Eurasian Journal of Analytical Chemistry
ISSN: 1306-3057 OPEN ACCESS 2018 13 (4): 853-857

Feasibility Study on Improving the Power Efficiency of Single Crystalline Silicon Solar Cell by Surface Texturing

J.D. Joseph, Dr.M. Jasmin

Received: 29 March 2018 ▪ Revised: 19 April 2018 ▪ Accepted: 01 June 2018

Abstract: Silicon is well studied and abundantly available material for making CMOS integrated circuit and high power electronic devices. When a normal and simple p-n junction diode is shined with s spectrum of light in the vicinity of its junction, electron-hole pairs are generated and they are accelerated by the built-in electric field to produce the electromotive force between its terminals. This is known as photovoltaic effect. The conventional efficiency of a p-n junction solar cell mainly limited by reflection of part of shined light due to Fresnel reflection. However, its reflection itself may be utilized to increase total absorption light by a p-n junction solar cell, if we texture the surface in such a way that multiple reflection and hence improved absorption of light occur between the facets on its surface. This paper focuses mainly on the studies made by researchers to achieve a textured surface thereby increasing the possibilities of improved efficiency.

Keywords:Surface Texturing, RIE, Damage removal Etch (DRE)

INTRODUCTION

PhotoVoltaic (PV) covers the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electro chemistry. Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transducer light energy. Virtually all photovoltaic devices are some type of photodiode.

WHAT IS A SOLAR CELL

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibits the photovoltaic effect. The collection of light-generated carriers does not by itself give rise to power generation. In order to generate power, a voltage must be generated as well as a current. Voltage is generated in a solar cell by process known as the "photovoltaic effect". The collection of light-generated carriers by the p-n junction causes a movement of electrons to the n-type side and holes to the p-type side of the junctions.Fig.1 shows the basic structure of simple solar cell. The bulk where in most of the light is absorbed is referred to as base and generated is p-type material. A top thin n- type region is diffused into the base and is known as the emitter. A top finger or grid contact and bottom rear contact form two metal pad or electrodes. Front surface is textured or coated with antireflection film or both are done to reduce the reflection loss and hence improve the efficiency.

The basic steps in the operation of a solar cell are:

- The absorption of incident light
- The generation of light-generated carriers.

J.D. Joseph, Assistant Professor, Department of Electronics and Communication Engineering, BIST, BIHER, Bharath Institute of Higher Education & Research, Selaiyur, Chennai.

Dr.M. Jasmin, PG Scholar, Department of Electronics and Communication Engineering, BIST, BIHER, Bharath Institute of Higher Education & Research, Selaiyur, Chennai.

- The collection of the light-generated carriers to generate a current;
- The generation of large voltage across the solar cell; and
- The dissipation of power in the load and in parasitic resistances.

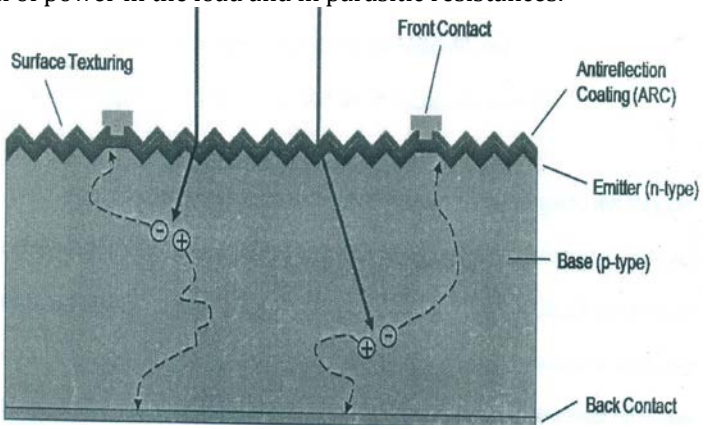

Figure 1: Basic structure of simple solar cell

Initial Research Done

In 1995, Jansen et al was the first to propose the mask-less Reactive –Ion Etching process. Until then, chromium or metal masks were used to isolate the etching areas and process them for dry etching. This method was very effective and subsequent studies were performed.

Following these above mentioned steps, Zhao et al in 1998 found out photolothographically defined etching process can be done for surface texturing. Patterns were defined by photolithography method, windows were opened and exposed areas were textured through RIE process. These 2 proposed methods became the foundation for the researchers to carry out different options in texturing thereby having accurate etch depth and roughness control. This was one of the motivations of this project to have aninsight and to get a better performance in efficiency.

Early 2000

In 2000, Martin Schnell et al., proposed Dry silicon surface texturing process to improve efficiency of solar cell due to reduced reflection and light trapping.

Texturing of front surfaces on solar cells improves the cell efficiency by means of its antireflection property and light trapping. The thinner the solar cells get, the more important the optical confinement is. State of the art surface texturing is alkaline wet chemical etching, e.g. in diluted KOH solutions. However, since this method is based on preferential etching along certain grain orientations it only works well on mono-crystalline silicon wafers of <1**OO>**crystal orientation. Resulting structures are either inverted pyramids if photolithographic etch masks are used, or random pyramids in a mask less process.

In 2002, Kumaravelu et.al, discussed that the surface texturing is an effective and more lasting technique in reducing reflections and improving light trapping compared to antireflection coatings A surface texturing technique using RIE technique method is suitable for crystalline and multicrystalline solar cells , which resulted in surfaces with negligible reflection in the visible band described. Different texturing structures were studied and compared. Higher cell efficiencies can also be achieved by light trapping of long wavelength light.

In 2005, (Jianming Li et al.,) A new technique for boosting efficiency of silicon solar cells, in which provide the improvement of power efficiency in the V shape solar cell module [4]. Proceedings of the 24th IEEE Photovoltaic Specialist Conference (Path, P et al),which provide the crystalline silicon including mechanical diamond saw cutting mechanism. Compared to solar cells of flat orientation, the VSM (V-shaped Module) enhances external quantum efficiency and leads to an increased power conversion efficiency. A new photovoltaic system with higher generation efficiency was studied in detail.

Late 2000

In the late 2000, D.S Ruby et al, developed a maskless plasma texturing technique and compared different metal-assisted texturing process. Al- assisted, Ti-assisted, Cr-assisted. These were used in conjunction with a dilute acid DRE (Damage removal etch, a KOH DRE and no DRE at all. They found out that the RIE texturing can be done without causing performance limiting damage to Si- cells.

In 2010, JinsuYoo, proposed the RIE process can provide high rates of isotropic etching, which makes it possible to vary the etch directionality between isotropic and anisotropic using SF_6/O_2 at various flow rates [8]. IN this study, surface texturing or the application in crystalline silicon solar cells was carried out by the conventional RIE process using SF_6/O_2 gas mixture. In order to remove the saw damages and contaminants from the silicon surface, acid etching (Damage removal etching DRE) and conventional SDR process were employed in this study.

Why Surface Texturing?

Front surface texturing is done using dry physical or chemical etching. Surface texturing improves efficiencies of solar cells, due to reduced reflection and light trapping. Surface texturing is an effective and more reliable technique in reducing reflection and improving light trapping compared to anti-reflection coating. In addition to minimizing reflection of the incident light, it also increases the effective area of incident surface of the solar cell.

Fig. 2 shows that any roughness in the surface reduces reflection by increasing the chances of reflected light bouncing back onto the surface, rather than getting out to the surrounding air. Surface texturing can be accomplished in a number of ways.

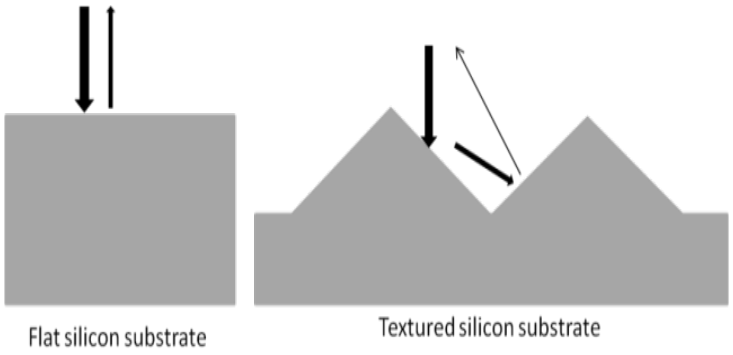

Figure2: Reflection of light from flat and textured surface

CONCLUSION

This chapter gives a detailed study made by researchers in order to improve the overall efficiency of a silicon solar cell by implementing a process called as surface texturing. A single crystalline substrate can be textured by etching along the faces of the crystal planes. The crystalline structure of silicon results in a periodic pyramid surface enhancing the light absorption on the surface thereby increasing the efficiency.

REFERENCES

[1] Krishnamoorthy, P., &Jayalakshmi, T. (2012). Preparation, characterization and synthesis of silver nanoparticles by using phyllanthusniruri for the antimicrobial activity and cytotoxic effects, *Journal of Chemical and Pharmaceutical Research,4*(11), 4783-4794.

[2] Amir, M., Gungunes, H., Slimani, Y., Tashkandi, N., El Sayed, H.S., Aldakheel, F., Sertkol, M., Sozeri H., Manikandan A., Ercan, I., & Baykal, A. (2019). Mössbauer studies and magnetic properties of cubic CuFe 2 O 4 nanoparticles. *Journal of Superconductivity and Novel Magnetism*, *32*(3), 557-564.

[3] Raj, M.S., Saravanan T., & Srinivasan, V. (2014). A modified direct torque control of induction motor using space vector modulation technique. *Middle - East Journal of Scientific Research,20*(11), 1572-1574.

[4] Khanaa, V., &Thooyamani, K.P. (2013). Using triangular shaped stepped impedance resonators design of compact microstrip quad-band. *Middle-East Journal of Scientific Research*, *18*(12), 1842-1844.

[5] Asiri S., Sertkol M., Güngüneş H., Amir M., Manikandan A., Ercan I., & Baykal A. (2018). The Temperature Effect on Magnetic Properties of NiFe 2 O 4 Nanoparticles. *Journal of Inorganic and Organometallic Polymers and Materials,28*(4), 1587-1597.

[6] Thaya, R., Malaikozhundan, B., Vijayakumar, S., Sivakamavalli, J., Jeyasekar, R., Shanthi, S., Vaseeharan, B., Ramasamy, P., &Sonawane, A. (2016). Chitosan coated Ag/ZnOnanocomposite and their antibiofilm, antifungal and cytotoxic effects on murine macrophages. *Microbial pathogenesis*, *100*, 124-132.

[7] Kolanthai, E., Ganesan, K., Epple, M., &Kalkura, S.N. (2016). Synthesis of nanosized hydroxyapatite/agarose powders for bone filler and drug delivery application. *Materials Today Communications*, *8*, 31-40.

[8] Thilagavathi, P., Manikandan, A., Sujatha, S., Jaganathan, S.K., & Arul Antony, S. (2016). Sol–Gel Synthesis and Characterization Studies of NiMoO4 Nanostructures for Photocatalytic Degradation of Methylene Blue Dye. *Nanoscience and Nanotechnology Letters*, *8*(5), 438-443.

[9] Sharma, D., Sharma, A., &w Agarwal, G. (2018). Review Paper on Digital Steganography in Android Application. *International Academic Journal of Innovative Research, 5*(2), 9-16.

[10] Vigneshwaran, S., Sajith, K., Vasanthakumar, M., &Rajkumar, R. (2015). Multi-Level Electronic Bank Locker Security System. *International Journal of Communication and Computer Technologies, 3*(1), 42-49.

[11] Thamotharan C., Prabhakar S., Vanangamudi, S., &Anbazhagan, R. (2014). Anti-lock braking system in two wheelers. *Middle - East Journal of Scientific Research,20*(12), 2274-2278.

[12] Thamotharan C., Prabhakar S., Vanangamudi, S., Anbazhagan, R., &Coomarasamy C. (2014). Hydraulic rear drum brake system in two wheeler. *Middle - East Journal of Scientific Research,20*(12), 1826-1833.

[13] Vanangamudi, S., Prabhakar S., Thamotharan C., &Anbazhagan, R. (2014). Collision control system in cars. *Middle - East Journal of Scientific Research,20*(12), 1799-1809.

[14] Vanangamudi S., Prabhakar S., Thamotharan C., &Anbazhagan R. (2014). Drive shaft mechanism in motor cycle. *Middle - East Journal of Scientific Research,20*(12), 1810-1815.

[15] Anbazhagan R., Prabhakar S., Vanangamudi S., &Thamotharan C. (2014). Electromagnetic engine. *Middle - East Journal of Scientific Research,20*(3), 385-387, 2014.

[16] Kalaiselvi, V.S., Prabhu, K., & Mani Ramesh, V.V. (2013). The association of serum osteocalcin with the bone mineral density in post-menopausal women. *Journal of clinical and diagnostic research: JCDR*, *7*(5), 814-816.

[17] Kalaiselvi, V.S., Saikumar, P., &Prabhu, K. (2012). The anti mullerian hormone-a novel marker for assessing the ovarian reserve in women with regular menstrual cycles. *Journal of clinical and diagnostic research: JCDR*, *6*(10), 1636-1639.

[18] Arul, K.T, Manikandan, E., Ladchumananandasivam, R., &Maaza, M. (2016). Novel polyvinyl alcohol polymer based nanostructure with ferrites co-doped with nickel and cobalt ions for magneto-sensor application. *Polymer International*, *65*(12), 1482-1485.

[19] Das, M.P., & Kumar, S. (2015). An approach to low-density polyethylene biodegradation by Bacillus amyloliquefaciens. *3 Biotech*, *5*(1), 81-86.

[20] Vanangamudi S., Prabhakar S., Thamotharan C., &Anbazhagan, R.(2014). Turbo charger in two wheeler engine. *Middle - East Journal of Scientific Research,20*(12), 1841-1847.

[21] Vanangamudi S., Prabhakar S., Thamotharan C., &Anbazhagan, R. (2014). Design and calculation with fabrication of an aero hydraulwicclutch. *Middle - East Journal of Scientific Research,20*(12), 1796-1798, 2014.

[22] Saravanan, T., Raj, M.S., &Gopalakrishnan, K. (2014). VLSI based 1-D ICT processor for image coding. *Middle-East Journal of Scientific Research*, *20*(11), 1511-1516.

[23] Ajona, M., &Kaviya, B. (2014). An environmental friendly self-healing microbial concrete. *International Journal of Applied Engineering Research*, *9*(22), 5457-5462.

[24] Hemalatha, R., &Anbuselvi, S. (2013). Physicochemical constituents of pineapple pulp and waste. *Journal of Chemical and Pharmaceutical Research*, *5*(2), 240-242.

[25] Langeswaran, K., Revathy, R., Kumar, S.G., Vijayaprakash, S., &Balasubramanian, M.P. (2012). Kaempferol ameliorates aflatoxin B1 (AFB1) induced hepatocellular carcinoma through modifying metabolizing enzymes, membrane bound ATPases and mitochondrial TCA cycle enzymes. *Asian Pacific Journal of Tropical Biomedicine*, *2*(3), S1653-S1659.

[26] Masthan, K.M.K., Babu, N.A., Dash, K.C., &Elumalai, M. (2012). Advanced diagnostic aids in oral cancer. *Asian Pacific Journal of Cancer Prevention*, *13*(8), 3573-3576.

[27] Asiri S., Güner S., Demir A., Yildiz A., Manikandan A., & Baykal, A. (2018). Synthesis and Magnetic Characterization of Cu Substituted Barium Hexaferrites. *Journal of Inorganic and Organometallic Polymers and Materials,* 28(3), 1065-1071.

[28] Dr.Sundararaju, K., & Rajesh, T. (2016). Control Analysis of Statcomunder Power System Faults. *International Journal of Communication and Computer Technologies, 4*(1), 1-6.

[29] Yakubu H. J., Aboiyar T., &Zirra P.B. (2016). Improvement of Power Quality Using PQ theory Based Series Hybrid Active Power Filter. *International Journal of Communication and Computer Technologies, 4*(1), 7-11.

[30] Poovarasan, S., &Brindha, R. (2016). Wireless Electricity Billing and Meter Reading Using IoT. *International Journal of Communication and Computer Technologies, 4*(1), 19-22.

[31] Poovarasan, S., &Brindha, R. (2016). Survey of Various Techniques to Reduce Leakage Power in FPGA. *International Journal of Communication and Computer Technologies, 4*(1), 23-28.

[32] Zarei, N., &Sepyani, A. (2016). Different methods of image mapping, its advantages and disadvantages. *International Academic Journal of Science and Engineering, 3*(4), 1-10.

[33] Shahmordi, S. (2016). Detection of fault location on transmission systems using Wavelet transform. *International Academic Journal of Science and Engineering, 3*(4), 23-32.

[34] Vellayappan, M.V., Jaganathan, S.K., &Manikandan, A. (2016). Nanomaterials as a game changer in the management and treatment of diabetic foot ulcers. *RSC Advances*, *6*(115), 114859-114878.

[35] Vellayappan, M.V., Venugopal, J.R., Ramakrishna, S., Ray, S., Ismail, A.F., Mandal, M., Manikandan, A., Seal, S.,&Jaganathan, S.K. (2016). Electrospinning applications from diagnosis to treatment of diabetes. *RSC Advances*, *6*(87), 83638-83655.

[36] Bavitra, K., Sinthuja, S., Manoharan, N., & Rajesh, S. (2015). The high efficiency renewable PV inverter topology. *Indian Journal of Science and Technology*, *8*(14), 1.

[37] Vanangamudi, S., Prabhakar, S., Thamotharan, C., &Anbazhagan, R. (2014). Design and fabrication of dual clutch. *Middle-East Journal of Scientific Research*, *20*(12), 1816-1818.

[38] Sandhiya, K., &Kaviya, B. Safe bus stop location in Trichy city by using gis. *International Journal of Applied Engineering Research*, *9*(22), 5686-5691.

[39] Kumar, S.S., Rao, M.R.K., Deepak Kumar, R., Panwar, S., & Prasad, C.S. (2013). Biocontrol by plant growth promoting rhizobacteria against black scurf and stem canker disease of potato caused by Rhizoctoniasolani. *Archives of Phytopathology and Plant Protection*, *46*(4), 487-502.

[40] Sharmila, S., & Rebecca, L.J. (2012). GC-MS Analysis of esters of fatty acid present in biodiesel produced from Cladophoravagabunda. *Journal of Chemical and Pharmaceutical Research*, *4*(11), 4883-4887.

[41] Ramkumar, M., Rajasankar, S., Gobi, V.V., Dhanalakshmi, C.,Manivasagam, T., Thenmozhi, A.J., Essa, M.M., Kalandar, A., & Chidambaram, R. (2017). Neuroprotective effect of Demethoxycurcumin, a natural derivative of Curcumin on rotenone induced neurotoxicity in SH-SY 5Y Neuroblastoma cells. *BMC complementary and alternative medicine*, *17*(1), 217.

[42] Selvi, S.A., &Sundararajan, M. (2016). A Combined Framework for Routing and Channel Allocation for Dynamic Spectrum Sharing using Cognitive Radio. *International Journal of Applied Engineering Research*, *11*(7), 4951-4953.

[43] Krupaa R.J., Sankari S.L., Masthan K.M.K., & Rajesh E. (2015). Oral lichen planus: An overview. *Journal of Pharmacy and Bioallied Sciences, 7,* S158-S161.

[44] Srividya, T., &Saritha, B. (2014). Strengthening on RC beam elements with GFRP under flexure. *International Journal of Applied Engineering Research*, *9*(22), 5443-5446.

[45] Kumar, J., Kumar, K.S., &Dayakar, P. (2014). Effect of microsilica on high strength concrete. *International Journal of Applied Engineering Research*, *9*(22), 5427-5432.

[46] Saraswathy, R., &Saritha, B. (2014). Planning of integrated satellite township at Thirumazhisai. *International Journal of Applied Engineering Research*, *9*(22), 5558-5560.

[47] Saritha, B., Ilayaraja, K., &Eqyaabal, Z. (2014). Geo textiles and geo synthetics for soil reinforcement. *International Journal of Applied Engineering Research*, *9*(22), 5533-5536.

[48] Iyappan, L., &Dayakar, P. (2014). Identification of landslide prone zone for coonoortalukusing spatialtechnology. *International Journal of Applied Engineering Research*, *9*(22), 5724-5732.

[49] Dejamkhoy, A., Najafi, R., Javanajdadi, K., &Hasanpour, J. (2016). Reactive Power Compensators for Maintaining Voltage Stability of the Wind Farm Using STATCOM in the presence Nonlinear Load. *International Academic Journal of Science and Engineering, 3*(4), 33-43.

[50] Choudhury, N., & Dr. Singh, C.T. (2015), Human Assistance Robot using Android Technology for Human Robot Interaction.*International Scientific Journal on Science Engineering & Technology,18*(1) , 30-38.