Highly efficient bulk heterojunction photovoltaic cells based on small molecule donor and C70

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Organic photovoltaic cells (OPVs) have attracted growing attention in recent years from both research and application perspectives. Small molecule or polymer-based photovoltaic devices can be processed from solution and have become a promising low-cost alternative to traditional inorganic solar cells. Due to upscaling and area losses for the interconnections, this in turn requires more than 11–12% efficiency for the individual solar cell on module relevant areas, i.e., square centimeters. Thus, one key issue is the efficiency. Over 7% power conversion efficiencies (PCEs) have been reported in polymer OPV[1]. PCE of small-molecule OPV devices reached over 5%[2].

In this study, solar cell performance of planar heterojunction (PHJ) and bulk heterojunction (BHJ) structures of AlClPc/C60 were compared and the BHJ structure showed improved power conversion efficiency (PCE). With the substrate temperature of 390K, the blend layer of AlClPc/C60 resulted in higher device performance; PCE was increased from 2.44% in the PHJ structure to 3.58% in the BHJ structure. Further, the blend layer of AlClPc/C70 was prepared in a BHJ structure and the PCE was enhanced up to 4.11%. The improvement of PCE mainly comes from the enhanced Jsc. AFM observation indicated that the nanocrystals with the size of 90.2 nm were formed by controlling appropriate substrate temperature at 390 K. To enhance the performance of OPV cells, preparation of organic nanometer-sized pillar arrays is fascinating because a significantly large area of a donor/acceptor heterointerface having continuous conduction path to both anode and cathode electrodes can be realized. We grew CuPc crystalline nanopillar arrays by novel thermal gradient sublimation technique, different with the conventional thermal evaporation method[3]. Mixed heterojunction cells with small amount of donor and C70 were prepared, the PCEs were enhanced greatly compared with the corresponding PHJ cells. No crystal in the blend layers contributed to the efficiency enhancement. AFM images showed that regular grains were dispersed in C70 on blend films. The assumed mechanism was that the dispersivity of donor molecules in C70 matrix greatly decided the hole transport and the final PCE.

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