Design a High-Efficiency Silicon Solar Cells Using Nanotechnology

P.Archana[1], J.Sumathi[2]

[1,2] *Assistant Professor, Teegala Krishna Reddy Engineering College, Telangana*

Abstract- **Basically the thin flim solar cells are fabricated on the foreign substrates like glass and stainless steel. The efficiency of nano crystalline solar cells is high compared to others. In vertically aligned nano wire solar cells the sensitivity is very less. First solar cell was introduced by bell in 1954. These solar cells are fabricated on the crystal silicon. The efficiency obtained after the fabrication is 6 to 22% from last 55 years. Depending upon the growth of technology the efficiency in solar cells also increased to 30.7%. In solar cells we use different number of materials but here as per development in technology we use semiconductors. By using semiconducting materials in solar cells the efficiency has increased up to 50%. In 1990s to generate energy we use photovoltaic effects that enable the use of nano structured materials. The nano structure depends upon the solar cells which exhibits the area by increasing the photon capture cells. So the main intent of this nano technology is to increase the energy efficiency compared to the conventional solar cells.**

I. INTRODUCTION

In old generation the solar energy is not widely used because of high cost. So to overcome this problem Japan, Germany and china countries started research to decrease the cost. After some years solar energy came into existence and it is most widely used in various applications and some of the applications like industrial, residential and commercial. Compared to past now solar cells are most widely used in Japan and Germany countries. There are many technologies used in the field of solar cells. Coming to cost of solar cell it is also reduced. Basically, to obtain high acceptance in solar energy there should be reduction in the cost.

The cost reduction is possible only by following conditions they are 1. A significant increase in conversion efficiency. 2. There should be reduction in processing cost and 3. The reduction in the amount of raw-material required to fabricate solar cells. Basically there are two ways to obtain the solar energy goals. They are crystalline silicon and thin films. For Every solar energy will have multiple options. The main purpose of using this multiple path characteristics is to obtain high potential in solar energy. As discussed earlier that solar energy is most widely used in residential and commercial applications because in this we use major silicon to obtain better result compared to others. To get more efficiency and reliability in commercial and residential applications some of the solar generating systems are used. Coming to the crystalline silicon technology, it is the best technology which produces 90% efficiency. The current efficiencies in crystalline silicon based technology vary from the 12% to 17%. But in the conventional solar energy solutions the cost is very high and it is not widely accepted by any energy solutions. So present crystalline silicon based solar energy is widely used.

This is about the crystalline silicon solar energy, now we will discuss about the thin flims. In thin flims number of materials are used they are given as amorphous silicon and copper indium dieseline, thin film silicon. These are the materials but we use mostly thin film silicon. The thin flim silicon encompasses the both crystalline and amorphous silicon. This thin flim silicon is used in pv module technology and it gives efficiency at commercial module level. This pv module technology is not only gives efficiency but also gives reliability. Basically thin flims have distinction between cells and modules. In this the efficiency varies from 5% to 10% and coming to the cost it is same as crystalline silicon solar energy. Because of the toxic nature in materials the solar cells are not accepted. From below figure (1) we can observe the best laboratory efficiency obtained from the different materials and technologies.

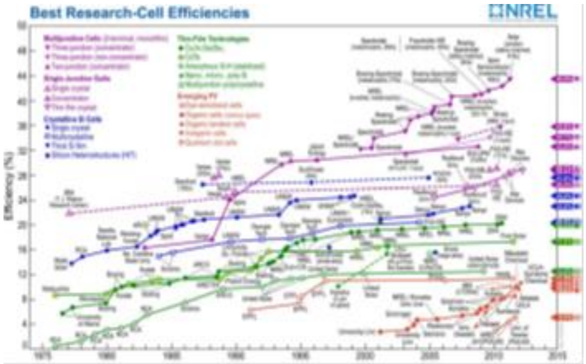

Fig. 1: Reported timeline of solar cell's conversion efficiencies (from National Renewable Energy Laboratory (USA))

In present field to obtain high efficiency conventional multi junctions are used. But the cost of materials and manufacturing are 10 times higher than the silicon solar cells. But this is only used for large applications, foe small applications we use the silicon based solar cell. So to increase the conversion of solar energy number of researches and developments are done. Coming to high efficiency silicon solar cell, it depends on the nanostructures. These are fabricated by using silicon integrated circuit technology. At last the main purposed behind using this silicon solar cell is that it eliminates the energy crisis occurred in the system.

II. SOLAR CELL TECHNOLOGY

A. Conventional Solar Cells and Structural Limitations

The below figure (2) shows the structure of solar cell. There are two layers in the structure of solar cells one is thin semiconductor layer and thick semiconductor layer. These both layers form an electrically conductive substrate. Between p-type and n-type semiconductor layer a p-n junction is formed. Electron hole is generated when sunlight incident into the cell. This incident light generates an electron hole pair. This electron hole pair absorbs the both p type and n type semiconductors. Now the photo generated electrons diffuses towards the p-n junction and enters into the p-n junction region. Basically, there are two factors in solar cell energy conversion they are photo carrier generation efficiency (PCGE) and photo carrier collection efficiency (PCCE). Basically, the photo carrier generation efficiency is achieved by making the p-type layer thicker. The electrons are generated but far from the p-n junction layer. But it does not collect the electrons effectively due to recombination process.

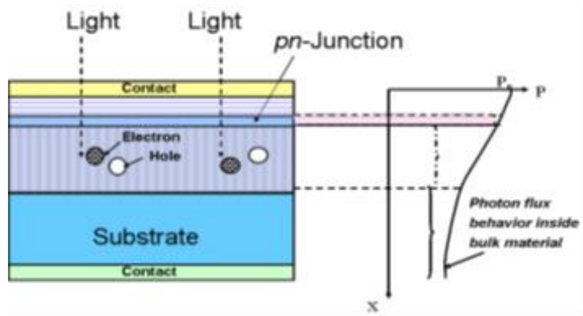

Figure 2: Standard solar cell structure (a) x-sectional view and (b) light flux penetration

Limitation on Conversion Efficiency

From figure 2(a) we can observe the behavior of monochromatic light intensity inside a semi conductor. The light intensity is represented as p(x) and it is expressed as $p(x) = p0\ e^{-\alpha x}$. Here p0 is the peak intensity and α is the absorption coefficient of semiconductor. In the same way coming to the figure 2(b) we can observe the behavior of light intensity inside a bulk semiconductor. Due to light flux carriers are generated and these generated carriers are effectively collected by the p-n junction. These carriers diffuse in all directions. This happens only when distance of p-n junctions equal or less than the diffusion length. In the same way if the diffusion length is smaller than distance then the entire data is are combined and lost.

B.Technical Approaches

i) Factors to Increase Conversion Efficiency

As discussed earlier that there are two factors in solar cells to increase the efficiency of solar energy conversions. Coming to the present generation solar cells they have wide range of solar cells but due to inherent material properties solar system cannot be absorbed. In the same way it consists of photo carrier collection efficiency which is very low, this is because of solar cell structure. Here the data will be lost up to 33% due to loss light and recombination of photo generated carrier. If we overcome this problem then there will be increase in 50% conversion efficiency in silicon based solar cell. Generally if we use different wavelengths in silicon based solar cells then there will be 100% efficiency. So, to do this process the both PCGE and PCCE gives some factors which are given as (a) large junction area within a given volume of a solar cell, (b) photo absorption region thick enough to capture all the photons entering the cell, (c) p-n junction located as close to the photo absorption region as possible, and (d) incorporation of a technique to capture a wide range of spectrum of light that enters a cell.

III. PROPOSED SOLAR CELL STRUCTURE

The below figure (3) shows the proposed solar cell structure. In this proposed structure there are number of micro nano scaled blocks. On the upper layer of these blocks the p-n junction is formed to increase the surface area. The p-n junction is formed near to the generated carriers. By recombination process all the carriers that are generated will be collected. Here quantum confinement is developed due to the incorporation of nano scaled blocks in to the solar cell structures. In this light passes through the semiconductor when front side contact in solar cells are transparent and in the same way substrate is formed on the back side.

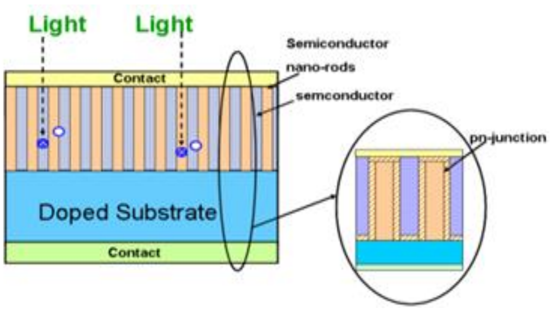

Fig. 3: The schematics of proposed solar cell structure made from nano-rods or nano-wires to increase the junction area for increasing the conversion efficiency: (a) cross-sectional view of a cell and (b) enlarged portion showing the junction.

The proposed solar cell structure is the independent of substrate materials. In this solar cell structure the efficiency is very high. Along with that it consists of good robustness and high reliability and density per unit area. Basically it is made from number of system materials they are Si, GaAs, and InP. If it is silicon system material then micro nano pillars are formed by etching approach. If it is substrate base material then micro nano pillars are formed on the substrate. To make solar cell flexible polymer is used. Now the main purpose is to develop the objective of proposed silicon cell by using silicon substrata. Because of this there is wide increase in energy conversion of solar cell structure.

This is about the proposed solar cell structure now let us discussing about the schematic view of solar cell array. The below figure (4) shows the schematic view of solar cell array. In this junction is formed on the surface by dopant diffusion. To receive sunlight there is a solar cell on the top side. Coming to the conventional solar cell, it has flat p-n junctions and the wafer thickness shows the efficiency of solar energy conversion.

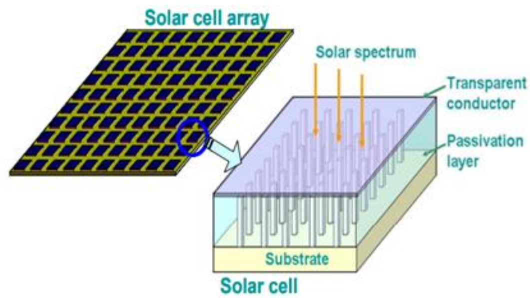

Fig 4: Schematic showing image of solar cell array. A single solar cell is shown.

IV. SIMULATION

In this we will discuss about the simulation result of silicon similar structure. The below figure (5) shows the simulation result of silicon solar cell structure. In this after the process of reflection and refraction the solar cells are not observed by the pillar in some of the region. If the pillar height is about 3µ then the degree of that pillar height is 87. So from this we can observe that it produces high efficiency at lower wavelengths. It produces high device current of 504 AMP/m2.

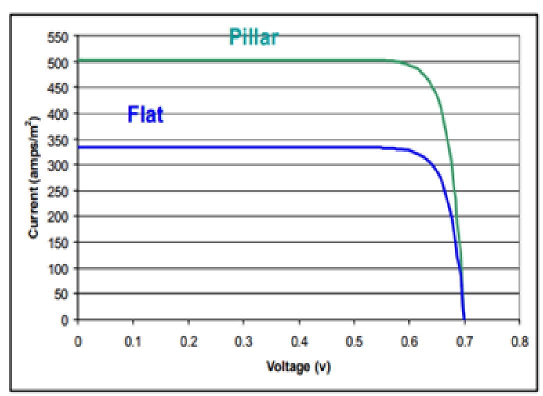

Figure 5: Silicon Pillar structure simulation results indicating the additional power harvesting versus non-pillar silicon.

V. CONCLUSION

At last we can conclude that the silicon solar cell has high efficiency and number of micro nano blocks. Because of this there will be increase in the ratio of surface area and top & bottom contacts. From simulation result we can observe that three is short circuit. Because of this short circuit there is increase in carrier generation sites. The short circuit current is based on the micro nano scale structure. This micro nano scaled structure uses number of materials to obtain better efficiency.

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