Appraising the validity of poly(3-hexylthiophene) nanostructures in interdigitated bilayer organic solar cells via theoretical modeling and experimental analysis

Jae-hyeong Lee

Department of Applied Chemistry and Biochemistry, Kumamoto University,
2-39-1 Kurokami, Chuo-ku, Kumamoto, Japan
leemin@kumamoto-u.ac.jp

It is known that interdigitated nanostructures can increase power conversion efficiency (PCE) by providing large interfaces for the dissociation of excitons and arrays for carrier transportation without recombination. Here, we demonstrate a modeling method to forecast the optimum size and shape for poly(3-hexylthiophene) (P3HT) nanopores in interdigitated P3HT: [6, 6]-phenyl C_{61} butyric acid methyl ester (PCBM) photovoltaic device, based on experimental results of P3HT:PCBM bilayer solar cell [1,2]. Thereafter, we appraise the validity of donor-acceptor nanostructures composed of well-aligned porphyrin-fullerene nanopillars based on their contribution to the PCE compared with bulk heterojunction (BHJ) and bilayer (BL) organic photovoltaic solar cells (OPVs) with high efficiencies [3]. Contrary to expectations, the results showed that P3HT: PCBM interdigitated nanostructures hardly enhanced the PCE, and precise control and elaborated manipulation is required to obtain benefit via nanopores. We suggested three reasons focused on the morphological characteristics: the misbalanced carrier transit time caused by differences in the travel distances and carrier mobilities, detrimental effects on carrier transportation due to the overlap of the pathways to the electrodes, and the dependence of the PCE on the shapes and sizes of the nanostructures.

References

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