PLASTIC SOLAR CELLS:IMPLEMENTATION OF NANOROD AND SCREEN PRINTING TECHNOLOGY

Abstract:

Energy is the key input to drive the improve the life cycle. The consumption of the energy is directly proportional to the progress of the mankind with ever growing population, improvement in the living standard of the humanity, industrialization of the developing countries like India . The global demand for energy is increasing on alarming rate. The primary source of energy is fossil fuel (like coal, diesel), which are decreasing day by day due to move energy demand and there is global warming problem due to these sources. So, we need non-conventional energy sources to full fill the demand of energy.

Recent improvements in the power conversion efficiencies of organic solar cells have brough-renewed attention to possibility of practical large-scale use of these devices. This paper deals with basic principal of operation of plastic solar cells and we demonstrate the implementation of the nanorad and screen-printing technology in the fabrication of organic-based bulk heterojunction solar cells.

Keywords: *Energy, consumption, Humanity, indutrialisation, alaram ink, fossil fuel, warming, non conventional energy,nanorad, heterojunction,screen-printing technology*

Conclusion: Harnessing of Non-Conventional energies is a human necessity. At the same time the solar energy at present we are tapping with the silicon cells. These cells at present they have not yet reached the economical feasibility. Hence the concept and developing a plastic solar cell would account to the economical feasibility and mass usage.

Introduction:

With the ever-increasing demand of electrical energy every one is looking towards Sun as a source of electrical energy along with its role as an important source of thermal energy. At the heart of all photovoltaic devices are two separate layers of materials, one with an abundance of electrons those functions as a "negative pole," and one with an abundance of electron holes (vacant, positively-charged energy spaces) that functions as a "positive pole". When photons from the sun or some other light source are absorbed, their energy is transferred to the extra electrons in the negative pole, causing them to flow to the positive pole and creating new holes that start flowing to the negative pole, thus producing electrical current which can then be used to power other devices. Conventional semiconductor solar cells are made of polycrystalline silicon or, in the case of the highest efficiency ones, crystalline gallium arsenide. The use of these devices has been limited to date because production costs are so high. Even the fabrication of the simplest semiconductor cell is a complex process that has to take place under exactly controlled conditions, such as high vacuum and temperatures between 400 to 1,400 degrees Celsius. Normal solar panels are rigid (shown in Figure 1), expensive, and their size is constrained by manufacturing techniques thus, limits their scalability to large area panels.

(CNN)

Figure 1

The group's first crude solar cells have achieved efficiencies of 1.7 percent, far less than the 10 percent efficiencies of today's standard commercial photovoltaic. The best solar cells, which are very expensive semiconductor laminates, convert, at most, 35 percent of the sun's energy into electricity.

Typical module efficiencies for commercially available screen-printed multi crystalline solar cells are around 12%.

Plastic solar cells

Polymers offer the advantage of solution processing at room temperature, which is cheaper and allows for using fully flexible substrates, such as plastics. Thus, replacing the silicon with polymer nanowires would make the solar cell much lighter, and eventually cheaper. The technology takes advantage of recent advances in nanotechnology, specifically the production of nanocrystals and nanorods as shown in Figure 2. These are chemically pure clusters of 100 to 100,000 atoms with dimensions on the order of a nanometer, or a billionth of a meter.

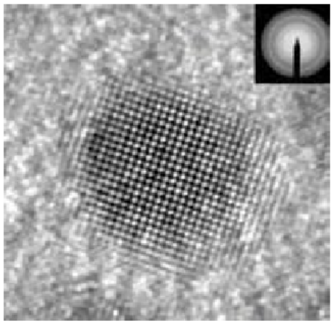

Figure 2

Because of their small size, they exhibit unusual and interesting properties governed by quantum mechanics, such as the absorption of different colors of light depending upon their size. We can manufacture nanorods in a beaker containing cadmium selenide, aiming for rods of a diameter - 7 nanometers – to absorb as much sunlight as possible. They also aim for nanorods as long as possible - in this case, 60 nanometers. It will play an important role in developing an improved polymer solar cell using nanomaterial additives by combining nanotechnology with plastic electronics.

Designing of plastic solar cells

Nanorod/polymer technology:

The plastic solar cell designed is actually a hybrid, comprised of tiny nanorods dispersed in an organic polymer or plastic. Figure 3 shows a schematic diagram of a hybrid "plastic" solar cell with a nanorod/polymer layer sandwiched between two electrodes.

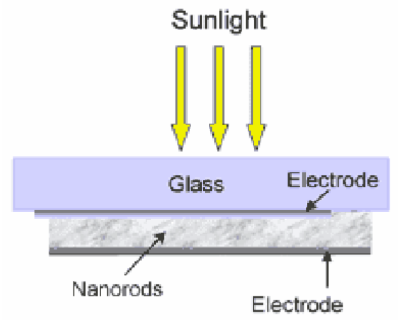

Figure 3: Schematic diagram of a hybrid "plastic" solar cell with a nanorod/polymer layer sandwiched between two electrodes. The middle layer, a mere 200 nanometers thick, is a jumble of nanorods embedded in the semi-conducting polymer.

Figure 4: A panel of eight plastic solar cells based on inorganic nanorods and semi conducting polymers. The shiny ovals are the aluminum back electrodes of the individual solar cells.

The middle layer, a mere 200 nanometers thick, is a jumble of nanorods embedded in the semi conducting polymer. Nanorods are mixed with a plastic semiconductor, called P3HT - poly- (3-hexylthiophene) - and coated a transparent electrode with the mixture. The thickness, 200 nanometers - a thousandth the thickness of a human hair - is a factor of 10 less than the micron-thickness of semiconductor solar cells. When nanorods 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 the aluminum electrode collects it. Thus, an aluminum coating as shown in figure 4 acting as the back electrode complete the device. The hole is transferred to the plastic, which is known as a hole-carrier, and conveyed to the electrode, creating a current.

The electrode layers and nanorod/polymer layers could be applied in separate coats, making production fairly easy. Further, using rod-shaped nano-crystals rather than spheres provided a directed path for electron transport help to improve solar cell performance. These types of hybrid solar cells are reported to achieve a monochromatic power conversion efficiency of 6.9 percent, one of the highest ever reported for a plastic photovoltaic device.

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Screen-printing technology:

Screen-printing is a commonly used industrial technique for fast, inexpensive deposition of dye films over large areas. From this standpoint, it is an ideal technology for large-scale fabrication of polymer-based solar cells. In addition, screen-printing allows patterning to easily define which areas of the substrate receive deposition. This is important, for instance, for fabricating a photovoltaic device that is integrated onto a substrate containing other electronic devices. Also, in the production of a large area energy collection system, it is necessary to fabricate many individual solar cells that are wired together. Using screen printing, individual’s devices can easily be defined on the same substrate in order to optimize the power generation of the entire system. In industrial processes, films fabricated with screen printing usually have a thickness greater than 0.5 mm. The use of screen-printing to fabricate a polymer layer with a thickness less than 100 nm, serving as the whole transport layer in an organic light-emitting diode has been recently demonstrated. However, in this case, the printed films were not smooth and the screen footprint was visible to the naked eye. Here, we use screen printing to deposit an ultra thin and smooth active layer in a bulk heterojunction photovoltaic device, consisting of a conjugated polymer/fullerene blend, with a thickness of 40 nm and root-mean-square (rms) surface roughness of 2.6 nm.

This device yields a power conversion efficiency of 4.3% when illuminated by monochromatic light with a wavelength of 488 nm.

The structure of the bulk-heterojunction solar cell is shown in Fig. 5(a). The principles of operation of this device are described elsewhere1, A 150 nm thick film of poly- (ethylene dioxythiophene) doped with polystyrene sulphonic acid [(PEDOT: PSS), Bayer AG] was first spin cast from a water solution onto an indium tin oxide (ITO)/glass substrate, where the ITO has a thickness of 120 nm (about 40 V/square) and 85%–90% transmission in the visible range. The PEDOT: PSS layer was then dried in vacuum for 3 h at 140 °C. The active layer, consisting of a blend of the conjugated polymer [poly (2-methoxy-5-(3,7dimethyloctyloxy) - 1, 4-phenylene vinylene)] (MDMO-PPV) and the methanofullerene ([6, 6]-phenyl C61-butyric acid methyl ester) (1:4 by Weight (PCBM) was then deposited onto the PEDOT: PSS layer from a chlorobenzene solution using the screen printing technique. The average thickness of the active layer was 40 nm. A description of the screen printing process, depicted in Fig. 5(b) follows. During deposition, the screen is placed a few millimeters above the surface of the substrate. Upon loading the polymer solution onto the screen, a rubber "squeegee" is then swept with a velocity of several centimeters per second across the surface of the screen, momentarily contacting it to the substrate. At this point, solution flows from the screen to the surface of the substrate. As the squeegee then passes over a region, the screen separates from the substrate, leaving behind solution that dries to yield a continuous film. For this study, a screen with a thread diameter of 30 mm and a mesh count of 181/cm was used. For the cathode, a 130 nm thick film of aluminum was thermally deposited onto the active layer through a shadow mask to define an active device area of 0.12 cm2. The aluminum was deposited in a high vacuum at 0.2–0.7 nm/s from a thermal source under an operating pressure of 1026 Torr. For characterization, the device was illuminated with the 488 nm line of

An argon laser with an intensity of 27 mW/cm2. The temperature of the device during characterization, performed in an inert environment, was approximately 25 °C.

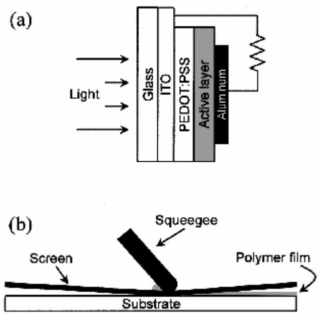

Fig. 5. Schematic diagrams of (a) the device structure of the bulk heterojunction solar cell connected to an external resistive load and (b) the screen-printing technique.

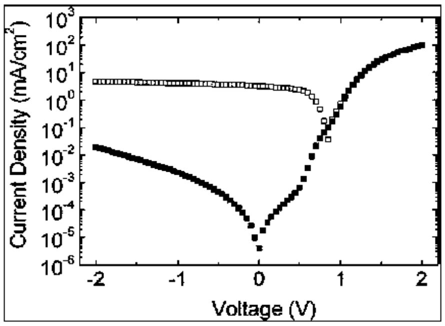

Fig. 6. Plot of the current density (absolute value) versus voltage for the solar cell operated in the dark (filled squares) and under illumination (hollow squares) by monochromatic light with a wavelength of 488 nm and an intensity of 27 mW/cm2. The short-circuit current, open-circuit voltage; fill factor, and power conversion efficiency are 3.16 mA/cm2, 841 mV, 0.44, and 4.3%, respectively. The temperature of the device during measurement was approximately 25 °C.

The current density–voltage characteristics of the device under illumination and in the dark are shown in Fig. 6. The rectification of the device in the dark is approximately 5000 at 1/22 V. This indicates a good diode behavior and a high shunt (parallel) resistance as a result of conformal coverage of the PEDOT: PSS layer by the screen printed MDMOPPV: PCBM active layer. Under illumination, the short circuit current density is 3.16 mA/cm2, which corresponds to external quantum efficiency (incident photons to converted electrons) of 30%. The open-circuit voltage and fill factor are 841 mV and 0.44, respectively, and the resulting power conversion efficiency is 4.3%. The external quantum efficiency of the device is limited by the optical absorption of the 40 nm thick active layer. By comparing the amount of light reflected from the device compared to the amount of light reflected from a glass/ITO/PEDOT: PSS/aluminum reference sample, the optical absorption of the active layer was measured to be approximately 33%. Thus, the internal quantum efficiency (absorbed photons to converted electrons) of the device under short-circuit conditions is approximately 90% at an incident wavelength of 488 nm.

In summary, the screen printing technique has been used to deposit the active layer in a bulk heterojunction “plastic” solar cell. The power conversion efficiency of the device was 4.3% under monochromatic illumination. We expect that the power conversion efficiency will be improved as the film thickness is increased and interfaces are modified. These results illustrate that screen printing can be a powerful technique for the fast, inexpensive fabrication of roll-to-roll polymer optoelectronic devices while retaining nanometer-scale control of the film thickness. The application of this technique to the fabrication of an organic solar cell further increases the strong potential that these devices have for practical use.

Applications

- Plastic formulations also open the possibility of printing solar cells onto various surfaces, much as ink is printed on a newspaper.
- Lightweight and flexible plastic solar cell painted on the back of it could power portable electronics equipments like PDAS, laptops and pocket calculators etc. anywhere we can access solar energy.
- The new cells also open up possibilities for wearable computing devices.
- Functions of plastic solar cell similar in visible region are needed in the infrared region for many imaging applications in the medical field and for fiber optic communications.
- Ultra high efficient plastic solar cells are expected to work well in low-light conditions and under artificial light along with the increased wavelength region.
- A big attraction of dye-based PVs. is that they can be colored and even patterned to resemble normal roofing material or military camouflage. The US military appears to agree, having already placed orders for PV material as part of on-going development programmers with army, navy, air-force and Marine Corps.