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A STEP AHEAD IN SOLAR ENERGY: NEXT GENERATION SOLAR CELL

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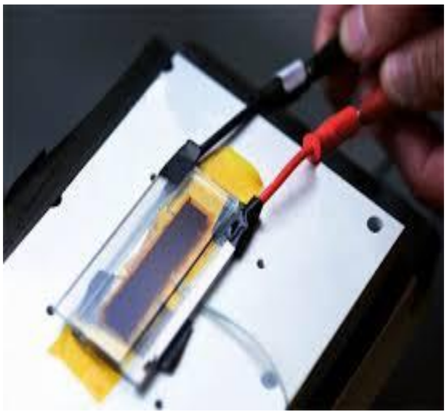
ABSTRACT

Solar cells, popularly known as PV cells, are actually electrical devices which help us to convert solar energy into direct current. When these cells are exposed to sunlight, they absorb protons and after completing the gap between two poles electric current starts to flow. These cells are helpful in controlling the voltage of electricity generated with reaction of positive and negatives cells. This field of technology came into practical use a few decades ago, when researchers were trying to find an affordable and efficient means of producing energy through the use of renewable resources. However, solar power continues to be the most fruitful source of renewable energy. Due to the use of solar technology, small business owners can generate their own electricity for personal use at cheaper rates as compared to the local service provider. The International Energy Agency hopes to make solar cells the largest source of electricity in the world by 2050. Solar energy has, so far, faced strong competition from hydroelectric and wind power, and only accounted for a small share of the total energy production. However, over time, solar power is emerging as perhaps, the greenest form of renewable energy and is in increasing demand across the world, with the global capacity for solar power generation now topping 100 GW. Significant progress has been made by the solar industry in bringing down the cost of solar electricity and in many parts of the world, it now competes with grid electricity in terms of cost, and since it requires fewer infrastructures, solar power can also be used in areas where conventional electricity is not an easy option. Usually, when people are asked to imagine a solar panel, they will immediately think of the large, dark blue, silicon-based panels commonly seen in residential rooftop installations. However, recent innovations in alternative photovoltaic technologies have opened the possibility of solar panels with features such as flexibility, customized shape, and transparency.

Flexible solar cells are lightweight due to the lack of heavy glass sheets and metal frames, thus, significantly reducing transportation and deployment costs. Requirements, limitations, and developments towards the conversion of solar power into electricity making use of solar cells have processed their (solar cells) development to present four generations with unique improvements related to their characteristics, such as solar spectrum, cost, safety, durability, and efficiency, etc., and next generation of solar cells with more exotic properties are in the pipeline in the near future.

Keywords: PV Cells, Renewable Resources,Alternative Photo-voltaic, Solar Spectrum etc.



I INTRODUCTION

1.1 TYPES OF SOLAR CELLS

Today, four generations of solar cells are available, thus, enabling the use of different types of solar cells according to our needs and preferences. Some of the significant ones have been described here.

1.1.1 First-Gen. (1G) Solar Cells

Traditionally, the first-generation (1G) PV technology is known to comprise of photovoltaic technology based on thick crystalline films (mainly Si) which not only leads to high efficiency, but also high cost. These were the first generation PV cells and silicon continues to rule in the commercial market due to its dominant qualities. Typically, these cells are made with crystalline silicon wafer.

1.1.2 Second-Gen.(2G) Solar Cells

The second-generation (2G) solar cells were developed with the aim of reducing the high costs prevalent in 1G through the utilization of thin film technology; the idea being to save on bulk material cost with a significant reduction in the quality and quantity of the material used and the challenge of increasing the thin film absorption to compensate for the reduced thickness in the photoactive layers. This 2G thin film technology was based on PV materials identified during the development of 1G PVs and was extended to include amorphous or polycrystalline Si, CIGS, and Cd-Te. While the 2G PV family addresses the cost issues associated with thick films, the performance of such 2G solar cells is known to be poor compared to their 1G counterpart. Therefore, the challenge was to improve the efficiency as much as possible within the inexpensive material envelope that encouraged the chemical vapour deposition of thin films and thermal crystallization, where appropriate. In the case of amorphous materials, to compensate for the significantly reduced active volume, an intrinsic layer was grown to produce p–i–n devices where photo-generated carriers could be swept to the doped materials by the built-in field. The key factor that worked in favour for 2G PV cells was the cost per watt delivery but the need for extended surface areas to compensate for the lower efficiency was an issue. This in turn pushed the development of the third-generation (3G) solar cells, including nano-crystalline films, PVs based on active

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quantum dots, tandem or stacked multi-layers of inorganics based on III–V materials such as GaAs/Ge/GaInP2, or novel device concepts such as hot carrier cells where the aim was to obtain higher performance than their 2G counterparts, at a lower cost. These cells were known as Plasma Enhanced Chemical Vapor Deposition (PECVD). In this generation, four types of solar cells were introduced, including the amorphous silicon cells which can be deposited over large areas with the help of PECVD. Their band gap was about 1.7 eV and function was similar to c-SI. Polycrystalline silicon, made of pure silicon grains, works better than the previous designs because of their mobility. These can be easily moved over a large magnitude. Cadmium telluride (Cd-Te) cells are formed with cadmium and tellurium mixed with zinc cubic crystal structure. This material is cheaper than silicon but not as efficient as silicon. Copper indium gallium diselenide (CIGS) alloy cells are deposited on glass or stainless steel and are a complex model. Their band gap is about 1.38 eV.

1.1.3 Third-Gen.(3G) Solar Cells

Thereafter began a true race to design materials at the nano-scale and scale-up to the macroscopic areas. For the first time, significant attention was paid to the charge and energy transfer processes and the respective routes to optimize charge collection, thereby enhancing the energy capture within the solar spectrum. With the introduction of organic materials exhibiting photovoltaic properties, their potential for low cost and high optical absorption placed them as a 3G technology. In addition to organic (or polymer) solar cells, another candidate that grew to dominate 3G PV technologies is dye or semiconductor sensitized solar cells (DSSCs). Despite the reasonable success of 3G cells, significant improvements in device performances are required if this technology is to be competitive with the previous PV generations in terms of cost per watt. This generation was very different from the previous one due to the use of innovative semiconductors. The various types of solar cells introduced in this generation, include Nano-crystal solar cells, Photo-electrochemical (PEC) cells, Graetzel Cell, Dye-sensitized hybrid solar cells, and Polymer solar cells. Nano-crystal solar cells were based on silicon substrate with coating of nano-crystals. A thin film of nano crystals is used along with it which was obtained by the process of spin coating. They create a higher potential for solar cells. PECs were second on the list and consisted of a semiconducting photo-anode. It works best with electrons and can also separate non-salacity of semiconductors. Graetzel cells were dye sensitized and used photoelectrons to increase power efficiently. Dyes were made of metal organic complex and its molecules are hit by increasing heat. The polymer solar cells were the last invention of this generation; they were lightweight, inexpensive, flexible, and disposable at any molecular level. They have little negative impact on the environment. In turn, these 3G cells offer significant cost improvements on first and second generation solar cells—based on crystalline and polycrystalline silicon—which are still responsible for over 90 percent of the solar power being generated today.

1.1.4 Fourth-Gen.(4G) Solar Cells

The fourth generation (4G) of PV technology which combines the low cost/flexibility of polymer thin films with the stability of novel inorganic nanostructures was introduced with the aim of improving the optoelectronic properties of the low-cost thin film PVs. These device architectures are meant to maintain the inexpensive nature of a solution processable PV device structure; but incorporate inorganic components to improve on energy harvesting cross-sections, the charge dissociation, and charge transport within the PV cells. While thepreviously introduced meso-scopic solar cells may be considered as a 4G technology due to the incorporation of an inorganic component (usuallytitania), especially when combined with a polymer or organic layer as a

IJARSE
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solid-state DSSC, this inorganic component is a requirement for the functionality of the cell and does not introduce additional benefits as for the inorganics-in-organics architectures.

Till date, the most effective polymer solar cells (PSCs) have been based on the bulk hetero-junction (BHJ) concept. The 4G solar cells are a hybrid that combine the low cost and flexibility of conducting polymer films (organic materials) with the lifetime stability of novel nanostructures (inorganic materials). This inorganicsin-organics technology improves the harvesting of solar energy and its conversion into electricity, offering better efficiency than the current 3G solar cells while maintaining their low cost base. These new generation materials for solar cells have been truly engineered at the nano-scale. They are designed to maximize the harvesting of solar radiation, and thereby efficiently generate electricity. It is believed that 4G solar cells will be the technology for future photovoltaic energy sources. This generation brings most successful types of solar cells for mankind and those were hybridnano-crystal cells. For generation of these cells polymers and nano-particles were mixed to make on layer which can help electrons and protons to move for producing better voltage and good quality of direct current.

1.1.5 Next Gen. Solar Cells

So far, most of the solar cells are entirely made of inorganic semiconductors, usually silicon, but these materials are not as energy efficient as organic semiconductors. The new method lies in the groundwork for building a new generation of solar cells made up of both organic and inorganic material. In silicon solar cells, every single particle of light (photon) can excite one electron only, but with a new material (naturally present in green leaves), the same quantity of light releases not one but two electrons, doubling the energy capacity of the semiconductor. This improves the energy efficiency ratio to up to 95 percent, a figure impossible to reach with conventional, inorganic semiconductors. The process 'clears the way for hybrid solar cells which could far surpass current efficiency limits'. The next generation solar cells could be infinitely more useful, thanks to a newly discovered nano-tube structure capable of transporting electrical charges 100 million times higher than previously measured. Most solar cells currently use silicon to absorb light, however inefficiencies in the material have led scientists to develop carbon nano-tubes that can be implemented to enhance the light absorption capabilities of current cells. However, until now the nano-tubes have been randomly placed within the solar cells in suboptimal structures as they are difficult to arrange. Scientists are able to manipulate the carbon nano-tubes using controlled, nano-scale dimensions inside a polymer matrix. This method allowed re-arranging the nano-tubes into complex networks that reduced the cost of nano-tubes needed. Extremely small amounts of nano-tubes can be used—less than 1 percent—and still produce efficient devices leading to lower material cost.

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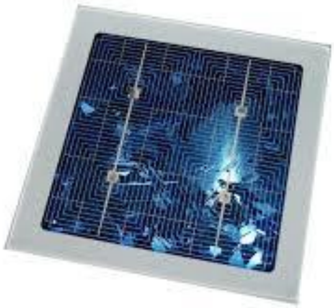
Solar cells made of these materials are solution processable, implying that do not require expensive equipment and yet increase the conductivity within the cell.



The resulting nano-networks possess exceptional ability to transport charges up to 100 million times higher than previously measured carbon nano-tube random networks produced by conventional methods.However, photovoltaic cells continue to depend on light to produce electricity, and so, generate a negligible amount of power when there are clouds overhead. But, researchers wondered whether it would be possible to create all-weather solar cells. Rain helps solar cells operate efficiently by washing away dust and dirt that block the sun's rays. Solar cells could someday generate electricity even during rain showers with the help of 'graphene'. Raindrops contain salts that split up into positive and negative ions. In order to manipulate that bit of chemistry, researchers turned to 'graphene', the one-atom-thick sheet of carbon. 'Graphene's electrons can attract the positively charged ions, such as sodium, calcium, and ammonium, resulting in separated layers of positive and negative ions that act much like a capacitor to store energy. With that in mind, scientists added graphene to a dye-sensitized solar cell, a kind of inexpensive thin-film solar cell, thereafter placed these on a flexible, transparent backing of indium tin oxide and plastic. The resulting flexible solar cell demonstrated a solar-to-electric conversion efficiency of up to 6.53 percent, and generated hundreds of micro-volts from slightly salty water that was used to simulate rainwater. Therefore, future solar cells may produce electricity in all-weather conditions with high efficiency, desired geometry and long life span.

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