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Review Paper on Solar Cell

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Abstract- The light from the Sun is a non-vanishing renewable source of energy which is free from enviromental pollution and noise. It can easily compensate the energy drawn from the non-renewable sources of energy such as fossil fuels and petroleum deposits inside the earth. The fabrication of solar cells has passed through a large number of improvement steps from one generation to another. Silicon based solar cells were the first generation solar cells grown on Si wafers, mainly single crystals. Further development to thin films, dye sensitized solar cells and organic solar cells enhanced the cell efficiency. The development is basically hindered by the cost and efficiency. In order to choose the right solar cell for a specific geographic location, we are required to understand fundamental mechanisms and functions of several solar technologies that are widely studied. In this article, we have reviewed a progressive development in the solar cell research from one generation to another, and discussed about their future trends and aspects. The article also tries to emphasize the various practices and methods to promote the benefits of solar energy.

Keywords- Solar Energy, Fossils, Power, Pollution, Renewable

I. INTRODUCTION

A solar cell, also known as a photovoltaic (PV) cell, is a semiconductor device that converts light into electricity through the photovoltaic effect. It is a fundamental component of solar panels, which are used to harness solar energy. Solar cells are typically made of silicon and rely on the interaction of photons from sunlight to generate a flow of electrons, creating an electrical current.

Function

Solar cells directly convert light energy into electrical energy.

Mechanism

The photovoltaic effect, a physical phenomenon, describes how light energy (photons) is absorbed by a semiconductor material (like silicon), exciting electrons and causing them to move, generating an electrical current.

Materials

Most solar cells are made from silicon, but other materials like cadmium telluride, thin-film silicon, and perovskite are also used.

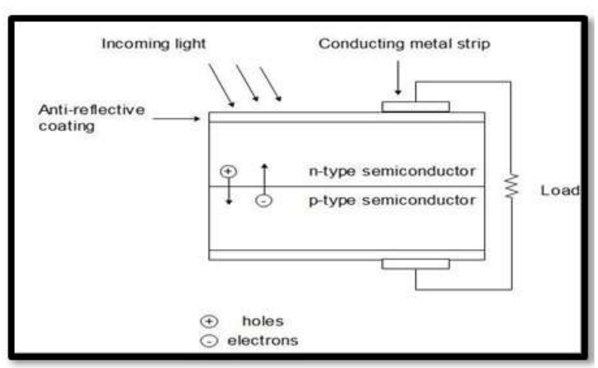

Fig 1: Solar Cell

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Structure
Solar cells are generally structured as a semiconductor with a p-type and n-type side, which allows for the separation and collection of charge carriers when light strikes the cell.

II. LITERATURE REVIEW

Samuel et.al (2019): "Awareness and use of solar energy as alternative power sources for ICT facilities in Nigerian university libraries and information centres". This paper reports a survey carried out to investigate the awareness and use of solar energy as alternative power source for ICT facilities in Nigerian library and information centres. Descriptive research design using survey method was adopted for this study. Questionnaire was designed and used as survey instrument. The population for this study includes the staff of three Nigerian university libraries. Finally, this study concludes that all the respondents have good knowledge of what solar energy is as they all responded in affirmative.

Ehsanul Kabir et.al (2018): "Solar energy: potential and future prospects". In this article the merits and demerits of solar energy technologies are both discussed. A number of technical problems affecting renewable energy research are also highlighted, along with beneficial interactions between regulation policy frame works and their future prospects. For that they provide a global scenario with regard to solar energy technologies in terms of their potential, present capacity, prospects, limitations and policies. This was help them to expand their understanding on how much further they can count on solar energy to meet the future energy demand. Finally, they concluded that despite a few drawbacks solar energy technology is of the most promising renewable energy sources to meet the future global energy demand

Suhas bannur (2018): "Concentrated solar power in India: current status, challenges and future outlook". In this article, some of the challenges that have inhibited the growth concentrated solar power are identified and possible solutions suggested. The critical challenges for CSP are related to the lack of reliable direct normal irradiance database, indigenous manufacturing and competition from PV. The results of this study carried out to assess the impact of indigenous manufacturing and economics of scale on capital costs and normalised cost of electricity are presented and this study also shows that even with indigenous manufacturing and considering economics of scale, the capital cost per megawatt of installed capacity is higher than the central electricity regulator commission benchmark costs.

Jean Baptiste et.al (2018): "A review of the solar energy situation in Rwanda and Uganda".
In this paper authors review the solar energy development and future in Rwanda and Uganda. In these two countries, solar energy sector plays an important role in supporting socio-economic development. The paper examines the development of solar energy market in both countries since their beginnings in the 1980s. This peer review paper also identified that supports from donors, investors and government to promote development of solar energy in these two countries. Finally, the challenges and opportunities facing Rwanda and Uganda in development of solar energy are presented in this study.

Farhard Taghizadeh-Hesary (2018): "Empirical analysis of factors influencing price of solar modules". In this paper authors examined the influence of wage, interest rate, exchange rate and oil price on the price of solar modules for five major solar module producing countries

III. METHODOLOGY

The basic methodology for manufacturing a solar cell involves several key steps, starting with purifying silicon to remove impurities, followed by ingots formation, wafer production, and cell fabrication which creates the photovoltaic effect. Finally, the cells are assembled into panels with wiring, encapsulation, and mounting on a frame.

Detailed Methodology

Purification of Silicon

Raw silicon is refined to remove impurities to achieve a high purity level necessary for efficient solar cell performance.

Ingot Formation

The purified silicon is then melted and cast into ingots, which are large cylinders of silicon.

Wafer Production

The ingots are sliced into thin wafers, typically 1 to 2 mm thick, using specialized sawing techniques.

Cell Fabrication

The wafers are then treated to create the photovoltaic effect, which is the process of converting light into electricity. This involves doping the silicon with specific elements to create p-type and n-type regions, which are crucial for the formation of a p-n junction.

Panel Assembly

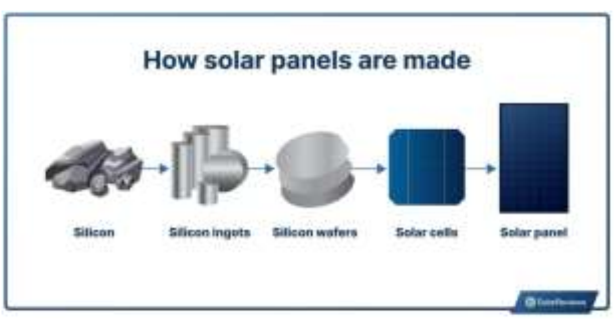
Once the cells are fabricated, they are assembled into solar panels. This process includes wiring the cells in series and parallel, encapsulating them in protective materials like glass and polymers, and mounting them on a frame for structural support.

Testing and Quality Control

After panel assembly, rigorous testing is conducted to ensure electrical performance, safety, and durability of the solar panels.

Packaging and Shipping

Finally, the finished solar panels are packaged and shipped to their destination.



IV. TYPES OF SOLAR CELL

There are three types of Solar Cells with each having distinguished features. They are as follows:

First-Generation Solar Cells: About 90 percent of the world's solar cells are made from wafers of crystalline silicon (abbreviated c-Si), sliced from large ingots, which are grown in super-clean laboratories in a process that can take up to a month to complete. The ingots either take the form of single crystals (monocrystalline or mono-Si) or contain multiple crystals (polycrystalline, multi-Si or poly c-Si).

Second-Generation Solar Cells: Classic solar cells are relatively thin wafers—usually a fraction of a millimeter deep (about 200 micrometers, 200μm, or so). But they're absolute slabs compared to second-generation cells, popularly known as thin-film solar cells or thin-film photovoltaic which are about 100 times thinner again (several micrometers or millionths of a meter deep). Although most are still made from silicon (a different form known as amorphous silicon, a-Si, in which atoms are arranged randomly instead of precisely ordered in a regular crystalline structure), some are made from other materials, notably cadmium-telluride and copper indium gallium diselenide.

Third-Generation Solar Cells: The latest technologies combine the best features of first and second generation cells. Like first-generation cells, they promise relatively high efficiencies (30 percent or more). Like second-generation cells, they're more likely to be made from materials other than "simple" silicon, such as amorphous silicon, organic polymers perovskite crystals, and feature multiple junctions.

Polymer Solar Cells

Polymer solar cells (PSC) are generally flexible solar cells due to the polymer substrate. The first PSC were in-vented by the research group of Tang et al. at Kodak Research Lab. A PSC is composed of a serially connected thin functional layers coated on a polymer foil or ribbon. It works usually as a combination of donor (polymer) and a acceptor (fullerene). There are various types of materials for the absorption of sunlight, including organic material like a conjugate/conducting polyme. In 2000,Heeger, MacDiarmid, and Shirakawa fetched the Nobel Prize in Chemistry for the discovering a new category of polymer materials known as con- ducting polymers. The PSC and other organic solar cells operate on same principle known as the pho- tovoltaic effect, i.e., where the transformation of the energy occurs in the form of electromagnetic radiations into electrical current. Yu et al. mixedpoly [2-methoxy-5-(2′-ethylhexyloxy)-p-phenylene vinylene] (PPV), C60 and its other derivatives to develop the first polymer solar cell and obtained a high power conversion efficiency. This process triggered the development of a new age in the polymer materials for capturing the solar power. After significantly optimizing the parameters, researchers achieved efficiency over 3.0% for PPV type PSCs. These unique properties of PSCs opened a new gateway for new applications in the formation of stretchable solar devices including textiles and fabric. A modern recycling concept known as polarizing organic photovoltaics (ZOPVs) was also developed for increasing the function of liquid crystal displays utilizing the same polarizer, a photovoltaic device and proper light conditions/solar panel.

Dye Sensitized Solar Cells (DSSC)

Recent research has been focused on improving solar efficiency by molecular manipulation, use of nanotechnology for harvesting light energy. The first DSSC solar cell was introduced by Michel Gratzel in Swiss federal institute of technology. DSSCs based solar cells generally employ dye molecules be- tween the different electrodes. The DSSC device consists of four components: semiconductor electrode (n-type TiO2 and p-type NiO), a dye sensitizer, redox mediator, and a counter electrode (carbon or Pt). The DSSCs attractive due to the simple conventional processing methods like printing techniques, are highly flexible, trans-parent and low cost as well [10]. The novelty in the DSSC solar cells arise due to the photosensitization of nano grained TiO2 coatings coupled with the visible optically active dyes, thus increasing the efficiencies greater than 10%. However, there are certain challenges like degradation of dye molecules and hence stability issues. This is due to poor optical absorption of sensitizers which results in poor conversion efficiency.

The dye molecules generally degrade after exposure to ultraviolet and infrared radiations leading to a decrease in the lifetime and stability of the cells. Moreover, coating with a barrier layer may also increase the manufacturing more expensive and lower the efficiency

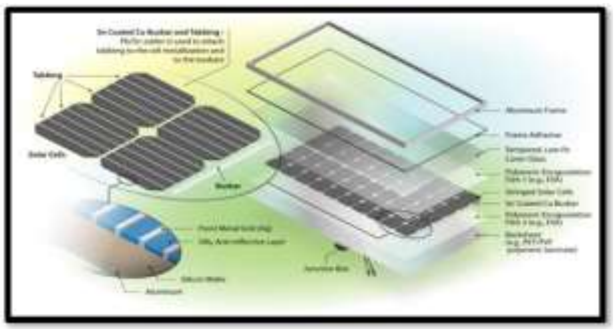
Advancements

Quantum Dots

Quantum dots are a special class of semiconductors, which are nano crystals, composed of periodic groups of II-VI, III-V or IV-VI materials. Quantum dot solar cells (QD) are structures with tunable band gap to match the spectral distribution of solar spectrum, which reduces cost/ watt ratio of solar electricity.

QDs offer the advantages like: they can be moulded into a variety of different types, in two- dimensional (sheets) or three- dimensional arrays; they can be processed to create junctions on inexpensive substrates such as plastics, glass or metal sheets; they can easily be combined with organic polymers and dyes (Jesim, K. E., 2015). Recently scientists at the University of Queensland achieved 16.6% efficiency by synthesizing a quantum dot solar cell from a halide perovskite (Hao, M., et al, 2020). U.S. National Renewable Energy Laboratory (NREL) set the previous record for quantum dot cell efficiency in 2017 at 13.4%, working with a similar lead halide perovskite (Sanehira, E. M. et Concentrated Solar Cells Concentrating photovoltaic (CPV) has been established since the 1970s. It is the newest technology in the solar cell research and development. The main principle of concentrated cells is to collect a large amount of solar energy onto a tiny region over the PV solar cell. The principle of this technology is based on optics, by using large mirrors and lens arrangement to focus sunlight rays onto a small region on the solar cell. The converging of the sunlight radiations thus produces a large amount of heat energy. This heat energy is further driven by a heat engine controlled by a power generator with integrated. CPVs have shown their promising nature in solar world. It can be classified into low, medium, and high concentrated solar cells depending on the power of the lens systems. Concentrating photovoltaic technology have the following merits, such as solar cell efficiencies >40%, absence of any moving parts, no thermal III.

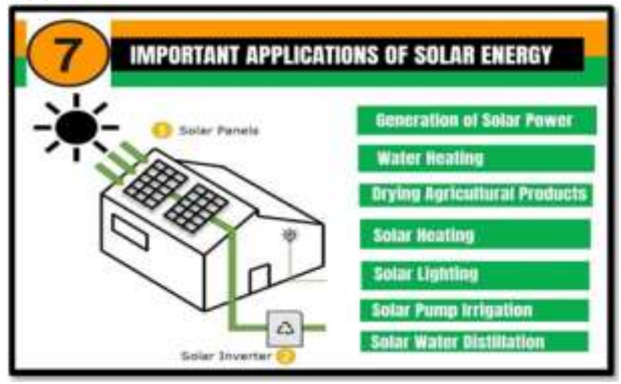
Future Trends



Continuous research and development in the field of solar photovoltaics is providing innovative materials to harvest maximum solar energy. Not only the materials but design of the products also plays important role in commercial application of the technology Many interesting applications have been realised and some are expect d in near future like : floating solar farms, where photovoltaic panels floating on reservoirs, dams and other water bodies save on large land area occupied by solar panels

(Choi, Y. K., et al, 2016) ; building integrated photovoltaics (BIPV) blend into building architecture in the form of roofs, canopies; photovoltaic glasses act as energy generating device as well as allow natural light inside houses and offices (Biyik,E. et al, 2017; Norton, B. et al, 2011); anti-solar panels working exactly opposite to conventional solar panelsi.e. by using heat radiated from earth's surface so that energy can be generated around the clock (Deppe, T. & Munday, J. N., 2020) and perhaps the most promising would be solar paint with quantum dot solar cells and perovskite solar cells (Abbas, M. A. et al mass, speedy response time and can be scalable to a range of sizes.

Applications



Including residential power generation, agriculture, remote locations, and even in space. They can be used to power homes, irrigate fields, provide lighting, and operate various electronic devices.

Specific Applications

Residential Power Generation

Solar panels on rooftops or in arrays capture sunlight to power household appliances, lighting, and more.

Agriculture

Solar-powered water pumping systems are used to irrigate fields, especially in remote areas.

Remote Locations

Solar cells can power remote navigation aids, telecommunication equipment, and monitoring stations, making them useful in areas where grid access is limited.

Portable Electronics

Solar cells are used to power calculators, wristwatches, and other small electronic devices.

Space

Solar cells are a vital energy source for spacecraft and satellites.

Large-Scale Power Gene Action

Solar farms can provide utility-scale power, contributing to grid-scale electricity generation.

Building-Related Needs

Solar cells can be integrated into buildings for heating, lighting, and other energy needs.

Transportation
Solar panels can be used to power electric vehicles or integrated into vehicles for charging.

Military Applications
Solar cells can power various military equipment and systems.

Water Heating
Solar water heating systems use solar cells to heat water for various uses.

Solar Drying
Solar drying of agricultural products is an efficient method of preservation.

Other Applications
Solar cells can also be used in light meters, photo detectors, and for detecting light or other electromagnetic radiation.

By 2025, the world's solar cell market could be worth over INR 135,000 crore. It's growing fast, at over 20% every year, showing how much we rely on this tech. Solar cells, or photovoltaic cells, turn sunlight into electricity. This makes energy both renewable and affordable.

These cells create energy that is clean and does not harm the planet. They are also tough, small, and need little upkeep. In places without power, solar cells can provide much-needed electricity. Solar energy is great for the environment because it doesn't add to carbon dioxide levels.

This alternative can lower energy bills. It works for homes, businesses, and even small gadgets. Fenice Energy is a leader in clean energy services. They have more than 20 years of experience. Their solar solutions help people meet their energy needs in an eco-friendly way. And it saves money too.

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Solar Cell Applications: Uses in Daily Life & Industry
Solar cell applications range from powering homes and businesses to charging portable devices. Explore the versatile uses of solar energy in daily life and industry.

Reduce your electricity bills by 90% Get an Estimate
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Solar cells directly convert sunlight into electricity, providing a renewable and clean energy source.

Solar energy has a wide range of applications, from powering homes and businesses to charging portable devices.

Fenice Energy offers comprehensive clean energy solutions, including solar, backup systems, and EV charging, backed by over 20 years of experience.

Solar energy can help reduce electricity bills and is an excellent replacement for non-renewable energies.

Solar cells are durable, compact, and low-maintenance, making them ideal for use in remote environments.

Solar cells find many uses, like in transportation, making our gadgets better, and producing power. These devices are now a part of many industries. They bring in new chances for using renewable energy and being more earth-friendly.

Solar Cells in Transportation

Solar-powered cars are a great example. They turn sunlight into the power needed to run them or charge up their batteries. This tech offers a greener way to move around. It cuts down our use of polluting fossil fuels.

Solar Cells in Calculators

Solar cells are also in calculators. These calculators work outdoors because they draw power from the sun. They don't need regular or rechargeable batteries. This makes them good for the environment and easy to use every day.

Solar Cell Panels

Everyone knows about solar panels on roofs. They warm water and create electricity. The power they gather can even be saved for when you need it most. This has become a popular pick in homes and businesses. With Fenice Energy's help, you can start using solar power for your energy need.

Solar Energy for Daily Life

Solar energy can be used in many ways in our daily routines. It helps with heating water and lighting our houses. In India, many families choose solar power for its benefits.

Solar Water Heating Systems

There are two types of solar water heaters, active and passive. They both work to heat water or fluid using solar collectors. This heated fluid is then used in homes for bathing, cleaning, and cooking. Active systems use pumps to move the fluid, while passive systems rely on natural heat movement.

Solar Space Heating

Hot air solar systems warm the air in homes or buildings using the sun. They help keep living spaces cozy during colder weather. This method is both eco-friendly and reduces heating costs significantly. Homeowners find it a great alternative to traditional heating systems.

Solar Lighting Solutions

Solar lighting comes in many types, like for landscapes or holidays. It uses sunlight to generate electricity for the lights. These lights are easy to maintain, dependable, and work well inside or outside thanks to their rechargeable batteries.

Fenice Energy offers many green energy solutions, including solar power and EV charging. With over two decades in the industry, they support Indian homes in saving energy costs and reducing their impact on the earth. Solar power is a great choice for many families to enjoy the benefits of a renewable energy source.

V. CONCLUSION

Solar power generation has been developed as one of the most demanding renewable sources of electricity. It has several advantages compared to other forms of energy like fossils fuels and petroleum deposits. It is an alternative which is promising and consistent to meet the high energy demand. Though the methods of utilizing solar energy are simple, yet need an efficient and durable solar material. Technology based on nano-crystal QD of semiconductors based solar cell can theoretically convert more than sixty percent of the whole solar spectrum into electric power. The polymer base solar cells are also a viable option. However, their degradation over time is a serious concern. There are various challenges for this industry, including lowering the cost of production, public awareness and best infrastructure. Solar energy is the need of the day and research on the solar cells has a promising future worldwide.

REFERENCES

1. Chu, Y. and Meisen, P. (2011) Review and Comparison of Different Solar Energy Technologies. Report of Global
2. Choubey, P.C., Oudhia, A. and Dewangan, R. (2012) A Review: Solar Cell Current Scenario and Future Trends. Re- cent Research in Science and Technology, 4, 99-101.
3. McEvoy, A., Castaner, L. and Markvart, T. (2012) Solar Cells: Materials, Manufacture and Operation. 2nd Edition, Elsevier
4. Ltd., Oxford, 3-25.
5. Fahrenbruch, A.L. and Bube, R.H. (1983) Fundamentals of Solar Cells. Academic Press Inc., New York.
6. (2015-2016) Energy from the Sun, Student Guide. National Energy Education Development Project (NEED).
7. Grisham, L.R. (2008) Nuclear Fusion in: Future Energy, Improved, Sustainable and Clean Options for our Planet, Edited by Trevor M. Letcher, 2nd Edition, Elsevier Ltd., Amsterdam, 291-301.
8. Rana.S. (2013) A Study on Automatic Dual Axis Solar Track r System using 555 Timer. International Journal of Scientific & Technology Research, 1, 77-85.
9. Bertolli, M. (2008) Solar Cell Materials. Course: Solid State II. Department of Physics, University of Tennessee, Knoxville.
10. Wall, A. (2014) Advantages and Disadvantages of Solar Energy. Process Industry Forum, 7 August 2013. Web. 2 Feb- ruary 2014.
11. Bagher, A.M., Vahid, M.M.A. and Mohsen, M. (2015) Types of Solar Cells and Application. American Journal of Op- tics and Photonics, 3, 94-113.
12. Whitburn, G. (2012) Exploring Green Technology, Fundamental Advantages and Disadvantages of Solar Energy.
13. Peplow, M. (2014) Organic Synthesis: The Robo-Chemist. Nature, 512, 20-22. http://dx.doi.org/10.1038/512020a