Tandem Structure for Organic Photovoltaic Solar Cells

Researchers from UCF have devised a three terminal organic tandem solar cell with aluminum doped zinc oxide (AZO) material layer as a common cathode, compatible with both rigid and flexible substrates.

While organic photovoltaic (OPV) solar cells offer low cost, light weight, ease of processing, and mechanical flexibility, they are hampered by inefficient charge carrier extraction, very low carrier mobility, and narrow absorption range. The efficiency of single-layer OPVs is still quite low and does not meet the 10% efficiency threshold required to commercialize such devices. This can be addressed by using a tandem structure, where two or more sub-cells with complementary absorption bands are stacked together, with the front cell consisting of the polymer with the wider bandgap and the back cell consisting of the polymer with the smaller bandgap. Since the overall open-circuit voltage (OCV) of the tandem cell is the sum of the OCVs of the individual sub-cells, the overall current is limited by any sub-cell with smaller current. As a result, to realize an efficient structure, the photocurrent of both sub-cells should match, or a charge buildup will take place at the intermediate layer, which will have a significant negative effect on the performance of the device.

Advantages
UCF researchers have designed a new three terminal parallel structure with AZO as a common cathode. This tandem structure for organic photovoltaic solar cells provides a highly transparent common cathode for the tandem cell and ensures a perfect insulation between the two sub-cells, so they can function independently. With the new structure, both sub-cells are expected to function more efficiently because of the presence of a hole blocking layer (HBL) and electron blocking layer (EBL), as well as the better control of the work function of the anode, through Ni-doping. This makes the structure universal, compatible with different bulk heterojunction sub-cells regardless of the conjugated polymer. This paves the road to a 10% efficiency device, which meets the requirements to commercialize OPVs.

Technical Details
This new technology from UCF consists of a back-to-back parallel tandem organic photovoltaic cell structure that includes a common cathode that separates two anodes within the parallel tandem organic photovoltaic cell structure. The presence of a very thin layer (approximately 1 nanometer) of a lithium fluoride material layer (LiF) provides ohmic contact for electrons from both of the back-to-back parallel tandem organic photovoltaic cell structures. Since the LiF is laminated to both sides of the AZO material layer, the lowest unoccupied molecular orbital of an active material layer within the OPV cell structure is about −4.0 eV. The nickel and tin doped indium oxide material layer (Ni-ITO) anodes include a nickel component that provides a work function in a range from at least about −5.0 eV to about −5.4 eV. By using a p-type NiO as a hole transport layer and an EBL for both sub-cells and an intrinsic ZnO (i-ZnO) layer as a HBL on the other side of the active layer, both layers are resistive to the formation of any short circuits/shunts. This design provides an enhanced hole extraction, with transfer and collection ability of the organic photovoltaic cell device with the Ni-ITO anode.

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Benefits
• Compatible with rigid or flexible substrates
• Enhanced hole extraction
• Increased shunt and short circuit resistance
• Universal structure

Applications
• Solar cells
• Photovoltaic cell arrays

Tech Fields
Clean Technologies, Semiconductors

Keywords
solar, photovoltaic, organic, tandem, OPV, HBL, EBL

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