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Performance improvement of inverted polymer solar cells

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Recently, the polymer solar cells have been popularly investigated due to their many advantages, such as low cost, light weight, and easy preparation on flexible substrates. The polymer solar cells investigated mostly is the P3HT:PCBM polymer solar cell, which typically has a structure of Al/LiF/P3HT:PCBM/PEDOT:PSS/ITO. Unfortunately, this kind of devices suffer from low stability and low efficiency. The drawbacks have been attributed to oxygen diffusion into the P3HT:PCBM active layer through the pinholes and the grain boundaries within the Al layer, which degrades the active layer, and the etching of the ITO anode by PEDOT:PSS hole transportation layer. To overcome these drawbacks, the inverted polymer solar cells were developed, where the Ag metal and the Al-doped ZnO (AZO) were utilized as the anode and electron transportation layer.

In this work, to improve the performance of the P3HT:PCBM inverted polymer solar cells, some technologies were developed. The AZO nanorod array and the ITO nanorod array were individually fabricated in the inverted polymer solar cells to increase the contact area between the AZO electron transportation layer and the active layer. That, consequently, improved the charge extraction efficiency and charge collection probability of the cells. For preparing these nanorod arrays, the combination technique of the laser interference photolithography method and the wet etching process was used. Since the performance of the cells was influenced by rod-length and array-period, various AZO rod-lengths and various ITO array-periods were used in the device fabrication to find the best device structure parameters. An extra PCBM interfacial layer and an extra P3HT interfacial layer were inserted into the inverted polymer solar cells, on the bottom and top of the active layer, respectively, which could enhance the electron and hole transportation. The CdSe/ZnS quantum dots (QDs) were added in the active layer to enhance the absorption of cells in the short wavelength region. The best QDs-doping content was experimentally determined. By designing the novel device structures and doping QDs in the active layer, the performance of the inverted polymer solar cells was substantially improved. The relevant mechanisms were also discussed.

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