Design & Simulation of Infrared Plastic Solar Cells

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Abstract

Photovoltaic electricity is considered as an alternative to the actual ways of producing electricity for its different advantages. Its friendly impact on the environment and projected low cost makes it an attractive substitute. The plastic photovoltaic technology has been developing in recent years with a need to improve yield efficiency to end-up taking an important place in the world market. Different plastic photovoltaic solar cells have been fabricated recently using a variety of designs including small molecules, polymers or hybrid materials Device design and deposition conditions of a-Si/a-SiGe/a-SiGe triple-junction solar cells were studied. To optimize their device structure, we applied several technologies such as a-Si0:H window p-layer for top cell, low temperature deposited pc-Si p-layer for middle bottom cells and hydrogen-dilution technique for a Si Ge: H i-layers. As a result, we obtained l cm^2 cell with 11 % stabilized efficiency. We found out effective deposition parameters such as increasing both hydrogen-dilution ratio and RF-power for Ge/Si > 0.5. In addition, we presented newly designed apparatus for the triple-junction 40cm x 80cm solar cells

Key words: **Renewable source of energy, infrared, nanotechnology, cost effective solution, etc.**

I. Introduction

The infrared plastic solar cells are promising candidates for low-cost renewable energy sources. Their power-conversion efficiencies can be greatly improved by incorporating specially designed photovoltaic material [1]. The plastic solar cells are made with layers of different materials, each with a specific function. One layer absorbs the light, another helps to generate the electricity, and others for taking electricity out of the device [2]. The photocurrent generation in the infrared plastic solar cell involves four steps: (i) Absorption of light by the primary layer, resulting in creation of charges, (ii) Disassociation of charges at the interface of donor/acceptor electrons and formation of free charges, (iii) Transport of the charges under an electric field, and (iv) Charge collection by electrodes [8]. As the layers don't stick well, and so the electricity ends up at the stuck and it becomes inconvenient to get out of the device, which leads to inefficient devices. A new process for printing plastic solar cells boosts the power generated by the flexible and cheap form of photovoltaic [1].

II. Infrared Plastic Solar Cell: Photovoltaic Material

The infrared plastic solar cell uses, the Nano rods which are derived from 1-(3-methoxycarbonyl) propyl-1-phenyl-[6,6] methanofullerene (PCMB) are mixed with plastic semiconductors called (P3HT) p3ht-poly-(3-hexylthiopene) which is transparent electrode coated with mixture. An aluminium coating acting as back electrode completes the device. Such infrared plastic solar cell have potential to have solar power conversion efficiency up to 5% [8].

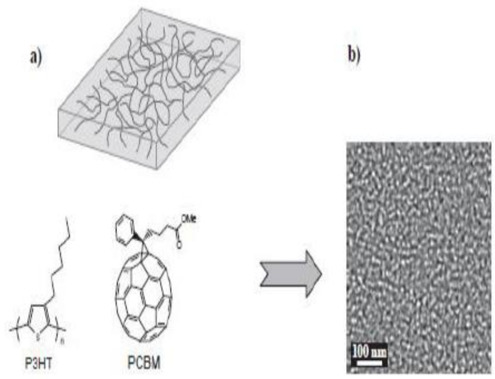

Figure 1: Combined Structure of P3HT and PCMB

Figure 1, shows the combined structure of P3HT and in which figure 1a) shows the black material is interconnected network of the fullerene (PCBM) and the white material is an interconnected network of a semiconducting polymer (P3HT). Each of these two components is fully interconnected. Figure1b) shows a 100 nm electron micrograph [4].

III. PLASTIC SOLAR CELL

The infrared plastic solar cells are, produced by printing technology. The technology to print plastic solar cells originated from a discovery made in laboratory at UC Santa Barbara in 1992 [1]. These solar cells become attractive for next generation photovoltaic due to their potential for low-cost roll-to-roll (R2R) processing on to a substrate. While the stability of polymer solar cells has been a concern in the past. The demonstration sample of a plastic solar cell was fabricated by a company called Konarka Technologies. The cells have passed critical lifetime aging tests according to IEC 61646; indicating device stability does not appear to an issue [9]. The principle of this old mature technology can be adapted to print solar cells roll-to-roll like newspapers. The potential impact of such printed 'plastic' solar cell on a market for solar technology could be tremendous.

IV. CHARGE FORMATION AND COLLECTION

In infrared plastic solar cell the charges are formed by potential interaction between semiconducting polymers and the fullerene molecules. The absorption of photon and electron transfer reaction (from polymer to fullerene) occurs on remarkably short time scale [6]. The rate of this photo induced electron is two orders of magnitude faster than the step in the photosynthesis. This ultra-fast electron transfer reaction implies to separate charges with quantum efficiency [1].

Material stated above, includes heterojunctions that is charge separating junctions between donor and acceptor material [4]. As demonstrated in figure 1). This remarkable nanostructure can be achieved through controlled phase separation of two incompatible components both are soluble in the same solvents [1]. This is so called heterojunctions material has charge separating junction everywhere. Each component forms a network that can deliver charges to electrode [5].

By using this bulk heterojunctions concept, the photo generated charge carriers are collected but how the electron will knows which way to go. This is simple question; all one need to do is the symmetry by using two different metals for electrodes [1]. Also controlling morphology of the heterojunctions material it is achievable that photo generated charge carriers are collected efficiently with power conversion efficiency up to 5% [5].

V. EFFICINIENCY IMPROVEMENT

The particular material shown in figure 1), which results in solar cell with 5% efficiency, has an absorption spectrum poorly matched to the solar spectrum. It is obvious to improve efficiency by applying proper science. Synthesizing new micro molecules with electronic structure that yields absorption spectra better matched to the solar spectrum as shown in figure 4) [4]. The improved conversion efficiency graph shows solar emission spectrum received on the earth at twelve noon on a sunny day by fluctuating black line and absorption spectrum of material by smooth grey line and improved conversion efficiency by dashed line, particularly at wavelengths beyond 650 nm. Wavelengths above 750 nm belong to the infrared spectrum [5].

Also improved performance is achieved using processing additives. Next one is to create multilayered system using printing technology, which further increases the performance of solar cell [7]. The multilayer is possible by processing multilayer from solution in successive deposition of electronic inks [2]. By using this structure more power can draw, through the device. As if we connect two batteries of voltages V1 and V2 are in series, then total voltage will equal to (V1+V2), so the open circuit voltage can be increased.

The figure 3) contains multilayered structure of plastic solar cells connected in series. The images on the left are electron micrographs of cross-section cut through multilayer structure, turned over then imaged by electron microscopy [6].

Although some improvements made in chare collection efficiency, further improvements can be done by optimizing nano-scale morphology of structure, by optimizing electrochemistry of semiconducting polymers [5]. In this way power conversion efficiency is improved by 25%, and the interesting thing is that all these efficiency improvements have been successfully implemented already. Which will enables major impacts on the future solar cell technology, and thus future energy system [1].

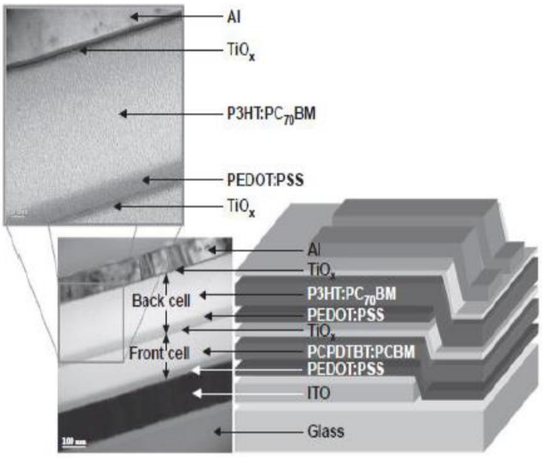

Figure 3: Multi-layer structure of plastic solar connected in series.

VI. LIFETIME OF INFRARED PLASTIC SOLAR CELL

As stated above the infrared plastic solar cell have passed a critical lifetime aging tests according to IEC 61646, and is achieved by using a very thin layer of titanium oxide. Although solar cells are less sensitive to water vapors and oxygen, it needs a barrier film as a protective layer [2]. With the help of this layer the overall sensitivity to oxygen and water vapors has been reduced by considerably. By using this inexpensive layer sensitivity to oxygen and water will sufficient to yield the long life time that are required [3]. Progress on a lifetime issues is a continuous process to improve the infrared solar cells. However the infrared plastic solar cell module that is on rooftop as shown in figure 6). This is for testing efficiency over a one year [1]. From observation it is found that the efficiency did not decrease; in fact a slight increase was recorded. In the course of November, the efficiency started to fall, but in turned out that the temperature coefficient of the efficiency is opposite to that of polymeric material. When winter came, efficiency decreased slightly, but it came up again in spring [7].

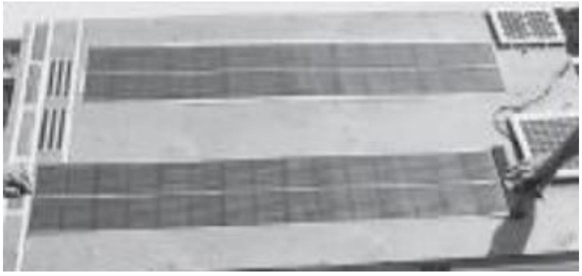

Figure 5: Infrared plastic solar cell on the rooftop

VII. CONCLUSION

Clearly, plastic solar cells have a very promising future as they are lightweight, portable, and can be produced quickly in large quantities. In addition, their flexibility makes plastic solar cells useful not only for standard areas such as rooftops but also for a vast number of new applications such as tent and umbrella surfaces, backpacks, or sails. In terms of efficiency of plastic solar cells, efforts are being made to achieve impressive figures of merit. Among the plastic and standard solar cells in terms of watts per gram, plastic solar cells are more competitive. If a roll-to-roll manufacturing of plastic solar cells is achieved, then with such a mass production, plastic solar cells becomes more cost effective and can become a very important contribution on the path towards a renewable energy system.

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