even now and no improvement is done over the past decade [1], [2]. Incident light reflection from the surface of the solar cell is one of the major losses affecting the efficiency of solar cell. About 90% of industrial solar cells are made of crystalline Si [3]. An average of 37% light is reflected from the surface of a solar cell. Minimizing reflection from the surface of the solar cell has been a major focus of researchers for several years [4-9]**.** Solar cell production includes of raw silicon wafers processing to complete solar cell in different steps. The reflection of light from the upper surface of a solar cell is a major factor in affecting its efficiency. Antireflective coatings are helpful in minimizing this loss. The reflection coefficient can be reduced by anti-reflective coatings. Anti-reflective coating is crucial for solar cell performance as it provides a high photocurrent by minimising reflectance. SiN_X films deposited by Plasma Enhanced Chemical Vapour Deposition are widely used as standard antireflection coatings for industrial silicon solar cells. Various films have been considered as ARC for silicon solar cells, but SiN_X has shown strong potential. This is because SiN_X has a good surface passivation and a tuneable refractive index ranging from 1.9 to 2.9 due to which it can be optimized for its application. Also it has bulk passivation due to hydrogen and it reduces front side optical reflection [10], [11]. In this work experiments have been performed on monocrystalline and multicrystalline silicon wafers. Spectral analysis of coated and uncoated wafers of both type is performed by an infrared spectrometer and results were compared. The wafer used here is the raw material for commercial solar cells which are made up of semiconductor silicon. Its dimensions are 156mm ×156mm and 200µm thick with chamfered corners as shown in Figure. 1.

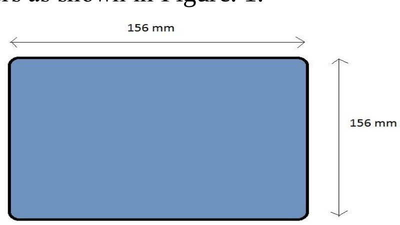


Figure 1. Silicon wafer

Volume 4 Issue VI, June 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

II. EXPERIMENTAL PROCEDURE

The technology used here is a direct plasma reactor technology which achieves higher cell efficiency than the remote plasma reactor. The PECVD system is based on technology developed by Japanese manufacturer Shimadzu.

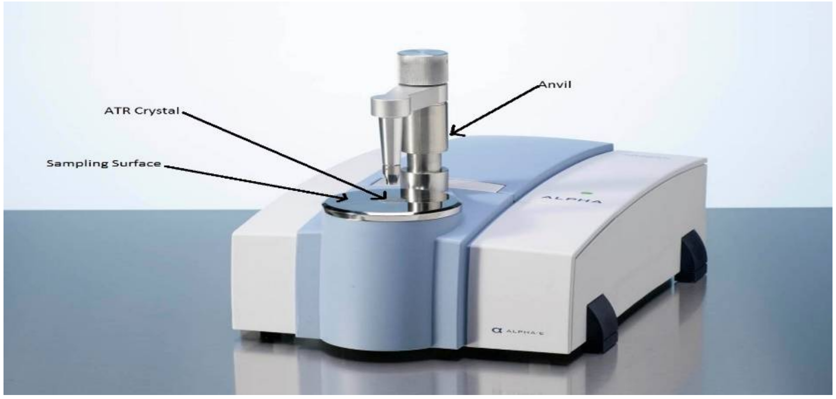


Figure 2. Bruker Alpha - E Spectrometer

Four samples of both monocrystalline silicon wafers and solar grade silicon wafers were collected. First the absorbance of IC grade monocrystalline wafers is measured with the help of Bruker Alpha - E Spectrometer. Then these samples are passed through PECVD machine for silicon nitride deposition. In the PECVD (Plasma Enhanced Chemical Vapour Deposition) coating system the wafer is coated with an anti-reflection layer consisting of silicon nitride.

The samples were placed at the ATR (Attenuated Total Reflection) crystal in a proper way. We made sure that the sampling surface, ATR crystal and anvil were clean. Sample is placed on the middle of the sampling surface. Small amount of sample is used, only enough to cover the ATR crystal. The anvil is pressed against the sample making sure that the optimum contact pressure is used to press the sample against the ATR crystal. When the spectrum is acquired, the pressure application device is moved up again and the sample is removed.

III. RESULT AND DISCUSSION

The absorptivity versus wavelength graph is plotted as shown in the Figure 3(a) and Figure 3(b). Now same process is repeated with four samples of solar grade wafers. Their absorbance graph is also plotted as shown in Figure 4(a) and Figure 4(b).

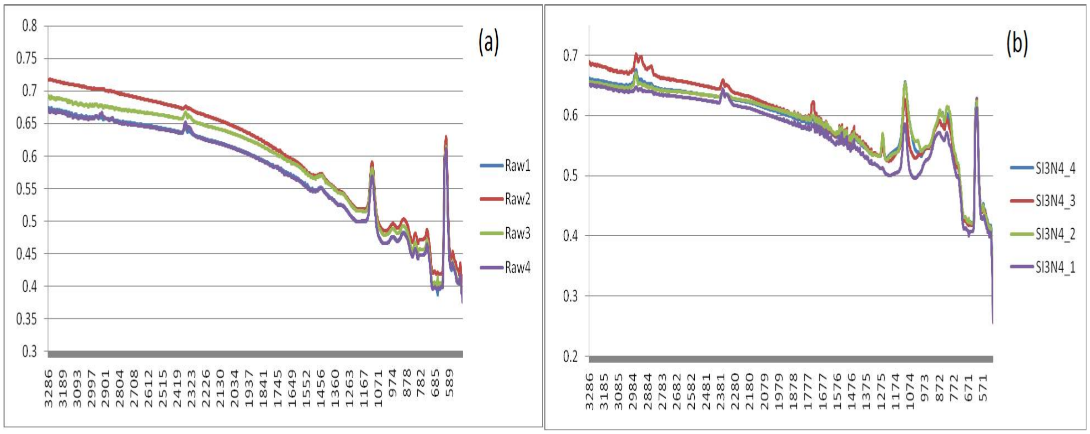


Figure 3. FTIR GRAPH of IC Grade Mono crystalline Wafers: (a) Raw Wafers & (b) Silicon Nitride coated Wafers

By comparing the two graphs we can clearly see the effect of silicon nitride coating on the absorbance of the wafer. In FTIR spectrum of raw wafer where nitrogen is not present, at near IR rays there is absorption coefficient of 0.47. But after coating the FTIR spectrum shows a rise in absorption coefficient from 0.47 to 0.62 at around 860nm. This wavelength corresponds to the vibrational frequency of Silicon nitride and maximum energy is absorbed at this point. The increase in the absorptivity is around 30%.

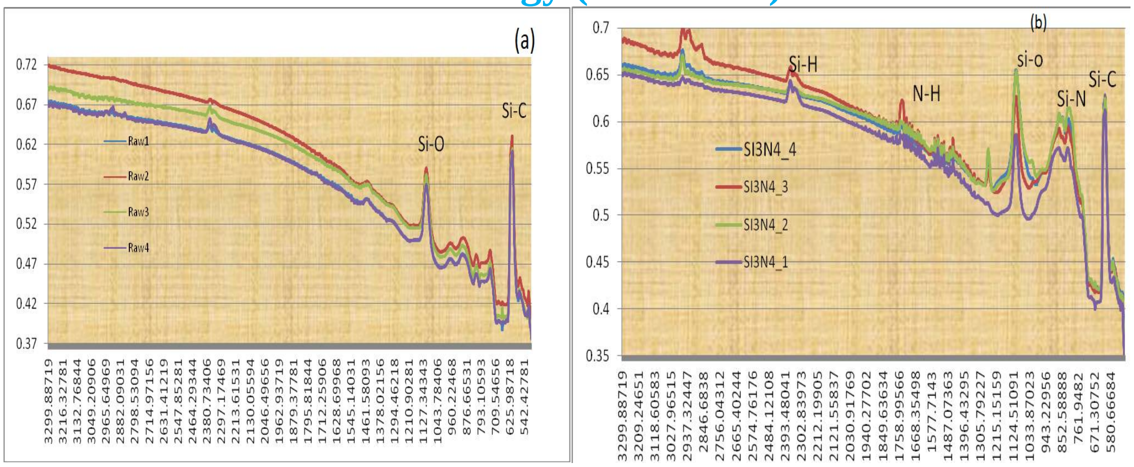


Figure 4. FTIR GRAPH of SIN Solar Grade Wafers: (a) Raw Wafers & (b) Silicon Nitride coated Wafers

As can be inferred from the above graphs, the coating of silicon nitride increase the absorptivity around 853 nm from 0.45 to 0.58. It can be inferred that the above process can bring about 28% increase in absorptivity.

IV. CONCLUSION

The optical properties of silicon nitride films deposited by direct plasma reactor PECVD onto crystalline and solar grade silicon wafers were studied. It was shown that the absorptivity of these films increased and can be considered for optimisation of solar cells. The absorptivity of a photovoltaic cell is the fraction of incident solar irradiance that is absorbed. By all the results conducted above it can inferred that by using silicon nitride PECVD coating by direct plasma reactor technique, there is an increase in the absorptivity of about 30% in mono-crystalline silicon wafers and increase in absorptivity of about 28% in solar grade silicon wafers.

V. ACKNOWLEDGEMENTS

We would like to thanks all the staff of Indosolar Limited, Greater Noida for their support in conducting this experiment in their production line which sometimes also causes to disrupt their continuous production.

REFERENCES

[1] M. A. Green, "The path to 25% silicon solar cell efficiency: History of silicon cell evolution", Progress in Photovoltaics: Research and Applications, 17(3), 183-189, 2009.

[2] M. A. Green, K. Emery, K. BuÈcher, D. L. King & S. Igari, "Solar Cell Efficiency Tables (Version 9)", Progress in Photovoltaics: Research and Applications, 5, 51-54, 1997.

[3] L. A. Dobrzański & A. Drygała, "Laser processing of multicrystalline silicon for texturization of solar cells", Journal of Materials Processing Technology, 191(1), 228-231, 2007

[4] J. Zhao & M. A. Green, "Optimized antireflection coatings for high-efficiency silicon solar cells", IEEE Transactions on Electron Devices, 38(8), 1925-1934, 1991.

[5] L. Schirone, G. Sotgiu & F. P. Califano, F. P. (1997), "Chemically etched porous silicon as an anti-reflection coating for high efficiency solar cells", Thin Solid Films, 297(1), 296-298, 1997.

[6] M. Tao, W. Zhou, H. Yang & L.Chen, "Surface texturing by solution deposition for omnidirectional antireflection", Applied Physics Letters, 91(8), 081118, 2007.

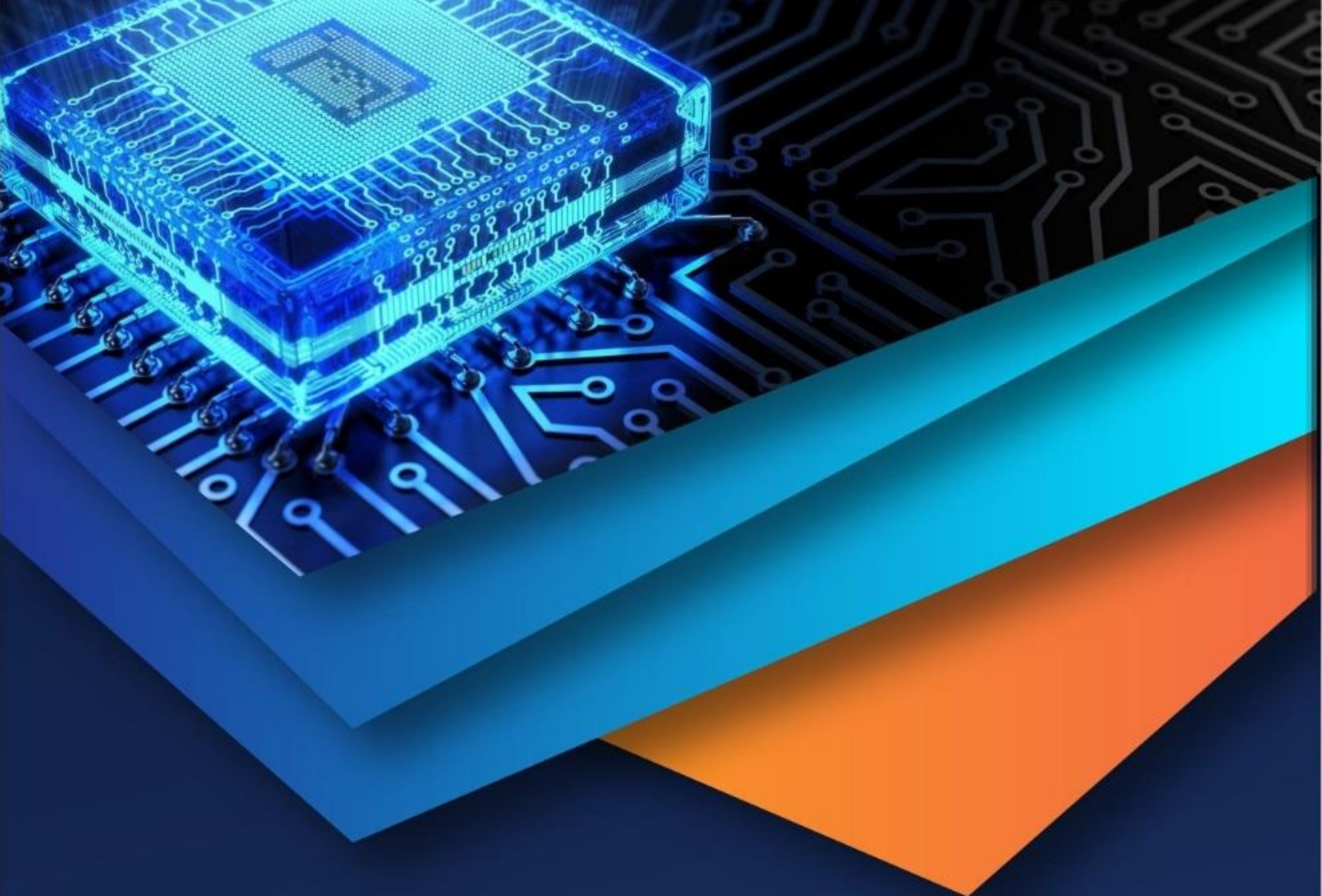
[7] C. Lee, S. Y. Bae, S. Mobasser, & H. Manohara, "A novel silicon nanotips antireflection surface for the micro sun sensor", Nano letters, 5(12), 2438-2442, 2005.

[8] Y. F. Huang, S. Chattopadhyay, Y. J. Jen, C. Y. Peng, T. A. Liu, Y. K. Hsu & C. S. Lee, "Improved broadband and quasi-omnidirectional anti-reflection properties with biomimetic silicon nanostructures", Nature nanotechnology, 2(12), 770-774, 2007.

[9] C. H. Sun, P. Jiang & B. Jiang, "Broadband moth-eye antireflection coatings on silicon", Applied Physics Letters, 92(6), 061112, 2008

[10] H. Nagel, A. G. Aberle & R. Hezel, "Optimised antireflection coatings for planar silicon solar cells using remote PECVD silicon nitride and porous silicon dioxide", Progress in Photovoltaics: Research and Applications, 7(4), 245-260, 1999.

[11] S. Duttagupta, F. Ma, B. Hoex, T. Mueller & A. G. Aberle, "Optimised antireflection coatings using silicon nitride on textured silicon surfaces based on measurements and multidimensional modelling", Energy Procedia, 15, 78-83, 2012.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY