

INFRARED PLASTIC SOLAR CELL

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Abstract: Nanotechnology is the nexus of sciences. Nanotechnology is the engineering of tiny machines - the projected ability to build things from the bottom up using techniques and tools being developed today to make complete, highly advanced products. It includes anything smaller than 100 nanometers with novel properties. As the pool of available resources is being exhausted, the demand for resources that are everlasting and eco-friendly is increasing day by day. One such form is the solar energy. The advent of solar energy just about solved all the problems. As such solar energy is very useful. But the conventional solar cells that are used to harness solar energy are less efficient and cannot function properly on a cloudy day. The use of nanotechnology in the solar cells created an opportunity to overcome this problem, thereby increasing the efficiency. This paper deals with an offshoot in the advancement of nanotechnology, its implementation in solar cells and its advantage over the conventional commercial solar cell.

Keywords: Nanotechnology, solar energy, solar cell, infrared light.

I. INTRODUCTION

Nanotechnology is the engineering of tiny machines - the projected ability to build things from the bottom up using techniques and tools being developed today to make complete, highly advanced products. It includes anything smaller than 100 nanometres with novel properties. As the pool of available resources is being exhausted, the demand for resources that are everlasting and eco-friendly is increasing day by day. One such form is the solar energy. The advent of solar energy just about solved all the problems. As such solar energy is very useful. But the conventional solar cells mainly due to the construction process and also the materials used in it have a limited number of applications. Latest inventions have opened doors to whole lot of applications that is creeping in to use the solar panels that have been developed out of plastic. In the sector of harnessing renewable form of energy, silicon as an element failed to make a mark in the wide range of applications of solar panels. The use of nanotechnology in the solar cells created an opportunity to overcome this problem, thereby increasing the efficiency. This technology deals with an offshoot in the advancement of nanotechnology, its implementation in solar cells and its advantage over the conventional commercial solar cell.

In order to the miniaturization of integrated circuits well into the present century, it is likely that present day, nano-scale or nano electronic device designs will be replaced with new designs for devices that take advantage of the quantum mechanical effects that dominate on the much smaller, nanometre scale. Nanotechnology is often referred to as general purpose technology. That is because in its mature form it will have significant impact on almost all industries and all areas of society. It offers better built, long lasting, cleaner, safer and smarter products for the home, for ammunition, for medicine and for industries for ages. These properties of nanotechnology have been made use of in solar cells.

II. MOTIVATION

The conventional solar cells that are used to harness solar energy are less efficient and cannot function properly on a cloudy day. The use of nanotechnology in the solar cells created an opportunity to overcome this problem, thereby increasing the efficiency. Infrared plastic solar cells can function on the cloudy weather and thereby increasing the efficiency.

III. WORKING OF CONVENTIONAL SOLAR CELL

Basically, conventional type solar cells Photovoltaic (PV) cells are made of special materials called **semiconductors** such as silicon, which is currently the most commonly used. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely. PV cells also all have one or more electric fields that act to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off to use externally.

For example, the current can power a calculator. This current, together with the cell's voltage (which is a result of its built-in electric field or fields), defines the power (or wattage) that the solar cell can produce. Conventional semiconductor solar cells are made by polycrystalline silicon or in the case of highest efficiency one's crystalline gallium arsenide.

But by this type of solar cell, it is observed that, only 35% of the suns total energy falling on it could be judiciously used. Also, this is not so favorable on cloudy days, thus creating a problem. This major drawback led to the thought of development of a new type of solar cell embedded with nanotechnology. The process involved in this is almost the same as explained earlier. But the basic difference lies in the absorption of the wavelength of light from the sun.

IV. INFRARED PLASTIC SOLAR CELL

Ever since the discovery of conducting plastic, there has been interest in using these materials in fabrication of solar cells. Scientists have invented a plastic solar cell that can turn the suns power into electric energy even on a cloudy day. Existing solar materials are only able to harness the sun's visible light. While half of the sun's power lies in the visible spectrum, the other half lies in the infrared spectrum. The new material is first plastic compound that is able to harness infrared portion. The plastic material uses nanotechnology and contains the 1st generation solar cells that can harness the sun's invisible infrared rays. This

breakthrough made us to believe that plastic solar cells could one day become more efficient than the current solar cell.



Fig 1. Infrared Plastic Solar Cell

The researchers combined specially designed nano particles called quantum dots with a polymer to make the plastic that can detect energy in the infrared. With further advances the new plastic solar cell could allow up to 30% of sun’s radiant energy to be harnessed completely when compared to only 6% in today plastic best plastic solar cells. A large amount of sun’s energy could be harnessed through solar farms and used to power all our energy needs. This could potentially displace other source of electrical production that produce greenhouse gases like coal.

V. MORPHOLOGY AND DESIGN

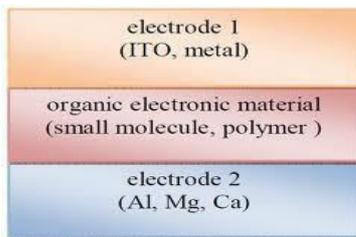


Fig 2: Basic structure of plastic solar cell

The plastic solar cell created by the Berkeley research group is actually a hybrid, comprised of tiny nanorods dispersed in an organic polymer or plastic. Figure 2 shows the hybrid plastic solar cells has nanorod/polymer layer sandwiched between two electrodes. The active layer, a mere 200 nanometer thick, is a jumble of nanorods embedded in a semiconducting polymer. Vacuum evaporation and solution processing techniques are the most commonly used thin film preparation methods in the production of plastic solar cells. Polymers decompose under excessive heat and have too large molar mass for evaporation. Therefore, most polymer-based photovoltaic elements are solution processed at low temperatures. The printing/coating techniques are used to deposit conjugated semiconducting polymers.

Donor-acceptor blends can be prepared by dissolving donor and acceptor components in a common solvent (or solvent mixture) this is called solution processing and solution processing requires soluble polymers. Blends are deposited by using one of the techniques mentioned above. Sometimes, a soluble monomer is cast as a thin film using a post deposition polymerization reaction afterward. Soluble precursor polymers can also be converted into the final semiconducting form with a post deposition conversion reaction. The advantage of this latter method is that the resulting conjugated polymer thin films are insoluble. For plastic solar cells, spin-coating, doctor blading, as well as screen-printing methods are applied. Such large-scale printing/coating techniques open up the possibility for an upscaling of the production with low-energy consumption.

The plastic solar cells are fabricated in sandwich geometry. As substrates, transparent, conducting electrodes (for example, glass or plastic covered with ITO) are used. ITO (indium tin oxide) electrodes are transparent and conductive but expensive. The substrate electrode can be structured by chemical etching. On the transparent conducting substrate, PEDOT-PSS, poly(ethylenedioxythiophene) doped with polystyrenesulfonic acid, is coated from an aqueous solution. This PEDOT-PSS layer improves the surface quality of the ITO electrode as well as facilitates the hole injection/extraction. Furthermore, the work function of this electrode can be changed by chemical/electrochemical redox reactions of the PEDOT layer. The active layers are coated using solution or vacuum deposition techniques. The nanorods which are derived from 1-(3-methoxycarbonyl)propyl-1-phenyl-[6,6]-methanofullerene(PCBM) are mixed with a plastic semiconductor called (P3HT) p3ht-poly-(3hexylthiophene) a transparent electrode is coated with the mixture. An aluminium coating acting as the back electrode completed the device. The nanorods act like wires. When they absorb light of a specific wavelength, they generate an electron plus an electron hole-a vacancy in the crystal that moves around just like an electron. The electron travels the length of the rod until it is collected by aluminium electrode. The hole is transferred to the plastic, which is known as a hole-carrier, and conveyed to the electrode, creating a current.

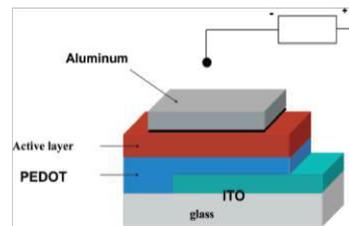


Fig 3: Schematic device structure for polymer/fullerene bulk heterojunction solar cell.

VI. WORKING OF IR PLASTIC SOLAR CELL

The solar cell created is actually a hybrid, comprised of tiny nanorods dispersed in an organic polymer or plastic. A layer only 200 nanometers thick is sandwiched between electrodes and can produce about 0.7 volts. The electrode layers and nanorods/polymer layers could be applied in separate coats, making production fairly easy. And unlike today's semiconductor-based photovoltaic devices, plastic solar cells can be manufactured in solution in a beaker without the need for clean rooms or vacuum chambers. Plastic solar cell (PSC) structure is the most successful structure invented, in which a blend of donor and acceptor with a bicontinual phase separation can be formed. When the sunlight getting through the transparent electrode is absorbed by the semiconducting donor and acceptor materials in the photoactive layer, excitons (bounded electron-hole pairs) are formed, and then the excitons diffuse to the interfaces of the donor/acceptor where the excitons dissociate into electrons on the lowest unoccupied molecular orbital level of the acceptor and holes on the highest occupied molecular orbital level of the donor. The dissociated electrons and holes are driven by built-in electric field and then moved to negative and positive electrode, respectively, and then collected by the electrodes to realize the photon-to-electron conversion.

The absorption band of P3HT/PCBM covers the range from 380 to 670 nm, which means that the photons with energy between 2.0eV and 3.3 eV can be absorbed by the active layer, and the

excitons will be formed. In order to make better utilization of the sunlight, active layer materials with broad absorption band is required, and for this purpose, more and more low band gap (LBG) materials have been developed and great successes have been made in the past decade.

Since, the lowest unoccupied molecular orbital and the highest occupied molecular orbital level of P3HT is higher than that of PCBM, the excitons will separate into positive and negative charges at the interface of the P3HT phase and PCBM phase. The negative charge will transport through the lowest unoccupied molecular orbital of PCBM and the positive charge will transport through the highest occupied molecular orbital level of P3HT, and then the charges can be collected by the electrodes. In order to get efficient charge separation, highest occupied molecular orbital level and lowest unoccupied molecular orbital of the donor material should be 0.2–0.3 eV higher than that of the acceptor material, respectively. If the offset is too small, it would be hard to get efficient charge separation; if the offset is too big, much energy loss would be happened. As known, open-circuit voltage (Voc) of BHJ OPV devices are directly proportional to the gap between highest occupied molecular orbital level of the donor and lowest unoccupied molecular orbital of the acceptor. Although, the energy of the photon that can be utilized by the P3HT/PCBM system is higher than 2.0 eV, Voc of P3HT/PCBM based OPV device is typically around 0.6 eV, meaning that more than 70 % energy loss is taking place during the photoelectric conversion process. Therefore, to minimize the energy loss, highest occupied molecular orbital level and lowest unoccupied molecular orbital levels of the donors and the acceptors should be tuned carefully.

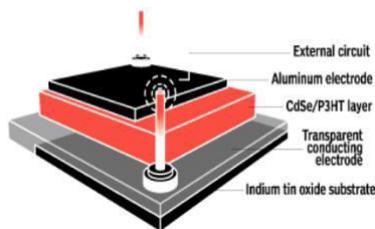


Fig 4: Structure of plastic solar cell

VII. APPLICATIONS OF IR PSC

1. Silicon possesses some nanoscale properties. This is being exploited in the development of a super thin disposable solar panel poster which could offer the rural dwellers a cheap and an alternative source of power. Most people living in remote areas are not linked to national electricity grid and use batteries or run their own generator to supply their power needs. Disposable solar panels can be made in thin sheets with about 6-10 sheets stacked together and made into a poster can help them to some extent in this regard. This poster could be mounted behind a window or attached to a cabinet.
2. Like paint the compound can also be sprayed onto other materials and used as portable electricity.
3. Any chip coated in the material could power cell phone or other wireless devices.
4. A hydrogen powered car painted with the film could potentially convert energy into electricity to continually recharge the car's battery.
5. Solar farms consisting of plastic materials could be rolled across deserts to generate enough solar energy to supply the entire planet's power needs.

VIII. ADVANTAGES AND LIMITATIONS OF PSC

ADVANTAGES:

1. They are considered to be 30% more efficient when compared to conventional solar cells.
2. They are more efficient and more practical in application.
3. Traditional solar cells are bulky panels. This is very compact.
4. Conventional solar cells are only used for large applications with big budgets. But the plastic solar cells are feasible as they can be even sewn into fabric- thus having vast applications.
5. Flexible, roller processed solar cells have the potential to turn the sun's power into a clean, green, consistent source of energy.

DISADVANTAGES:

1. The biggest problem with this is cost effectiveness. But that could change with new material. But chemists have found a way to make cheap plastic solar cells flexible enough to paint onto any surface and potentially able to provide electricity for wearable electronics or other low power devices.
2. Relatively shorter life span when continuously exposed to sunlight.
3. Could possibly require higher maintenance and constant monitoring.

IX. CONCLUSION

Plastic solar cells help in exploiting the Infrared radiation from the solar energy. They are more effective when compared to the conventional solar cell. The major advantage is that they can even work on cloudy days, which is not possible in the former. They are more compact and less bulky. Though at present, cost is a major drawback, it is bound to be solved in the near future.

As explained earlier, if the solar farms can become a reality, it could possibly solve the problem of depending too much on the fossil fuels, without a chance of even polluting the environment.

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