ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 2, May 2016

A REVIEW: COMPARISON OF SILICON SOLAR CELLS AND THIN FILM SOLAR CELLS

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Abstract

With the use of various materials and techniques, the fabrication of solar cells has been passed through large number of improvements from first generation to another on the basis of low cost and high efficiency. Solar cells based on silicon were the first generation solar cells grown on silicon wafer with disadvantage of high cost and low efficiency. With further development towards thin films, second generation of solar cell fabrication technologies to produce electrical energy came into existence with enhanced cell efficiency. Thin film solar cells consist of different layers which help to reduce the current losses. That's why as compared to the traditional silicon solar cells, thin film solar cells have high efficiencies. In this paper, we have reviewed a development in solar cells from one generation to other generation solar cell and a comparison is carried out (literature reviewed) between traditional solar cells and thin film based solar cells indicating thin film based solar cells are more economical than traditional solar cells.

Keywords: Solar cells, Thin Film Solar Cells, Efficiency

I. INTRODUCTION

In the form of heat and radiation a huge amount of energy is given by sun known as solar energy. It is almost available at zero cost, so it is limitless source of energy [1].The incident sunlight can be directly harvested into electricity by use of tiny photovoltaic solar cells which is the major benefit of solar energy [2-3]. Due to the conversion efficiency and the low manufacturing cost, solar cell is valuable. In the traditional silicon solar cell, when the sunlight strive on the surface of solar cell, some of the photons energy is absorbed and then converts into electrical power and some will be converted into heat and rest will be lost [4]. While thin film solar cells comprise of different absorber layers and buffer layer leading to enhanced efficiency as different layers in one cell reduce the current loss (Jsc) in solar cell i.e. with the strive of incident light at the solar cell, high energy photons will be absorbed by higher layers and vice versa which helps preventing the energy wastage of cells as compared

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to the silicon solar cell [5]. Inspite the advantages of the thin film , traditional solar cells are still leading the market by more than 80% coverage but with the development in the field of thin film cell technology, market share is extending day by day[6].

In figure 1, we can see the market global share. In this article we are providing a review on different types of solar cells and from collected information shows that thin film solar cells are more economical than traditional solar cells.

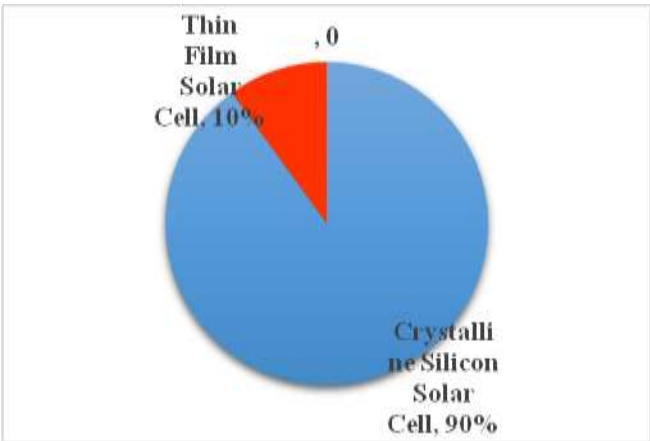

Figure 1: Global Market Share of Solar Cell

II. BACKGROUND

In 1839, Alexandre Edmond Becquerel was the first to observe the photovoltaic effect. Then Russel Ohi invented the first modern solar cell made of silicon in 1946[7]. The use of thin film that is nowadays changing PV industry in global scale was conceived by Chapin [8]. The technology used in earlier thin films are thin silicon wafer which use to convert the sunlight energy into electrical power. In the recent photovoltaic technology, the principle of electron hole pair creation is used in which each cell consist of two different layers of semiconductor material forming p_n junction, as shown in figure 2. When a photon with sufficient energy strikes at pn-junction, an electron is ejected by gaining energy from the striking photon and then transport to another layer leaving a hole behind, thus generating electrical power [9].The various materials applied for the solar cell include silicon (single crystal, multi crystalline, amorphous silicon), Cadmium Telluride (CdTe), Copper Indium Gallium Selenium (CIGS).

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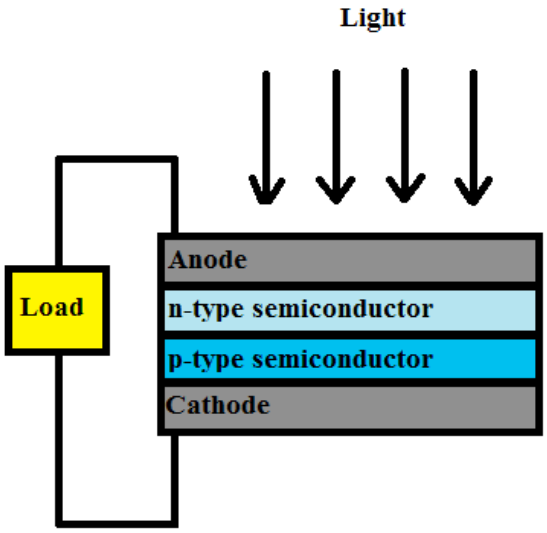

Figure 2: The semiconductor pn- junction under load

III. FIRST GENERATION SOLAR CELL- WAFER BASED

As already mentioned, solar cells produced on the silicon wafer are the first generation solar cell. They cover 80% of the solar market and currently are the oldest and most popular technology available for the residential use due to its high power efficiencies and longer lasting. Diagram classifying different types of solar cells (Figure 3).

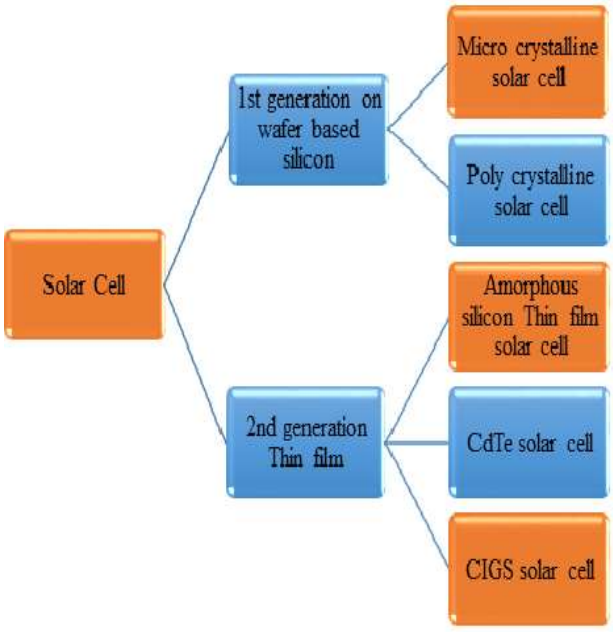

Figure 3: Various types of Solar Cell

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The silicon wafer based technology is categorized into two groups namely,

- Single/Mono crystalline silicon solar cell
- Poly/Multi crystalline silicon solar cell

A. Mono crystalline silicon solar cell

As the name indicates mono crystalline silicon solar cell is manufactured from single crystals of silicon is one of the oldest and most popular and efficient solar cells. In the manufacturing process, the cells are sliced from large crystals grown under controlled conditions. One of the issue with mono crystalline solar cell is that growing the large crystals of pure silicon is difficult, so the production cost of this type of panel historically been the highest of all solar panels types. Due to improvement in the production method, the prices for the raw silicon and mono crystalline panels have decreased over years. Second issue with the panels made from mono crystalline silicon cells is that as temperature increases above 25C, they lose efficiency, so they should be installed in such a way to permit the air for circulation over and beneath panel to improve efficiency [5].

B. Poly crystalline silicon solar cell

Poly crystalline module generally consist of number of different crystals, coupled to one another in single cell. It is less expensive to produce silicon wafer in molds from multiple crystals rather than from single crystal as tightly controlled condition for growth are not required. Poly crystalline silicon based solar cell processing is more economical, produced by cooling graphite mold filled with molten silicon [10]. Panels based on Poly crystalline based silicon solar cell are cheaper per unit area than mono crystalline panels but with slightly less efficiency.

IV. SECOND GENERATION SOLAR CELL- THIN FILM SOLAR CELLS

Second generation solar cell consist of the thin film solar cells when compared to first generation silicon wafer based solar cell are more economical. Thin film solar cells are 100 times thinner than silicon wafer having very thin light absorbing layers of order of 1 micro meter as compared to silicon wafer of 350 micro meter thick [11].

Thin film solar cells can be classified as

- Amorphous silicon solar cell
- Cadmium Telluride solar cell(CdTe)
- Copper Indium Gallium Selenium solar cell(CIGS)

A. Amorphous Silicon Thin Film Solar cell

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Figure 4, shows schematic structure for amorphous silicon thin film solar cell which is comparatively less expensive and widely available because the manufacturing of a_Si solar cell is at low processing temperature thus permitting the use of low cost polymers and flexible substrates. The word "Amorphous Silicon" means a non- crystalline structure, lacks a definite arrangement of atoms. As compared to traditional silicon methods, silicon is deposited as very thin layer on backside of substrate. The manufacturing method is less energy intensive yet complex than crystalline panel. The issue of amorphous silicon is that they are much less efficient per unit area (upto 10%). They are suitable for conditions where sun shines for few hours as they can easily operate at low light levels [12].

Figure 4: Structure of standard a-Si Thin Film Solar cell

B. Cadmium Telluride Solar Cell

For the development of cost effective PV, thin film CdTe is one of the leading materials with direct band gap of 1.45ev enabling conversion of more energy from sunlight than lower energy band gap silicon of 1.2ev [13]. It is group II-VI element of the periodic table having high optical absorption coefficient. Some of the characteristics of CdTe solar cell are as given: First is that, the CdTe based solar cells are manufactured from polycrystalline material and glass as substrate. Second is the different low cost methods can be used for deposition of CdTe solar cell. Thirdly, the band gap of CdTe is 1.45ev with high absorption coefficient over 5X 10 power 15/cm means photons having higher energy than band gap will be absorbed within a few micro meter of CdTe absorber layer. The environmental issues related to CdTe are that firstly, cadmium is considered as heavy metal and toxic in nature causing illness to the humans and animals. Secondly is the limited supply of Cadmium material [14].

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The schematic structure of CdTe thin film solar cell having several layers of materials is shown in the figure [5]. During the Last 17 years only 1.5% of efficiency increased was noticed in the cell efficiency of CdTe solar cell. Maximum recorded efficiency is 16.5%

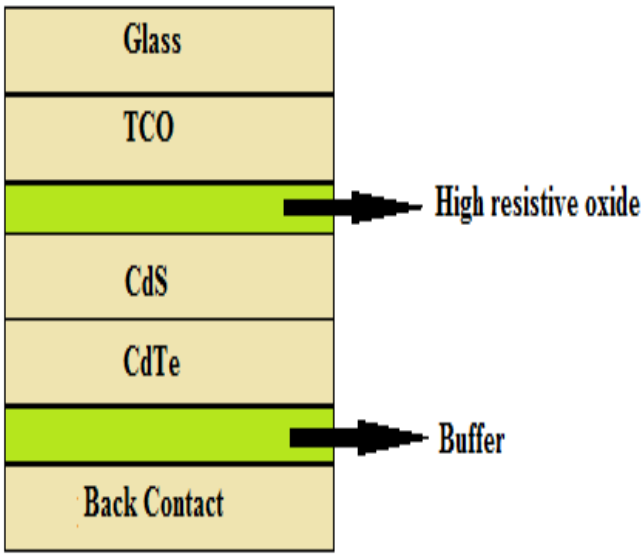

Figure 5: Structure of standard CdS/CdTe Thin Film Solar cell

but efficiency of 21.5% has been recorded by First Solar Research group [verified by NREL] and 13.9% of module efficiency has been recorded under the lab conditions [15].

C. Copper Indium Gallium Selenium Solar Cell

CIGS consist of group I_III_VI elements of periodic table with direct band gap varying with value of x from 1ev to 1.7ev [CuInxGa(1-x)Se2]. As the CIGS material has high absorption coefficient of more than 10 power 15/cm for 1.5ev and of higher energy photons and it strongly absorbs the sunlight, a thin layer is required as compared to other material of semiconductors [16]. Different layers of CIGS solar cell have been shown in the figure 6. CIGS based solar cell is the most likely leading contender of thin film technologies due to their high efficiencies and economy CIGS based solar cells are more stable and have better conversion efficiency than other cells.20.4% of efficiency was achieved in 2013 by scientists at the Swiss Federal laboratories for Material Science and Technology on the flexible polymer foils. Then 21.7% efficiency have been recorded by NREL till date [17].

V. COMPARISON

As compared to thin film based solar cells silicon cells are non-toxic and abundant in nature. To have optimum Jsc and Voc, the band gap must lie between 1.4ev to 1.6ev but energy gap for silicon based solar cell is 1.1ev which is less than the thin film based solar cells. Although

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the 80% of commercial market covers first generation silicon solar cell compared to thin film solar cell but with the development in thin film technology market share is increasing. Efficiencies of different solar cells can be viewed below in figure 7.

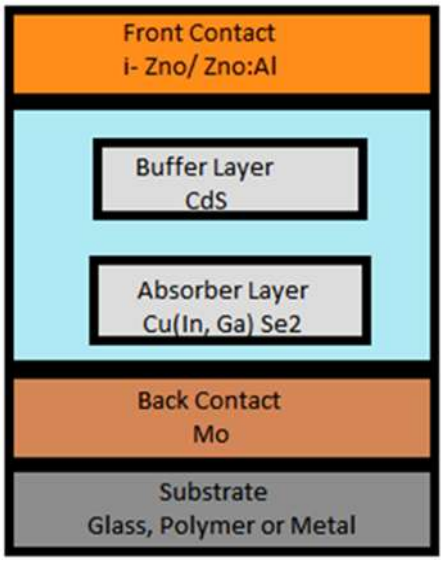

Figure 6: Standard structure of CIGS solar cell

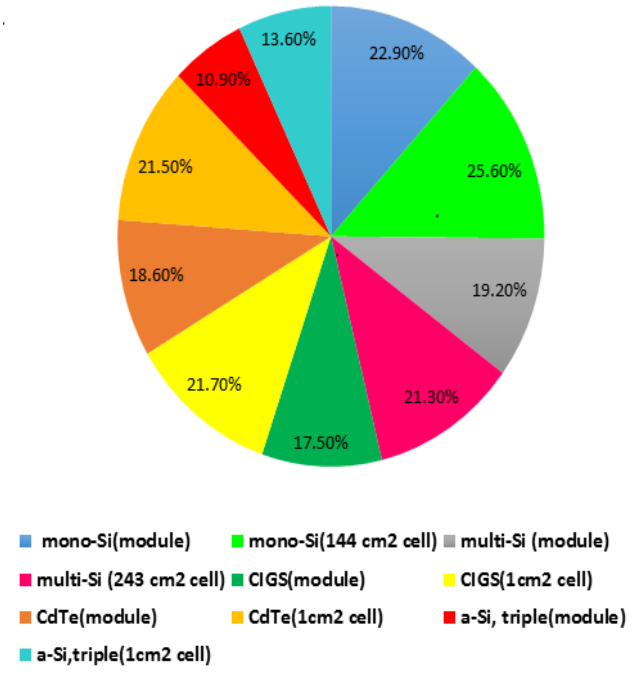

Figure 7: Chart of Efficiencies [17]

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- Pros of Thin film solar cells:
- Low production cost
- Lower costs per watt can be achieved
- Flexible
- High absorption coefficient

- Cons of Thin film solar cell:
- Toxic material
- Cons of traditional silicon solar cell:
- Manufacturing methods are expensive.
- Growing of crystal is high energy intensive process.
- Much of energy is wasted as heat.

VI. CONCLUSION

From the study, we came to conclude that second generation of solar cells (thin film solar cells) have many advantages over traditional silicon solar cells based on energy and cost efficiency. Secondly, low cost and high conversion efficiency of the cell are basis of evaluation of solar cell. Although as compared to thin film based solar cells, traditional silicon solar cells have high efficiencies recorded till now but pure silicon as well as energy requiring process makes it expensive as compared to output power. On the other hand thin film solar cells require less material, energy, time and cost. Due to this second generation thin film solar cells are preferred to be used as the cost is not high as compared to output power. The main motive of this research is to explain that thin film based solar cells are more economical and less expensive as compared to traditional silicon solar cells.

REFERENCES

[1] M.A. Green," Third generation photovoltaics: solar cells for 2020 and beyond," Physica E: Low-dimensional Systems and Nanostructures, vol. 14, pp. 65-70, 2002.

[2] McEvoy,A, Castaner, L. and Markvart, T.(2012) Solar Cells: Materials, Manufacture and Operation. 2nd Edition, Elsevier Ltd., Oxford, 3-25.

[3] Fahrenbruch A.L. and Bube,R.H."Fundamentals of Solar Cells". Academic Press Inc., New York(1983).

[4] Chu, Y. and Meisen, P. (2011)," Review and Comparison of Different Solar Energy Technologies", Report of Global Energy Network Institute (GENI), Diego.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
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[5] G. Conibeer, M. Green, R. Corkish, Y. Cho, E. C. Cho, C. W. Jiang, T. Fangsuwannarak, E. Pink, Y. Huang and T. Puzzer, " Silicon nanostructures for third generation photovoltaic solar cells, "Thin Solid Films, vol. 511, pp. 654-662, 2006.

[6]X. Wu, "High- efficiency polycrystalline Cdte Thin –Film Solar Cells, " Solar Energy, vol. 77, pp. 803-814, 2004.

[7] Yadav, A. and Kumar, P. (2015) Enhancement in Efficiency of PV Cell through P&O Algorithm International Journal for Technological Research in Engineering, 2, 2642-2644.

[8] R. W. Miles, K. M. Hynes and I. Forbes, " Photovoltaics Solar Cells: An overview of State-of-the art cell development and environmental issues, "Progress in Crystal Growth and Characterization of Materials 51,1-42, Elsevier Ltd., 2005.

[9] Srinivas, B. Balaji, S., Nagendra Babu, M. Reddy and Y.S (2015), " Review on Present and Advance Materials for Solar cells. International Journal of Engineering Research-Online,3 , 178-182.

[10] Shruti Sharma, Kamlesh Kumari Jain, Ashutosh Sharma,"Solar cells: In Research and Applications", Material Sciences and Applications 2015,6,1145-1155.

[11] Chopra,K.L., Paulson, P.D. and Dutt, V. (2004) Thin-Film Solar Cells: An Overview. Progress in Photovoltaics, 12, 69-92.

[12] Maehlum, M.A. (2015) Energy Informative The Homeowner's Guide to Solar panels, Best thin Film Solar Panels—Amorphous, Cadmium telluride or CIGS?

[13] V. Avrutin, N. Izyumskaya and H. Morko, "Semiconductor solar cells: recent progress in terrestrial applications," Super- lattices and Microstructures, vol. 49, no.4, pp. 337-364, 2011.

[14] Bagher, A.M., Vahid, M.M.A and Mohsen, M.,"Types of Solar cells and Application.", American journal of Optics and Photonics, 3, 94-113, 2015.

[15] S. Khosroabadi, S.H. Keshmiri, S. Marjani," Design of a high efficiency CdS/CdTe solar cell with optimized step doping, film thickness and carrier lifetime of the absorber layer", J. Europ, Opt. Soc. Rap. Public. 9, 14052 (2014).

[16] Stanbery, B.J. (2002). "Copper Indium Selenidides and Related Materials for Photovoltaic Devices". Critical Reviews in Solid State and Materials Science 27(2):73.

[17] Martin A.Green, Keith Emery, Yoshihiro Hishikawa, Wilhelm Warta and Ewan D. Dunlop," Solar Cell efficiency tables (version 47)",Progress in Photovoltaics: Research and Applications, Prog. Photovolt: Res. Appl. 2016; 24:3-11.