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Advance Solar Cells and Printed Solar Cell: A Review

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ABSTRACT

Solar cell technology begin with first generation and third generation solar cells is discussed here by considering different advanced materials on which these technologies are based. The efficiencies attained with different new age solar cell technologies, limitations in their commercial application is overcome with the new technology used in solar cell. This paper is an overview of the advances technology used in solar cell and printed solar cell.

KEYWORDS: *efficiency of solar cell, DSSC, perovskite solar cell, quantum dot solar cell, solar cell technology, solar photovoltaic's*

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1. INTRODUCTION

Solar cell is a semiconductor device that converts the sun (solar light) energy into the electrical energy in photovoltaic energy conversion. In most cases, semiconductor is used for solar cell material. The energy conversion consists of absorption of light (photon) energy producing electron–hole pairs in a semiconductor and charge carrier separation. A p–n junction is used for charge carrier separation in most cases. It is important to learn the basic properties of semiconductor and the principle of conventional p–n junction solar cell to understand not only the conventional solar cell but also the new type of solar cell. The comprehension of the p–n junction solar cell will give you hints to improve solar cells regarding efficiency, manufacturing cost, consuming energy for the fabrication, etc.

Photovoltaic's, the direct conversion of solar light to electricity, is now the rapidly growing technology for power generation. Present "first generation" products use the same silicon wafers as in microelectronics. "Second generation" thin-films, now entering the market, have the potential to greatly improve the economics by eliminating material costs. this Paper that "second generation" photovoltaic's will eventually reach its own material cost constraints, engendering a "third generation" of high performance thin-films. This review paper explores, self-consistently, the energy conversion potential of advanced approaches for improving photovoltaic performance and outlines possible implementation paths.

2. SOLAR CELLS

Solar cells are semi-conductor devices which use sunlight to produce electricity. They are manufactured and processed in a similar fashion as computer memory chips. Solar cells are primarily made up of silicon which absorbs the photons emitted by sun's rays. The process was discovered as early as 1839. Silicon wafers are doped and the electrical contacts are put in place to connect each solar cell to another. The resulting silicon disks are given an anti-reflective coating. This coating protects sunlight loss. The solar cells are then encapsulated and placed in an aluminum frame. The process requires continuous monitoring to ensure quality control over a period of time. After the manufacturing process is complete they undergo final test to check their efficiency under normal conditions. Figure 1.1 show the conversion of solar light into electricity.

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3. DYE SENSITIZED SOLAR CELLS

A dye sensitized solar cell is the third generation of solar cells. It belongs to the thin-film solar cell category. This advanced solar cell transforms visible light into electrical energy. The dye within the solar cell generates electricity while in contact with sunlight. These solar cells are among the cheapest solar cells available on the market. They are an excellent alternative to silicon solar cells due to their low fabrication cost and simple configuration. This technology Extracts energy from both artificial and natural light & Converts that energy into electric power. And use the generated power for charging electronic devices and other indoor and outdoor purposes.

These cells comprise a coated layer of titanium dioxide nanoparticles made from mesoporous oxide electrodes. This layer is covered with a light-sensitive dye that extracts energy from the sun's rays. The solar cells are made of titanium dioxide as they can resist electron transfer better than any other material. Although they can only absorb limited photons from the solar rays, this limitation can be curbed by the molecular sensitizers of the dye molecule. These solar cells are placed on a semiconductor's surface to absorb more photons from the sunlight.

Finally, the titanium dioxide is immersed in an electrolyte solution and placed above a platinum-based catalyst.

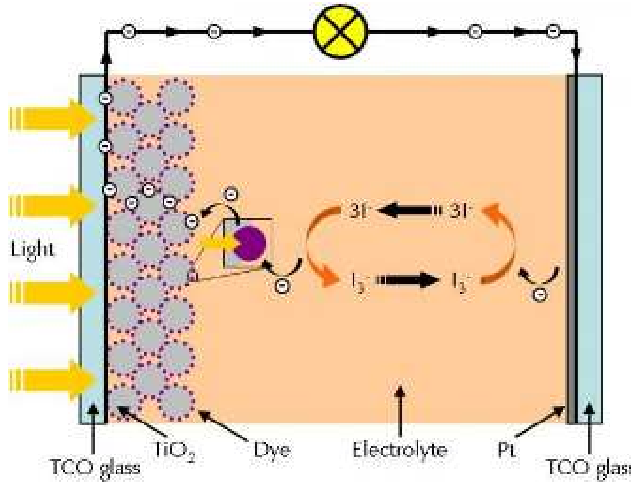

Figure 1.2 show the working of Dye Sensitized Solar Cells

4. OPV CELL (ORGANIC SOLAR CELL)

An OPV cell (also known as an organic solar cell) is a type of solar cell where the absorbing layer is based on organic semiconductors (OSCs). Typically, these are either polymers or small molecules. For organic materials to be used in organic electronics they will need to be semiconducting which will require a high level of conjugation (alternating single and double bonds). Conjugation of the organic molecule results in the electrons associated with the double bonds becoming delocalized across the entire length of conjugation. These electrons have either directly used for applications such as drying, water heating, space heating etc. or is converted into electricity. In photovoltaic conversion, the devices called as solar cells directly convert the solar radiation falling on them into electricity. Increasing the efficiency of solar cells and limiting the production cost is the key factors on which most of the research in this area are based upon.

As with other solar cell technologies, the purpose of an OPV is to generate electricity from sunlight. This is achieved when the energy of light is equal to or greater than the band gap, leading to absorption and excitation of an electron from the HOMO to the LUMO. The excited electron will leave behind a positively-charged space known as a 'hole'. Due to the opposite charges of the hole and electron, they become attracted and form an electron-hole pair, also known as an'exciton . To remove the charged particles from the solar cell, the electron-hole pair must be separated, and this process is known as 'exciton dissociation.

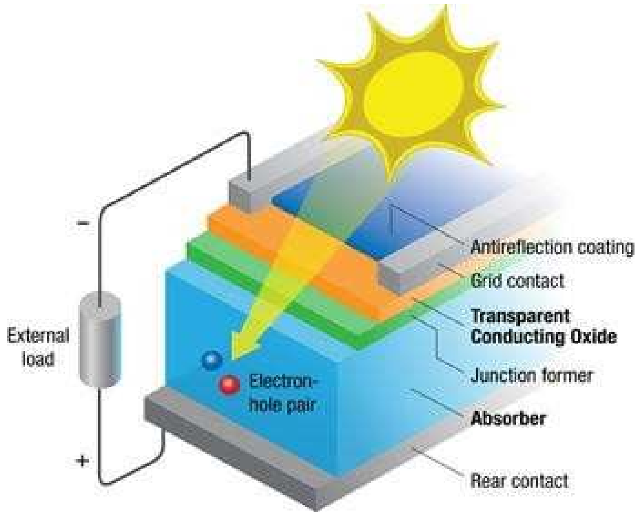

Figure 1.3 show the working of OPV Solar Cells

5. PEROVSKITE SOLAR CELL

A perovskite solar cell is a thin film photovoltaic device. In these devices, perovskites absorb sunlight and convert it into electrical energy. Certain perovskites have fundamental properties which make them excellent at this. In some ways, perovskites are even better than the materials used in current solar cells.

This means we could use perovskite solar cells in many interesting ways, and this is one of the reasons that they have caused a lot of excitement in the scientific community.

the term perovskite describes a material with a specific crystal structure. These crystals are naturally occurring in the form of calcium titanate, and have few practical uses. However, if you combine certain organic and inorganic materials in the same structure, you can create a perovskite semiconductor. It is these synthetic perovskites which can be used to make highly efficient solar cells.

Advantages of Perovskite Solar Cells

They can be flexible, lightweight, and even semi-transparent

Perovskites absorb visible light very efficiently as they are a direct band gap semiconductor. This means that high efficiency devices can be achieved with a very thin perovskite layer (often less than 1μm thickness).

Perovskite solar cells could potentially be used in situations where silicon solar cells are too heavy, thick, or rigid. For example, flexible PSC devices have been made on plastic substrates, semi-transparent PSCs devices have been used to shade windows while producing small amounts of electricity, and ultra-thin PSC modules have even been used to power a very tiny plane.

They could be cheaply and easily manufactured

Perovskite solar cells can be entirely solution processed. This means that they can be made with methods like slot die coating and ink jet printing, which are often used in large scale manufacturing. This could indicate they can be easily adapted for large area manufacturing. For the dreamers among us, we imagine factories printing solar modules at an extraordinary rate on massive rolls or even a future with paint-on or spray on solar cells. However, PSCs are still a long way from this yet. Additionally, perovskites solar cells can be created and deposited through other techniques, such as vacuum deposition and atomic layer deposition – so they are extremely adaptable materials. Figure 1.3 show the layer of perovskite solar cell.

Tandem Solar Cells

In a tandem solar cell, multiple solar devices are stacked on top of one another to increase the amount of electrical energy that we can gain from solar irradiance. Perovskites can more efficiently use smaller wavelengths of the sun's spectrum, so the efficiency of a C-Si solar cell can be improved by depositing a perovskite solar cell on top! Perovskite-silicon tandem devices have achieved efficiencies of up to 31.3%, which is significantly higher than either C-Si or perovskite solar cells individually!

6. PRINTED SOLAR CELL

Solar cells can be mass produced with printing presses just like newspapers and banknotes. The very latest photovoltaic materials can be fabricated using solution-based processing methods, making them highly amenable to printing on thin and flexible substrates. This means a hopeful future for the availability of mass-producible and highly affordable photovoltaic technology.

The advancement of photovoltaic technology has the potential to positively impact global energy generation, decrease pollution and mitigate climate change. Progress so far has been stalled by a number of limitations:

- **Power Conversion Efficiency** (PCE)
- Stability
- Upscaling
- Module Design

The advancement of solar cell research requires "lab to fab" techniques that provide a solution to issues such as bulky, inflexible materials and complicated, highly expensive production costs.

The mass production of photovoltaic technology at low cost is desperately needed in the solar industry. The power that a PV panel generates is proportional to the surface area exposed to sunlight. According to

Cheng et al. (2016) "the world consumes approximately 20,000 terawatt-hours of electricity each year. Meeting this need would require enough PV devices to cover around 100,000 square kilometres, an area about the size of Iceland."

Printed and **flexible solar cells** are cheaper to fabricate and produce far less waste. They are lightweight, flexible and translucent in comparison with other materials. They use little material and can generate electricity even in low light conditions.

Printed solar cells can be utilized in a range of applications. They can easily be rolled up and are thus transportable, so can be used for outdoor activities such as camping. They can also be used in walls and windows, wearable devices and even clothing.

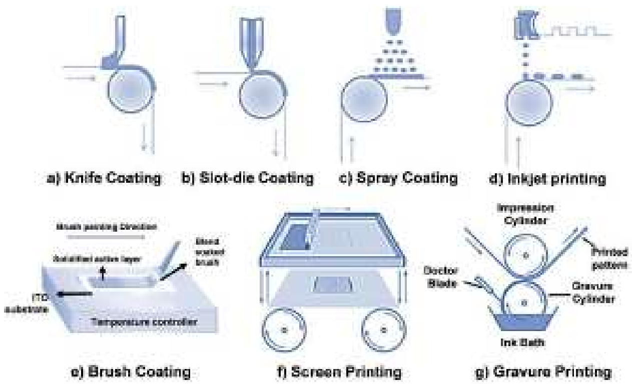

Figure 1.4 show the types of printing in printed solar cell.

7. FUTURE SCOPE

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. Currently, perovskite solar cells, organic solar cell and printed solar cells are at the research stage of development. Although they have very high efficiencies, they still have some stability issues which need to be tackled before they hit the marketplace. Researchers also need to work out how to convert small area devices to large-area devices and modules without sacrificing efficiency.

However, there are a few companies currently working on commercializing perovskite solar cells, and there is huge scientific interest in this subject. There is plenty of scope for perovskite solar cells to be improved, optimized, and scaled in the not-too-distant future. Printed solar cell can reduce the price of exiting solar cell in maximum amount in future.

REFERENCES

[1] Shanmugam V, Wong J, Peters I, Cunnusamy J, Zahn M, Zhou A, Yang R, Chen X, Aberle A, Mueller T (2015) Analysis of Fine-Line Screen and Stencil-Printed Metal Contacts for Silicon Wafer Solar Cells IEEE Journal Of Photovoltaics, Vol. 5, No. 2

[2] Glunz S, Mette A, Aleman M, Richter P, Filipovic A, Willeke G (2006) New concepts for the front side metallization of silicon solar cells, 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, pp.746-749

[3] Kaydanova T, Miedaner A, Curtis C, Perkins J, Alleman J, Ginley D. (2003) Ink Jet Printing Approaches to Solar Cell Contacts. National Renewable Energy Laboratory (NREL): Golden, CO.USA

[4] Teng, K. F., & Vest, R. W. (1988). Metallization of solar cells with ink jet printing and silver metallo-organic inks. IEEE Transactions on components, hybrids, and Manufacturing Technology, 11, 291

[5] Bag M, Jiang Z, Renna L, Jeong S, Rotello V, Venkataraman D (2016) Rapid combinatorial screening of inkjet-printed alkyl-ammonium cations in perovskite solar cells Materials Letters164 472–475 http://dx.doi.org/10.1016/j.matlet.2015.11.058

[6] Huster F, Gerhards C, Spiegel M, Fath P, & Bucher, E. (2000). Roller printed multi crystalline silicon solar cells with 16% efficiency and 25 µm finger width. Proceedings of *27th IEEE Photovoltaic Specialists Conference*, 205-208. doi: 10.1109/PVSC.2000.915790

[7] Glunz, S. W., Mette, A., Aleman, M., Richter, P. L., Filipovic, A., & Willeke, G.(2006). New concepts for the front side metallization of silicon solar cells. Proceedings of the 21st European Photovoltaic Solar Energy Conference.746-749.

[8] Bag, S., Deneault, J.R., & Durstock, M. F. (2017). Aerosol-Jet-Assisted Thin-Film Growth of $CH_3NH_3PbI_3$ Perovskites—A Means to Achieve High Quality, Defect-Free Films for Efficient Solar Cells, Advanced Energy Materials, https://doi.org/10.1002/aenm.201701151.

[9] Vak, D., et.al. (2014). 3D Printer Based Slot-Die Coater as a Lab-to-Fab Translation Tool for Solution-Processed Solar Cells, Advanced Energ https://d9

[10] Ralph, E. L. (1976). Recent advancements in low cost solar cell processing. Proceedings of the *11th IEEE Photovoltaic Specialists Conference*, 315-316

[11] M. Fischer (2018) ITRPV 9th edition 2018 report release and key findings, PV CellTech conference, March 14th 2018

[12] Prudenziati, M., Moro, L., Morten, B, Sirotti, F., & Sardi, L. (1989). Ag based thick film metallization of silicon solar cells. Active and Passive Elec. Comp. 13,133-150

[13] Sopori, B., Mehta, V., Rupnowski, P., Appel, J., Romero, M., Moutinho, H., Domine, D., To, B., Reedy, R., Al-Jassim, M., Shaikh, A., Merchant, N., Khadilkar, C., Carlson, D., & Bennet,

[14] M. (2007) Fundamental mechanisms in the fire-through contact metallization of si solar cells: A Review. Proceedings of 17th Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes, 93-103.

[15] Young, J.L., Mehta, V., Guhabiswas, D., Moutinho, H., Bobby To, Ravindra, N. M., & Sopori, B. (2009, August). Back contact formation in si solar cells: Investigations using a novel cross-sectioning technique. Poster session presented at 19th Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes, Vail, CO

[16] Mehta VR (2010) Formation of screen-printed contacts on multicrystalline silicon (mc-Si) solar cells. Ph.D. thesis, New Jersey Institute of Technology

[17] Schubert G, Beaucarne G, Tous L, Hoornstra J (2017) Results of the survey conducted during 7th Workshop on Metallization and Interconnection for Crystalline Silicon Solar Cells, 7th Workshop on Metallization and Interconnection for Crystalline Silicon Solar Cells, 2017, http://dx.doi.org/10.2139/ssrn.3152250. Accessed on 9th Sept 2019.