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A MILESTONE IN SOLAR CELLS: ORGANIC SOLAR CELL

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ABSTRACT

Organic solar cells are mostly flexible and lightweight—a good solution to low cost energy production, which can have a manufacturing advantages over inorganic solar cell materials. An organic solar cell uses organic electronics, which deals with conducting polymers or small organic molecules. In 1959, Kallamann and Pope reported a photovoltaic effect in a single crystal of anthracene which was sandwiched between two similar electrodes and illuminated from one side. But they could not explain the phenomenon completely

Keywords : Organic Electronics, Photovoltaic Effect, Illuminated etc.

I. INTRODUCTION

The first organic solar cell was reported by Tang in 1986, with a power conversion efficiency of 1 per -cent (Tang *etal*.). The simple working principle for photovoltaic devices is that of ‘light in and current out’ which can be analyzed by seven processes: photon absorption, excitation formation and migration, exciton dissociation, charge transport and charge collection at the electrode. The structure of an organic solar cell is very simple. A setup with one photoactive material and electrodes constructed at top and bottom can show a photovoltaic current. In Figure 1, the organic solar cell consists of a photoactive layer composed of two different materials: donor and acceptor. Here the conducting glass acts as an anode and the metal acts as a cathode. The donor and acceptor material has two energy levels one is the Highest Occupied Molecular Orbital (HOMO) and the other is the Lowest Unoccupied Molecular Orbital (LUMO) and the energy gap between these two layers is the band gap.

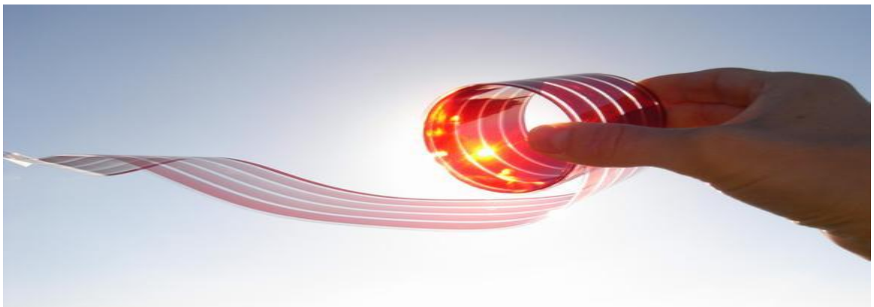

Fig.1 Organic Solar Cell

There are fundamental differences between an inorganic semiconductor and organic semiconductor. The most obvious difference is that in an inorganic semiconductors the free charge carriers, electrons and holes are created directly upon light absorption, while electro-statically bound charge carriers, excitations are formed in organic semiconductor. The dielectric constant of organic semiconductors is low as compared to inorganic semiconductors. The other primary difference is the small Bohr radius of carriers in organic semiconductors as compared to inorganic semiconductors. An organic semiconductor has simpler processing at lower temperatures (20-200oC) than an inorganic cell, like Si (400-1400oC). The advantage of organic solar cells over electrochemical cells is the absence of a liquid electrolyte. The thickness of the active layer of organic solar cells is only 100 nm thin, which is 1000 times thinner than Si-solar cells and 10 times thinner than inorganic thin film solar cell. So, organic solar cells have potential for low cost and large area application. These can be deposited on a flexible substrate and the material can be tailored according to the demand.

II. CHALLENGES FOR IMPROVEMENT

There are three issues that one needs to overcome in developing organic solar cells. Firstly, in terms of the crucial efficiency value, organic solar cells are still inferior to all inorganic counterparts. The second issue is device stability under ambient operating condition while the third is processing technologies for mass production.

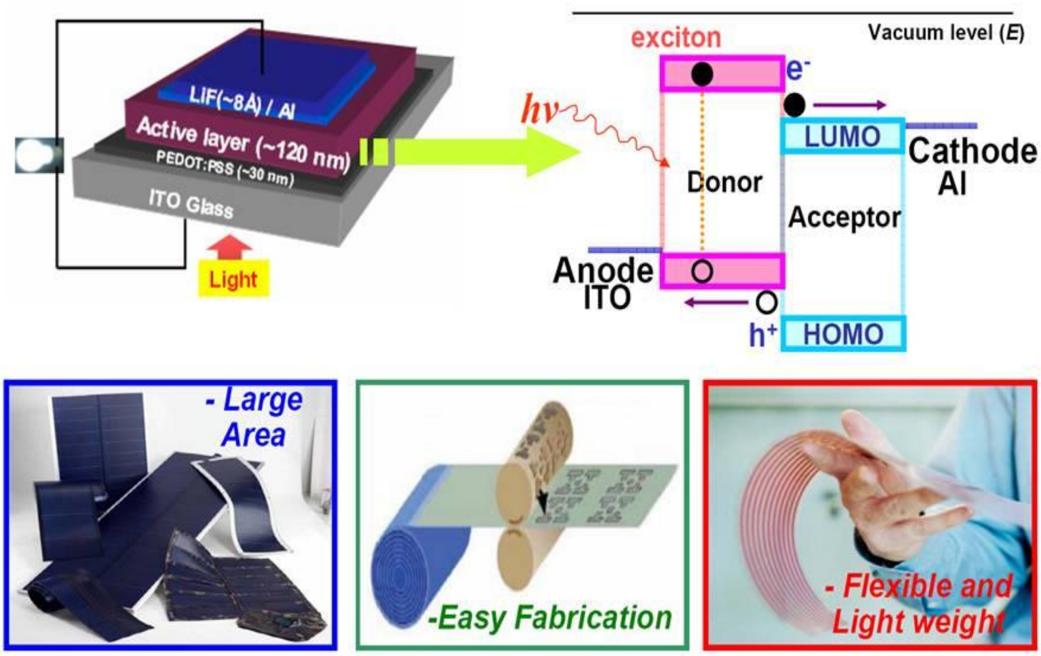

Fig .2 Typical Mechanism of Organic Solar Cell

III. INCREASING THE EFFICIENCY

The available conjugated polymers for organic solar cell are of band gaps ≥2 electron volt (eV). Hence there is a clear mismatch between the absorption spectrum of the materials and the solar spectrum, which extends into the near infrared. By introducing low band gap materials the solar photon harvesting can be increased.

Recently, Sheng *et al*. reported a process of synthesis of poly 3 hexyl thiophene (P3HT) with low band gap which can increase the efficiency up to 17 percent (Fig.2). They incorporate 1 weight percent P3HT into the PCPDTBT/PC61BM system to make a ternary active layer to enhance the power conversion efficiency. P3HT can improve the phase separation of the active layer and also increase the light harvesting into the 400 to 500 nanometres (nm) range. To achieve high quantum efficiency, all photo-generated excitons have to reach and dissociate at a donor-acceptor and subsequently all created charges have to reach the respective electrodes. The two main approaches can be identified as either modification of the photoactive layer itself or introduction of transport or blocking layers for an improvement of the contacts. Recently Ju Min Lee *et al.* reported carbon nano tube hybrid material as a layer for exciton dissociation and charge transport enhancement and the quantum efficiency was reported as 8 per cent. They proposed that it can increase the diffusion length of the material. So the charge transport can be easily done without losing the electron by recombination. Chien Jung Huang *et al*. reported that the buffer layer in the organic solar cell can improve the efficiency of the cell by increasing the ability of electron transfer. A buffer layer is the layer between the electrode and photoactive layer, which can be applied in both sides in anode or in cathode side. By using this layer the charge transport can be easily done.

IV. STABILITY OF THE DEVICE

Although the efficiency reached has been 10 percent, the stability has not been so good. Scientists are trying to improve the performance in terms of power conversion efficiency and operational stability for organic solar cells and are rapidly approaching the key 10-10 targets (10 percent efficiency and 10 years of stability). Organic solar cells get degraded very fast. The materials used in organic solar cell are very sensitive to oxygen and moisture. Maxim *et al.* reported that water is the primary species to degrade the solar cell. So the encapsulation of the cell should be such that the oxygen and moisture should not come in contact directly with the materials of the solar cell. The research in the encapsulation of solar cell and the actual reason of degradation needs to be studied in detail. An ideal solution is to search for stable materials that are less sensitive to oxygen and moisture.

Fig.3 P30T-PCBM Organic Solar Cell Deposited On ITO Glass

V. PROCESSING TECHNOLOGIES FOR MASS PRODUCTION

There are different types of fabrication techniques: printing and casting methods, a roll-to-roll technique, and other film formation techniques. Usually techniques used for fabrication of organic solar cell are spin coating, doctor blade coating, casting, spraying, knife over edge coating, meniscus coating, curtain coating, screen printing, inkjet printing, flexographic casting etc. The techniques that have been suited for fabrication in small substrates are spin coating, doctor blading and casting. The problem is that in terms of industrial production these processes are not cost effective. So, people are trying to find a way to improve both the economic and technical aspects of energy production. Roar *et al.* reported that roll to roll fabrication of a solar cell is a possible way of industrial production of organic solar cells—a low cost technique which doesn't compromise efficiency.

VI. RECENT RESEARCHES

Flexible solar cells : The currently developed low-cost, light weight and flexible solar cell, from the Massachusetts Institute of Technology, based on sheets of flexible graphene coated with a layer of nanowires can transform the light of the sun for an onsite source of power.

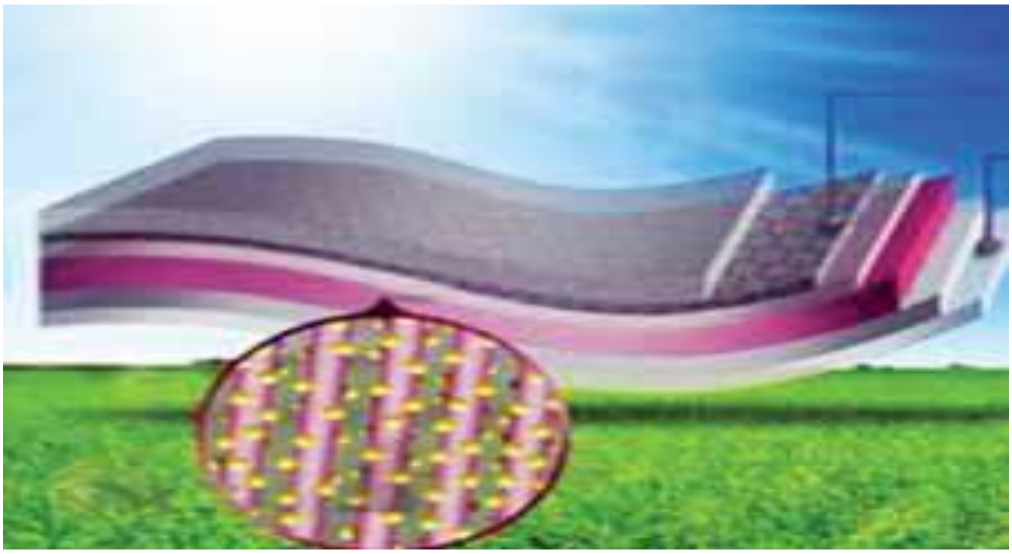

Fig.4 Flexible Solar Cells

llustration shows the layered structure of the new device, starting with a flexible layer of graphene, a one-atom-thick carbon material. A layer of polymer is bonded to that, and then a layer of zinc-oxide nanowires (shown in magenta), and finally a layer of a material that can extract energy from sunlight, such as quantum dots or a polymer-based material. Low cost, light-weight and flexible solar cells are envisaged for the next generation construction materials known as building integrated PVs windows, roofs and facades that could transform the light of the sun for an on-site source of power. Now, researchers from the Massachusetts Institute of Technology have come up with a new solar cell that could fulfi l these three requirements and has an added benefit of being transparent. The new cell is based on sheets of flexible graphene coated with a layer of nanowires. According to associate professor of materials science and engineering, Silvija Gradečak,building semiconducting nanostructures on a graphene surface without impairing its electrical and structural properties is a challenge. To overcome this, the team used a series of polymer coatings to allow the graphene to bond a layer of zinc oxide nanowires. They then overlayed a material that responded to light waves. The team also used and tested a series of overlay materials in their devices– including lead-sulfide quantum dots and a polymer calle P3HT. They achieved the best result with the quantum dots, getting a efficiency of 4.2 percent. Currently only proof-ofconcept devices about a half-inch in size have been demonstrated. Even so, Gradečak and her colleagues believe that the manufacturing process is highly scalable and larger commercial sized devices based on these cells will be developed within a couple of year.

VII. CONCLUSION

The ultimate goal of energy production is that it should be environment friendly, cost effective and user responsive. The organic solar cell is a promising way to meet all these three requirements. It can be used in large areas and also for small ranges, in flexible substrates. But it needs more time and research to gain a respectable position with respect to silicon or other inorganic materials. Then, perhaps, a day may arrive when we can produce electricity for ourselves by just wearing a T-shirt.

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