Abstract

The development of fabrication processes in terms of morphological changes and vacuum free process for efficient and low cost organic solar cells (OSC) has been studied. The effect of annealing and interlayer to the device performances were investigated. Devices that were post-annealing after top electrode deposition have increased the solar cell performances significantly as compared to that of the devices without post-annealing. Post-annealing induced polymer crystallization and resulting in enhancement in the absorption. Vertical phase segregation also could occur as a result of annealing. In regular bulk heterojunction (BHJ), both polymer crystallization and vertical phase segregation contributed to the better device performance, whereas in the inverted BHJ, the concentration gradient remains unchanged after annealing because of the insertion interlayers. Therefore, the increased in inverted device performances is due to the polymer crystallization. The OSC device performance can be further enhanced by inserting interlayer such as poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS) which acts as both hole transporting layer and electron blocking layer, and titanium (IV) oxide (TiO_x) which function as electron transporting layer as well as hole blocking layer. These interlayers promoted charge collection, prevent charge recombination and current leakage. To reduce the device fabrication cost, we investigated inverted bulk heterojunction solar cells fabricated with gold (Au) leaf as laminated top electrodes to replace the costly and time consuming vacuum evaporation process. We demonstrated that the Au leaf can be successfully transferred from a supporting polyethylene terephthalate (PET) substrate to the surface of PEDOT:PSS due to sufficiently higher work of adhesion of Au leaf with PEDOT:PSS compared to PET. By optimizing the lamination conditions by increasing the lamination temperature, the contact between the Au leaf and the PEDOT:PSS becomes homogeneous, thus the power conversion efficiency (PCE) improves. Using Naphtho[1,2-c:5,6-c']bis[1,2,5]thiadiazole based polymer as the p-type semiconductor, the PCE reached 5.07%. The laminated devices exhibited excellent stability comparable to that of the evaporated devices. Although silver and alloys leaves are cheaper than Au leaf, they exhibit lower PCE because of the oxidation, thus not suitable materials as an electrode. Vacuum free process not only reduced the waste of materials but also shortened the fabrication time, which lead to the low cost OSC.

Keywords: Organic solar cells, Thermal annealing, Lamination, Work of adhesion, Low cost device