

Plastic Solar Cell Technology

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Abstract- *This paper represents a review on recent developments in PLASTIC SOLAR CELL TECHNOLOGY. Solar cells that are primarily of the conventional type. Photovoltaic (PV) cells are comprised of unique materials called semiconductors, the most common of which being silicon. When light strikes the cell, some of it is absorbed by the semiconductor material. This indicates that the absorbed light's energy is transmitted to the semiconductor. Electrons are knocked loose and allowed to move freely as a result of the energy. In addition, all PV cells feature one or more electric fields that act to push electrons released by light absorption to travel in a specific direction. We can pull this current off the top and bottom of the PV cell and use it externally by installing metal contacts on the top and bottom of the cell.*

For example, the current can power a calculator. This current, together with the cells voltage (which is a result of its built-in electric field or fields), defines the power that the solar cell can produce. Conventional solar cells are made up of polycrystalline silicon or in the case of high efficiency one's crystalline gallium arsenide. However, it has been discovered that only 35% of the sun's total energy falling on it can be used wisely by this form of solar cell. Additionally, this is unfavourable in foggy days, posing a dilemma. This fundamental flaw prompted researchers to consider developing a new form of solar cell that incorporates nanotechnology. This involves a technique that is nearly identical to the one described previously. But the basic difference lies in the absorption of the wavelength of the light from sun.

Indexed Terms- Photovoltaic, Solar cell.

I. INTRODUCTION

Solar cells use freely available daytime to make energy. At the present time, Solar energy is currently not inexpensive, due to the fact that solar panels are very costly. Now don't forget that we might also additionally need to reduce fees with the useful resource of the use of printing solar panels like we print newspapers! We can do in reality that with plastic solar cells. In this newspaper, we deliver a reason of the primary running mind of those novel plastic solar cells after which display how a cute threefold increase in solar power typical overall performance may be completed with the beneficial aid of the usage of along a totally specific additive to the printing solar cells. The function of this kind of specific additive seems almost magical, but as scientists, we understand that right magic is really unusual and we clearly had to find out why and the manner it works. That has become the problem of our modern investigations and in this article, we describe how we divulged the call of the game of the specific additive.

II. CHEAP SOLAR ELECTRICITY

While you're studying this article, your laptop is the usage of energy. Where does this electricity come from? In 2013, around 67% of the energy used with inside the U.S. turned into generated with the aid of using burning coal or herbal fuel line [1]. What if the delivery of coal and herbal fuel line runs out? And what approximately the pollutants and weather extrude as a result of burning fuel line and coal? There is a far friendly supply of electricity: the solar! Best of all, it is free! The solar usually shines and presents electricity to the earth with inside the shape of mild, even on cloudy days. Solar panels convert this mild into energy, however, solar panels are nevertheless quite expensive. If solar panels had been much less

expensive, we should use the solar to its complete ability and feature very reasonably-priced energy!

III. PRINTING PLASTIC SOLAR CELLS

Scientists currently discovered a brand-new manner to make solar panels through printing them! Most people think about printing things like books, but we can also use a special kind of printer to print objects made out of plastics. Plastics are made of polymers, which are very long molecules. Under a totally robust microscope, polymers seem like cooked spaghetti, but, in fact, they may be 1,000,000 instances smaller. To print plastics, you simply replace the ink cartridge in your printer at home with “plastic ink.” Plastic ink is a combination of two polymers dissolved in a liquid. When printed, the liquid dries and the two polymers form a thin film. For solar cells, we use a unique sort of polymer that can convert daylight into electricity.

Plastic solar cells may be revealed on massive rolls of bendy foil. Recently, a hundred m-lengthy solar panels had been revealed [2]. Using those reasonably-priced solar panels, most effective round 1.5% of the electricity with inside the daylight is transformed to electricity. This efficiency is still low compared to the expensive solar panels you can buy now, which can convert 15–20% of the sun’s energy into electricity. But destiny seems bright. In laboratories around the world, small plastic solar cells are already being made with much higher efficiencies, up to about 12% [3].

One of the tricks to increase efficiency is adding a special additive to the plastic ink before printing. This unique additive changed into determined with the aid of using an accident [4], however, if we need to enhance the performance of the plastic solar panels even similarly, we want to recognize why this unique additive works.

Understanding how plastic solar cells work is not easy. Many scientists have worked on this topic for years. As background, we provide an explanation for the maximum essential findings with inside the subsequent paragraphs, however in case you sense which you are greater keen to find out about the secrets and techniques of the unique additive you may bypass those paragraphs and study approximately our investigations and our effects similarly on. Plastic

solar cells consist of a plastic layer on glass or a flexible foil. In the lab, we use glass plates with an obvious electric-powered contact [the positive (+) pole]. At the pinnacle of this contact, we positioned the ink for the energetic layer, which's the part of the sun molecular that converts daylight to electricity. This ink carries polymers, a protracted inexperienced one and a shorter pink one [5]. The polymers shape a combined layer, as proven in Figure 1. On pinnacle of that layer, we positioned a steel layer, which capabilities because the negative (–) pole. We then flip the complete stack of layers the other way up such that daylight can shine via the glass into the energetic layer.

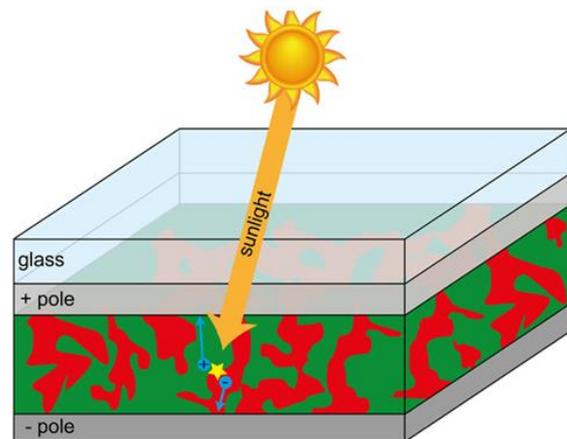


Fig - Diagram of a plastic solar cell. Sunlight creates a plus (+) and a minus (–) charge at the interface between two polymers. The (–) charge moves to the (–) pole of the solar cell and the (+) charge to the (+) pole. These poles work just like those in a battery, but are powered by the sun and never run out as long as the sun shines.

The drawn shape of red and green polymers in Figure 1 is precisely what we want! There is a lot of interface, or area of contact, between the two polymers. This is necessary because sunlight creates electrical charges only at the areas where the two polymers are in contact. When the mild is absorbed (the yellow star), high-quality (+) and poor (–) electric costs are generated. Normally, the + and – entice every different and the power is lost. In plastic solar cells, the pink and inexperienced polymers make certain the costs may be separated. The high-quality and poor costs then pass to the + and – poles. Now, light is converted to moving charges, which is electricity! Think approximately how beneficial this is – we use unfastened daylight and

reasonably-priced plastics to make electric energy! The green and red polymers are so small that we cannot see them easily, even when using a normal microscope. But we can see them with an electron microscope. But we can see them with an electron microscope, which does not use light, but electrons to “look” at the solar cells. In Figure 2, we display electron microscopic photos of actual plastic solar cells. These are photos searching down at the lively layer [6]. The two polymers show up as dark and bright areas and not as red and green because electrons are “colour-blind.” On the left, a poorly working plastic solar cell is shown. The massive droplets create a totally little interface and the performance is low: 1.5%. On the right, a far higher plastic sun molecular is shown. The structure between dark and bright areas is now so small that it is actually hard to see, but it means that there is a lot of interfaces [7]. This lets in for extra costs to be made and triples the performance to over 5%. These solar cells are nonetheless now no longer the best; however, they are able to assist us to apprehend how plastic sun cells work.

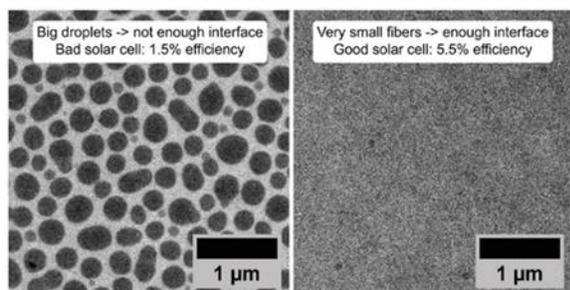
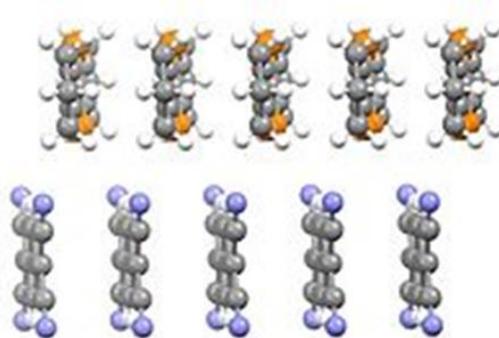


Fig - Top view microscopic image of a bad solar cell (left) and a good solar cell (right), taken with an electron microscope.

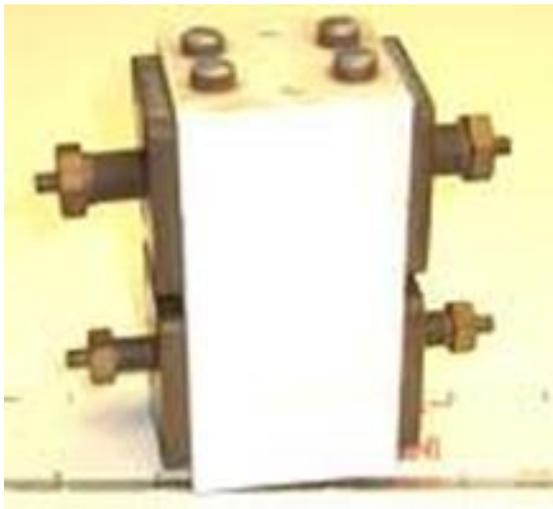
Remember that we're searching at very small things the duration of the size bar is one-millionth of a meter (approximately three millionth of a foot). The scale bar could match 100× with inside the width of a human hair! The huge droplets with inside the photo at the left have little interface among the 2 polymers, which's terrible for sun molecular efficiency [8]. The photo at the proper has very small fibers, which create a big interface among the 2 polymers, which is right for sun molecular efficiency.

IV. HISTORY



In 1862, acquired an in part conductive fabric with the aid of using anodic oxidation of sulfuric acid. The fabric becomes likely polyaniline. In the 1950s, researchers discovered that polycyclic aromatic compounds formed semi-conducting salts with halogens. In particular, excessive conductivity of 0.12 S/cm become mentioned in 1954. This locating indicated that natural compounds may want to bring current. The truth that natural semiconductors are, in principle, Insulators however turn out to be semiconducting whilst price companies are injected from the electrode(s) turned into found via way of means of Kallman and Pope. They found that a hole current can flow through a crystal contacted with a positively biased electrolyte containing iodine that can act as a hole injector. This painting became inspired via way of means of the sooner discovery via way of means of Akamatsuetal. That aromatic hydrocarbons become conductive when blended with molecular iodine because a charge-transfer complex is formed. Since it was readily realized that the crucial parameter that controls injection is the of the electrode, it turned into sincere to update the electrolyte with a strong metal or semiconducting touch with the correct painting function. When both electrons and holes are injected from opposite contacts, they can recombine radiatively and emit light. It became determined in natural crystals in 1965 via way of means of Sanoetal. In 1972, researchers observed steel conductivity withinside the charge-switch complicated TTF-TCNQ. In charge-transfer complexes were first reported in the (TMTSF)2PF6 in 1980. In 1973 Dr. produced the first device incorporating an organic semiconductor. This took place kind of 8 years earlier than the following such tool became created. The

bistable switch" currently is part of the chips collection.



In 1977, Shirakawa stated excessive conductivity in oxidized and iodine-doped polyacetylene. They acquired the 2000 Nobel prize in Chemistry for "The discovery and improvement of Similarly, exceptionally conductive polypyrrole turned into rediscovered in 1979. Rigid-spine natural semiconductors at the moment are used as energetic factors in gadgets along with (OLED), (OFET), electrochemical transistors, and lately in biosensing applications. Organic semiconductors have many advantages, such as easy fabrication, flexibility, and low cost. The discovery with the aid of using Kallman and Pope paved the manner for making use of natural solids as energetic factors in semiconducting digital gadgets, along with natural light-emitting diodes (OLEDs) that depend upon the recombination of electrons and hollow injected from "ohmic" electrodes, i.e. electrodes with an unlimited supply of charge carriers. The subsequent foremost step toward the technological exploitation of the phenomenon of electron and hollow injection right into a non-crystalline natural semiconductor become the paintings with the aid of using Tang and Van Slyke.

They confirmed that green electroluminescence may be generated in a vapor-deposited skinny amorphous bilayer of an aromatic diamine (TAPC) and Alq3 sandwiched amongst an indium-tin-oxide (ITO) anode and an Mg: Ag cathode. Another milestone towards the development of organic light-emitting diodes

(OLEDs) was the recognition that also conjugated polymers can be used as active materials. The efficiency of OLEDs was greatly improved when realizing that phosphorescent states (excitons) may be used for emission while doping a natural semiconductor matrix with a phosphorescent dye, including complexes of iridium with sturdy Work on the conductivity of anthracene crystals contacted with an electrolyte confirmed that optically excited dye molecules adsorbed on the floor of the crystal inject rate carriers. The underlying phenomenon is referred to as sensitized photoconductivity. It happens while photo-interesting a dye molecule with suitable oxidation/discount capability adsorbed on the floor or included withinside the bulk. This effect revolutionized electrophotography, which is the technological basis of today's office copying machines. It is also the basis of (OSCs), wherein the energetic detail is an electron donor, and an electron acceptor fabric is mixed in a bilayer or a bulk. Doping with sturdy electron donors or acceptors can render natural solids conductive even withinside the absence of light. Examples are doped and doped light-emitting diodes. Today organic semiconductors are used as active elements in (OLEDs).

V. TYPES OF HYBRID SOLAR CELL POLYMER-NANOPARTICLE COMPOSITE

Nanoparticles are a category of semiconductor substances whose length is as a minimum one measurement degrees from 1 to one hundred nanometers, at the order of exciton wavelengths. This length manipulate creates quantum confinement and lets in for the tuning of optoelectronic houses, which includes band hole and electron affinity. Nanoparticles actually have a massive floor vicinity to extent ratio, which gives greater vicinity for fee switch to occur.

The photoactive layer may be created by blending nanoparticles right into a polymer matrix. Solar gadgets primarily based totally on polymer-nanoparticle composites most bear a resemblance to polymer sun cells. In this case, the nanoparticles take the region of the fullerene primarily based totally acceptors utilized in completely natural polymer sun cells. Hybrid sun cells primarily based totally upon nanoparticles are a place of studies hobby due to the

fact nanoparticles have numerous shapes that might cause them to be better than fullerenes, which includes

- Fullerenes are synthesized with the aid of using a mixture of an excessive temperature arc technique and non-stop gas-segment synthesis, which makes their manufacturing tough and strength intensive. The colloidal synthesis of nanoparticles with the aid of using assessment is a low-temperature process.
- PCBM (a not unusual place fullerene acceptor) diffuses at some stage in lengthy timespans or whilst uncovered to heat, which could regulate the morphology and decrease the performance of a polymer solar cell. Limited trying out of nanoparticle sun cells suggests they'll be extra solid over time.
- Nanoparticles are extra absorbent than fullerenes, which means extra mild may be theoretically absorbed in a thinner device.
- Nanoparticle length can have an effect on absorption. This blended with the reality that there are numerous viable semiconducting nanoparticles lets in for exceptionally customizable bandgaps that may be without problems tuned to sure frequencies, which could be high-quality in tandem solar cells.
- Nanoparticles with lengths close to their Bohr radius can generate excitons whilst strike with the aid of using a sufficiently active photon.

VI. STRUCTURE AND PROCESSING

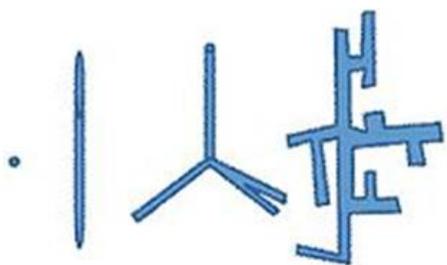


Fig. Four different structures of nanoparticles, which have at least 1 dimension in the 1–100 nm range, retaining quantum confinement. Left is a nanocrystal, next to it is nanorod, third is tetrapod, and right is hyperbranched.

For polymers used on this device, hole mobilities are more than electron mobilities, so the polymer

segment is used to move holes. The nanoparticles shipping electrons to the electrode. The interfacial place among the polymer segment and the nanoparticles wishes to be large. This is carried out via way of means of dispersing the debris in the course of the polymer matrix. However, However, the nanoparticles want to be interconnected to shape percolation networks for electron shipping, which takes location via the way of the approach of hopping events. Efficiency is tormented by issue ratio, geometry, and extent fraction of the nanoparticles. Nanoparticle systems consist of nanocrystals, nanorods, and hyperbranched systems.[3] Figure three consists of a photo of every structure. Different structures change the conversion overall performance thru manner of approach of affecting nanoparticle dispersion withinside the polymer and presenting pathways for electron shipping.

The nanoparticle segment is needed to offer a pathway for the electrons to attain the electrode. By the usage of nanorods in place of nanocrystals, the hopping occasion from one crystal to every other may be avoided. Fabrication strategies consist of blending the 2 substances in an answer and spin-coating it onto a substrate, and solvent evaporation (sol-gel). Most of those strategies do now no longer contain high-temperature processing. Annealing will increase order withinside the polymer segment, growing conductivity. However, annealing for too lengthy reasons the polymer area length to increase, finally making it large than the exciton diffusion length, and in all likelihood permitting a number of the steel from the touch to diffuse into the photoactive layer, decreasing the overall performance of the device.

VII. MATERIALS

Inorganic semiconductor nanoparticles utilized in hybrid cells encompass CdSe (length stages from 6–20 nm), ZnO, TiO₂, and PbS. Common polymers used as picture graph substances have significant conjugation and also are hydrophobic. Their performance as a picture graph-cloth is suffering from the HOMO stage role and the ionization potential, which at once influences the open-circuit voltage and the stableness in air. The maximum not unusual place polymers used are P3HT (poly (3-hexylthiophene)), and M3H-PPV (poly[2-methoxy, 5-(2'-ethyl-

hexyloxy)-p-phenylenevinylene)). P3HT has a bandgap of 2.1 eV and M3H-PPV has a bandgap of ~2.4 eV. These values correspond with the bandgap of CdSe, 2.10 eV. The electron affinity of CdSe stages from 4.4 to 4.7 eV. When the polymer used is MEH-PPV, which has an electron affinity of 3.0 eV, the distinction among the electron affinities is big sufficient to force electron switch from the CdSe to the polymer. CdSe additionally has excessive electron mobility ($600 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$)

VIII. PERFORMANCE VALUES

The maximum tested performance is 3.2%, primarily based totally upon a PCPDTBT polymer donor and CdSe nanoparticle acceptor. The tool exhibited a brief circuit modern of $10.1 \text{ mA} \cdot \text{cm}^{-2}$, an open circuit voltage of .sixty-eight V, and a fill element of .51.

IX. CHALLENGES

Hybrid solar cells need extended efficiencies and stability over time in advance than commercialization is feasible. In the evaluation of the 2.4% of the CdSe-PPV system, silicon photodevices have electricity conversion efficiencies extra than 20%.

Problems include controlling the amount of nanoparticle aggregation as the photo layer forms. The debris wants to be dispersed with a purpose to maximize interface vicinity however wants to mixture to shape networks for electron transport. Fabrication circumstances have an impact on network creation. Flow can be obstructed by dead quiet paths. Implementing ordered heterojunctions, where the structure is well regulated, is one feasible option.

The structures can vary morphologically over time, which is known as phase separation. Eventually, the polymer area length might be more than the provider diffusion length, which lowers performance.

Even eleven though the nanoparticle bandgap may be tuned, it desires to be matched with the corresponding polymer. The 2.0eV bandgap of CdSe is bigger than an excellent bandgap of 1.4for the absorbance of light. The nanoparticles worried are generally colloids, that is stabilized in answer with the aid of using ligands. The ligands lower tool performance due to the fact

they function insulators that hinder interplay among the donor and nanoparticle acceptor in addition to lowering the electron mobility. Some, however now no longer entire fulfillment has been had with the aid of using changing the preliminary ligands for pyridine or any other brief chain ligand.

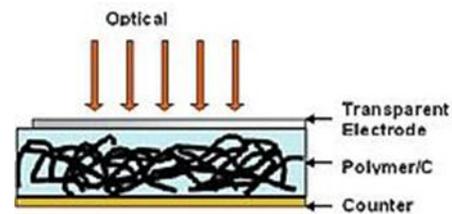
Hybrid solar cells show off fabric residences not as good as the ones of bulk silicon semiconductors. The service mobilities are a lot smaller than that of silicon. Electron mobility in silicon is $1000 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$, compared to $600 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ in CdSe, and less than $10 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ in other quantum dot materials. Hole mobility in MEH-PPV is $0.1 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$, while in silicon it is $450 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$.

X. CARBON NANOTUBES

Carbon nanotubes (CNTs) have excessive electron conductivity, excessive thermal conductivity, robustness, and flexibility. Field emission displays (FED), stress sensors, and subject impact transistors (FET) the usage of CNTs had been demonstrated. Each utility indicates the capability of CNTs for nanoscale gadgets and for bendy electronics packages. Photovoltaic packages have additionally been explored for this material.

Mainly, CNTs had been used as both the photo-brought on exciton service shipping medium impurity inside a polymer-primarily based totally photovoltaic layer or because of the photoactive (photon-electron conversion) layer. Metallic CNT is favored for the previous utility, at the same time as semiconducting CNT is favored for the latter.

XI. EFFICIENT CARRIER TRANSPORT MEDIUM

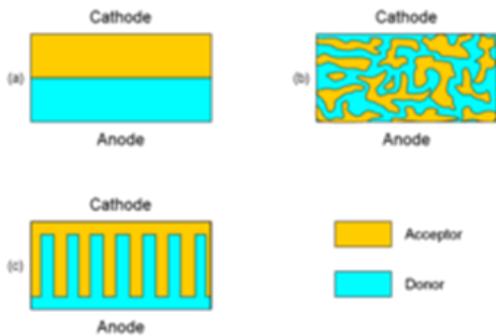


Device diagram for CNT as the efficient carrier transport medium.

To grow the photovoltaic efficiency, electron-accepting impurities need to be delivered to the photoactive region. By incorporating CNTs into the polymer, dissociation of the exciton pair may be carried out with the aid of using the CNT matrix. The excessive floor area (~1600 m²/g) of CNTs gives an excellent possibility for exciton dissociation. The separated vendors in the polymer-CNT matrix are transported with the aid of using the percolation pathways of adjoining CNTs, presenting the way for excessive service mobility and green rate switch. The elements of the overall performance of CNT-polymer hybrid photovoltaics are low as compared to the ones of inorganic photovoltaics. SWNT in P3OT semiconductor polymer proven open-circuit voltage (V_{oc}) of underneath 0.94V, with quick circuit current (I_{sc}) of 0.12 mA/cm².

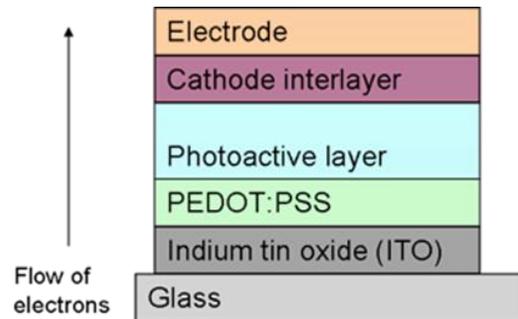
Metal nanoparticles can be implemented to the outdoors of CNTs to grow the exciton separation efficiency. The metallic offers a better electric-powered subject on the CNT-polymer interface, accelerating the exciton vendors to switch them extra successfully to the CNT matrix. In this case, V_{oc} = 0.3396 V and I_{sc} = 5.88 mA/cm². The fill component is 0.3876%, and the white mild conversion component 0.775%.

XII. STRUCTURE CONCLUSION



Three different schematic representations of blending electron donor and acceptor materials. Bilayer representation, with efficient charge generation but poor charge transport. Solution processed representation, in which rapid drying leads to a randomized network of acceptor/donor blending, currently the most optimal way to blend. Theoretical, ideal representation of acceptor/donor blending.

Materials utilized in polymer-primarily based totally photovoltaic cells are characterized via way of means of their general electron affinities and absorption power. Materials used in polymer-based photovoltaic cells are characterized by the electron-rich, donor materials tend to be conjugated polymers with relatively high absorption power, while the acceptor, in this case, is a fantastically symmetric fullerene molecule with a sturdy affinity for electrons, making, sure enough, electron mobility among the two.



The typical structural layout of photovoltaic devices. Transparent, conductive ITO is applied onto glass, and a hole transport layer of PEDOT: PSS (poly(3,4-ethylenedioxythiophene) poly (styrenesulfonate)) on top of that. The photoactive layer is a blend of electron acceptor and donor atoms, and the cathode interlayer is a low work function metal used to lower the work function of the electrode on top to accept electrons.

The arrangement of substances basically determines the general performance of the heterojunction solar cell. There are three donor-acceptor bulk morphologies the bilayer, the bulk heterojunction, and the “comb” structure. Typically, a polymer-fullerene bulk heterojunction solar cell has a layered structure.

XIII. FUNCTIONS/APPLICATIONS

The number one characteristic of a sun molecular is the conversion of mild electricity into electric electricity via the photovoltaic effect. In particular, polymer-fullerene bulk heterojunction sun cells are promising due to their capability in low processing fees and mechanical flexibility in assessment to traditional inorganic solar cells. Solution processing probably permits discounts in production fees thru display screen printing, health practitioner blading,

inkjet printing, and spray deposition at low temperatures. To conquer the slender spectral overlap of natural polymer absorption bands, Experiments have mixed conjugated polymer donors with immoderate electron affinity fullerene derivatives as acceptors to boom the spectral sensitivity. Ternary sun cells are a promising technique for elevated performance and mild harvesting houses of natural photovoltaic cells (OPV).

CONCLUSION

Plastic solar cells assist in exploiting the infrared radiation from the sun's rays. They are extra powerful while examine to the traditional solar cell. The most important benefit is they may even work the cloudy days, which isn't always viable with inside the former. They are extra compact and much less bulky.

Nowadays, it is able to likely resolve the planet's troubles of relying upon an excessive amount of fossil fuels, without a threat of even polluting the environment.

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