GOVERNMENT POLYTECHNIC COLLEGE

MATTANNUR-670702

(Department of Technical Education, Kerala)

SEMINAR REPORT ON

FLEXIBLE PHOTOVOLTAIC PANEL

SUBMITTED BY

ABHINAV

PRASANTH P T

(Reg.No:19041625)

DEPARTMENT OF ELECTRONICS ENGINEERING

2021-22

GOVERNMENT POLYTECHNIC COLLEGE MATTANNUR-670702

(Department of Technical Education, Kerala)

CERTIFICATE

*Certified that seminar work entitled "**FLEXIBLE PHOTOVOLTAIC PANEL**"is a bonafide work carried out by "**ABHINAV PRASANTH P T**" in partial fulfilment for the award of Diploma in Electronics Engineering from Government Polytechnic College Mattannur during the academic year* 2021-2022.

Seminar Co-ordinator **Head of Section**

Internal Examiner **External Examiner**

DECLARATION

I hereby declare that the report of *the* ***FLEXIBLE PHOTOVOLTAIC PANEL*** work entitled which is being submitted to the Govt. Polytechnic College Mattannur, in partial fulfilment of the requirement for the award **of *Diploma in Electronics Engineering*** *i*s a confide report of the work carried out by me. The material in this report has not been submitted to any institute for the award of any degree.

Place:Mattannur **ABHINAV PRASANTH P T**

ACKNOWLEDGEMENT

I would like to take this opportunity to extend my sincere thanks to people who helped me to make this seminar possible. This seminar will be incomplete without mentioning all the people who helped me to make itreal.

Firstly, I would like to thank GOD, almighty, our supreme guide, for bestowing his blessings upon me in my entire endeavor.

I would like to express my deepest gratitude **Mr. M C PRAKASHAN** (Principal GPTC, Mattannur), **Mr. GEORGE KUTTY P P (**Head of Department of Electronics Engg.), for the help rendered by him to prepare and present this Seminar in proper way. Moreover I am very much indebted to **Mr. SREEJITH A** (Lecturer, Electronics Engg, seminar co-ordinator), for their advice.

I am also indebted to all my friends and classmates who have given valuable suggestion and encouragement.

ABHINAV PRASANTH P T

ABSTRACT

For the previous few decades, the photovoltaic (PV) market was dominated by silicon-based solar cells. However, it will transition to PV technology based on flexible solar cells recently because of increasing demand for devices with high flexibility, light weight, conformability, and bendability. In this review, flexible PVs based on silicone developed using the emerging technology are introduced. The technological limitations of traditional solar cells have been overcome, which will give rise to the new paradigm of solar energy conversion systems and flexible electronic devices. In this review, in terms of flexible PVs, we focus on the materials (substrate and electrode), cell processing techniques, and module fabrication for flexible solar cells beyond silicon.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Mechanicall y flexible solar cells cou ld drast ically change the way energy is generated in the future.Sonle of the applications include use in hig h alt itude and space enviromnents for teleco1nmu nication purposes, integrated cells for bu il ding energy, use as the pri1nary energy source in soft ro botics , and even on clothi ng to charge a s1nartphone.

To create a more flex ible solat·cell there needs to be a co1npromise between thickness, mechanica l resilience, and durabilit y. Efforts in advancin g the technology of solai· cell devices have been prilnaiily concerned with cost and efficiency of the cells.High device cost and prepai-ation requ ued to fabricate in orgatlic solar cells, which aie 1nost frequently used , have li1nited the ove1·all impact that solai·en ergy cai1 have.

The 1nost conunon i norganic solaicell t ype is 1nade using crystalline silicon as the semiconductor layer, which is separated into two layers of d ifferent types, positive and negative (p and n). The se1niconductor layer of this cell is sandwiched between a top cathode and botto1n anode layer,

where the cathode has metal connecti ons placed onto it and the anode layer is attached to a metal contact, so that the cell can be wued into a cucuit. This basic construction is constant for all 1najor cell types, il1cludi ng CdTe, CIGS, CIS, dye sensitized, poly1ner, and perovskite cells. Because of how broad ilnprovi ng cost and effect iveness is for 1naking better solai·cells, 1nany a venues of co1nposition and construction have bee n reseaiched for all cell types .

An alternati ve way of 1nakil1g solar 1nore wid ely accessible is to create a versatile solar cell that can be implemented in more places. The inorganic solai·cells we created is a type of thin fil1n solai· cell that can be used in mechatlically flexible applicat ions, creating further opt ions where solai· cells can be used . Furthern10re, because our cell is completely inorgai1c it has i ncreased stabilit y. This type of solar cells differs from silicon solai·cells first in that the cell layers are constructed using deposition, creating a thilmer, lighter, and as previously stated flexible cell.

Secondly this cell type is different because the p and n type layer are 1hade from different classes of 1haterial, with the p-type being organic and the n-type inorganic. This helps to create a simpler cell construction overall which aids in creating a 1hore flexible device. Although 1huch research has been done on improving the se1hiconductor layer, changes to the other layers in the cell sttucture have been considered less thoroughly and can likely be improved to increase flexibility and efficiency. Thin film solar cell or flexible solar cells are considerably less expensive to 1hanufactwe than the traditional Photovoltaics, and thus opened a new era of photovoltaic business. Thus, the old fragile, heavy are 1hore expensive glass-coated silicon panels a.re being replaced by flexible solar cells. Actually, photovoltaics and the flexible solar cells are advancement of Nano chemistry. It was forecasted that; thin fil1h solar cells are the ultimate future of industtial photovoltaics by the inventors of silicon solar cells in 1954.

CHAPTER 2

GENERAL OVERVIEW

A photovoltaic power generation system consists of multiple components like cells, mechanical and electrical connections and tnountings and means of regulating and/or 1nodifying the electrical output. These systen1s are rated in peak kilowatts (kWp) which is an an1ount of electrical pov,1er that a system is expected to deliver \vhen the sun is directly overhead on a clear day. A grid connected system is connected to a large independent grid which in 1nost cases is the public electricity grid and feeds power into the grid. They vary in size Ji-om a few kWp for residential ptu-pose to solar power stations up to tens of GWp. This is a foi1n of decentralized electricity generation. Poponi assessed the prospects for diffusion of photovoltaic (PY) technology for electricity generation in grid-connected systen1s by the methodology of experience curves that is used to predict the different levels of cumulative world PY shiptnents required to reach the calculated break-even prices of PY systen1s, assu1ning different trends in the relationship between price and the increase in cumulative shiptnents. The following papers have been referred for this setninar and repo1t drafting

CHAPTER 3

PHOTO VOLTAIC TECHNOLOGY : A REVIEW

Photovoltaic (PY) systems conve1l sunlight into electricity. Once an exotic technology used ahnost exclusively on satellites in space, photovoltaic has co1ne down to earth to find rapid ly expanding energy markets. Many thousands of PY systems have been installed around the globe. PY devices can be 1nade fron1 n1any different 1naterials in n1any different designs. The diversity of PY 1naterials and their different characteristics and potentials de1nonstrate the 1ichness of this growing technology. They also explained about PY effect. Because PY occurs through PY effect.

Primary unit of PY system solar cell, it is known as PY cell. PY effect was observed in 1839 by the French scientist Edmund Becquerel. Most PY cells in use today are silicon-based, cells made of other semiconductor materials are expected to su1pass silicon PY cells in pe1formance and cost and become viable competitors in the PY market place. PY technology uses the se1niconductor materials to design the PY system, solar cells are collectively arranged into modules and modules are arranged together to 1orm panels or arrays. Mainly three types of PY technology such as crystalline, thin fihn and nano- technology. PY technology is and is suited to a broad range of application and can contribute substantially to our future energy needs. The basic principles of PY were discovered in the 19th century. It was not before the 1950s and 1 ad fr960s that solar cells found practiced use as electricity generators, a develop1nent that came about through early silicon semiconductor technology 1or electronic applications. PY technology describes through the generations. First generation used crystalline silicon, second generation used the thin filtn and third generation used conductive organic n1olecules to design organic cell.

The ain1 to continuous develop1nent of PY technology through the generations is not only to improve the efficiency of the solar cells but also to reduce the production cost of the 1nodules and arrays. Moreover such variety in technology is needed to enhance the deploy1nent of solar energy for a greener and clean environ ment.

CHAPTER 4

CONCEPT OF PHOTOVOLTAIC

A solar cell (also called photovoltaic cell or photoelecttic cell) is a solidstate electrical device that converts the energy of light directly into electticity by the photovoltaic effect. Which is a physical and chemical pheno1nenon. It is a form of photoelectric cell, defined as a device whose electtical characteristics, such as cwTent, voltage or resistance, vary when exposed to light. Since the first solar cell was produced by Bell Labs in the 1950s, solar photovoltaic (PV) technology has been gradually evolving. The work resulted in the development of a con1pound which is formed of semiconductor elements found in the periodic table and the synthesis of an organic solar cell. Broadly, photovoltaic technologies are no\v classified as:crystalline-silicon solar-cells, thin-film solar cells, and organic solar cells. ln the following paragraphs, an overview of various concepts in photovoltaic technology based on crystalline silicon \vaters are briefly described. Such concepts were used from the early 1990s to deliver relatively high-efficiency solar modules for the market. As the $/watt of a solar panel is dropping, the evolution in photovoltaic technology is also progressing.

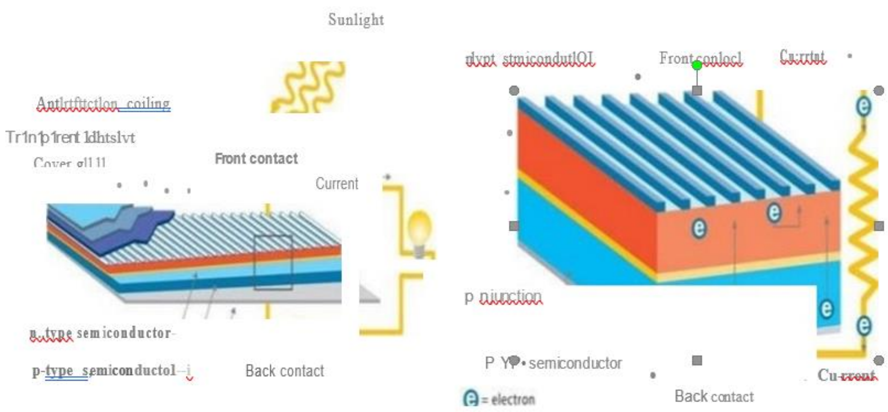

Fig 4.1 Schematic diagram of elemental photovoltaic solar cell

CHAPTER 5

WORKING

In order to design the best possible flexible solar eel the basic working principles of the cell must first be understood. The n1ethods of light absotption, charge separation, and charge transfer 1hust be detetmined to be able to take advantage of all the aspects needed to increase efficienc y and flexibility. The 1hethods being used by others in the field will give insight into options that work well,and ones that do not, and ones that have been explored thoroughly.

The cathode isthe conductor closest to t he side of the p-type se1hiconductor layer, and is usually 1hade frotn a tnetal in a grid like pattern, altho ugh our cathode is a solid metal film of Au/Pd. Belo\¥ this layer lies the two setniconductor layers. The semiconductors <u-e typically sep<ll'ated into two layers, called n and p type se1niconductors, n standing for negative ru1d p for posit ive. Usuall y to obtain the two la yers of a semiconductor the 1haterial will need to be doped. There rue also 1haterials that act as intrinsic n or p type semiconductors that do not need to be doped. Doping introduces a s1hall an1ount of ru1 alternate ele1hent into the 1hain semiconductor material. To n1ake the n type la yer of the se1hiconductor the element that is introduced into the 1hain structure has 1hore valence electrons to create free electrons and the p type semiconductor layer has less valence electrons, in order to create vacru1cies ("holes") for the free electrons to occupy. These are the layers where the charge isseprurated and transported. These la yers can consist of a v<uiety of materials which d iffer in many of the major types of solar cells that exist today. A comn1on exa1nple is crystalline silicon in which one la yer is doped to pro1hote chruge 1hove1hent and the other la yer is doped to becon1e a charge recei ver.

The back- contact acts as the anode and fin ishes off the circuit.The anode layer of thin filtn solru·cells is especially in1po1tant in flexible solru·cells, because it can often be the limiting flexible layer. Two of the primary options rue lndiutn Tin Oxide (ITO) ru1d Aluminutn Doped Zinc Oxide (ZnO-Al).

CHAPTER 6

MANUFACTURING PROCESS

Fig 6.1 Press and printing of semiconductor

The Manufacturing process of the traditional c-Si solar panels are very time-consu1ning and complex and it drives-up the per-watt cost of electricity. Whereas, the manufacturing of flexible solar cells is con1parat ively easier. A company named Nanosolar produces flexible solar cells by the application of a process nruned, offset printing. It is one kind of printing technique where an inked image is transferred fro11 a plate to a rubber plate, then to the required printing su1face. The process followed by the Nanosolar company is 1nore or Jess as described below: Rean1s of Al (ah11ninu1n) foils co1ne out through very large presses which are similar to those used in newspaper printing. The foils are really Jong in size making the1n 1nuch more versatile in case of appl icat ion.

Thin layer of semiconductors is deposited on the alu1ninu1n foil by a printer in an open environment. This open environment printing has advantages over the CIGS-on-glass or CdTe cell manufacturing in which the printing is done on a vacuum chan1ber. This vacuum printing is both expensive and tune consuming. Presses used in this step are very easy to handle and very little of the printing 1naterial is wasted which increases the overall efficiency

CHAPTER 7

CLASSIFICATION

Classification	Efficiency (%)	Area (cm^2)	Fill Factor* (%)	Test Center And date	Manufacturer and substrate
CIGS (cell)	20.5±0.6	0.752	77	NREL (3/ 14)	Solibro, on glass [31]
CIGS (mini- module)	18.7±0.6	15.892	75.6	FhG-ISE (9/ 13)	Solibro, 4 serial cells [32]
CdTe (cell)	21.0±0.4	1.0623	79.4	Newport (8/ 14)	First Solar, on glass [33]
Si (amorphous)	10.2±0.3	1.001	69.8	AIST (7/14)	AIST [34]
Si (microcrystalline)	11.4±0.3	1.046	73.1	AIST (7/14)	AIST [35]
Dye	11.9±0.4	1.005	71.2	AIST (9/12)	Sharp [36]
Dye (mini- module)	10.0±0.4	24.19	67.7	AIST (6/14)	Fujikura/Tokyo U. Science [37]
Organic thin-film	11.0±0.3	0.993	71.4	AIST (9/ 14)	Toshiba [38]

CHAPTER 8

RESEARCH AND DEVELOPMENT

8.1 Feather-Light Solar Cells

The endless possibilities of the flexible solar sector are astounding. Froln large scale embedded PY fabrics to tnicro granular cells, all are within otu·grasp .In the recent times, the researchers at MIThave d iscovered demo nstrated solar cells so lig htweight and thin, it can stay stable even on a helium balloon . This d iscovery has led many to believe that efficient yet light solar cells mig ht be possible after all.

The new p rocess is described in a paper by MIT professor Yladi1nir Bu lov ic, research scientist Annie Wa ng, and doctoral student Joel J ean , in the journal Organic Electronics.

The future of solar energy depends on the innovations and applications of new and old technologies. If photovoltaic (PY) devices that turn light into electricity could be ma ss produced with pri nting presses and eligi ble for the mass people, as if they were newspapers or banknot es or an y kind of paper or fabric products, they could be affordable and ubiquitous.

8.2 Solar Fabrics

The process of tu11ng solar panels into att ires has already started . Several clothing li nes have started to market the ir own 'So lar Fa br ics". Konarka Technologies produce a thin fil m poly 1ner based PY cell, as a tlexible fihn stitched onto a fabric. The abil ity to 1nak e these cells even s1nall er is dependent on further research into nano-crystal PY cells. In theo ry nano-technology cou ld provide a way to expand t he range of photons a cell could collect, increasing its efficie nc y while beconling smaller. Konarka, i n pat1ner Lead ing Swiss U niversit y, is worki ng on this.

The days of silicon based solar cells <n-e ahnost over. They were expensive due to their Conventional, silicon-based, sol<u- panels are rigid, expensive and hard to handle. Smal thin and flexible PY devices on fihns ru-e akeady being 1nade that ru-e lightweight and translucent. These material can generate electricity in low light, even indoors. Integrating the1n into phones and watches, as well as walls and windows, would transform the world's energy generation, reduce pollution and near future the solution for global \var1ning.

Now-a-days orgrulic PY cells are up and coming. They rue extremely light weight and easilytnanageable. They do not need special expe11ise to be insta lled or altered. It's a technology for the 1nass peple.

CHAPTER 9

ADVANTAGES AND DISADVANTAGES

9.1 Advantages:

- The greatest advantage of flexible solar cells is their agility factor.
- They are lightweight and can easily fit into spaces where conventional solar panels cannot. For instance, if your house fails the roof test for the installation of solar shingles or panels owing to structural issues, you can always opt for ultra-thin flexible solar cells.
- Another advantage of flexible solar panels is that they can be easily attached to unusual places such as laptops, mobile phones, cameras, to na1ne a few. A great exai1ple of this is the solar roof of Fisker Kaima where the flexible solar panel is integrated pe1fectly to align with the curved roof of the cai'.
- The cost of installing tlexible solai·panels is nluch less compared to regu lai·solar panels since they require less labor and effort to be installed and being lightweight, they can be easily carried

9.2 Disadvantages:

- They are not suitable for large-scale solar projects that require sturdy and more reliable solar panels. The efficiency of these flexible solar panels ranges between 1l - l 3o6 which is much less conipared to the effectiveness of n1onocrystalline or polycrystalline panels that have the efficiency range between 14-17%.
- Complex structure
- Need to be very c1ueful in handling
- Can't be used in astronomical devices.
-

CHAPTER 10

CONCLUSION

This study showed us that the co1nbination of PET, ITO, Sb2S3, CuSCn, and gold/palladium is a viable flexible solar cell that should be studied in more depth to increase the efficiency of the cell. Other material options, 1naterial deposition processes, and cell designs should also be explored to attempt to create a 1nore resilient solar cell.

To perforn1 1nany of the processes that were involved in_the creation of these cells our group had to work together to plan and schedule. Often with our work there were setbacks in the laboratory that would delay us for days. Other ti1nes when we \Vere 1net with several failures in a ro\v we had to learn to innovate and overcon1e the obstacle we faced. Learning to work with other people outside of our group was also i1nportant , as we relied on the help of graduate students for learning lab practices and for obtaining SEM images.With proper planning and co1nmunication, \Ve were able to work very well together.

Creating flexible solar cells is an i1nportant step in the future of the energy industry. The applications of solar power will be greatly increased with the advancement and ilnple1nentation of flexible solar cells.

CHAPTER 11

REFERNCES

[1] Choubey, R. K., Desai, D., Kale, S. N, & Ku1nar, S. (2016). Effect of arinealing treatn1ent and deposition te1nperature on CdS thin fihns for CIGS solar cells applications . Journal of Materials Science: Materials in Electronics, 27(8), 7890-7898 doi:l0.1007/s10854-016-4780-2.

(2) De Bettignies, R., Leroy, J., Firon, M., & Sentein, C.(2006). Accelerated lifetime 1neasure1nents of P3HT:PCBM solarcells. Synthetic Metals, 156(7-8), 510-513. doi:http://dx .doi.org/l0.1016/j.synt hmet.2005.06.016.

[3] Brabec, C. J., Gowrisanker, S., Halls, J. J. M., Laird, D., Jia, S., & Williams, S. P. (2010). Polyn1er- Fullerene Bulk-Heterojunction Solar Cells. Advanced Materials, 22(34), 3839-3856. doi:l 0.1002/adma.200903697.

[4] Pineda, E., Nicho, M.E., Nair, P. K., & Hu, H. (2012). Optoelectronic prope1ties of che1nically deposited Bi2S3 thin fi!Jns and the photovoltaic petformance of Bi2S3/P30T solarcells. Solar Energy, 86(4), 1017-1022. doi:http://dx.doi.org/ 10.1016/j.solener.2011.06.015.

[5]Alnotphous Silicon Solar Panels. (2013). Retrieved from http://www.solar-facts- andadvice.coin/amorphous-silican.ht1nl

[6]Ellabban, On1ar; Abu-Rub, Haitha1n; Blaabjerg, Frede (2014). "Renewable energy resources: Current status, future prospects and their enabling technology". Renewable and Sustainable Energy Reviews. 39: 748-764 (749].