The Morphology Change of P3HT: PCBM in the Different Hole-collecting Layers

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Polymer photovoltaic (PV) cells have tremendous potential as renewable, alternative sources of energy because they are flexible, light-weight, and inexpensive. The poly(3-hexylthiophene) (P3HT) and [6,6]-phenyl C_{61} butyric acid methyl ester (PCBM) blending film as the active layer has made great progress. This blending film would be deposited onto the hole-collecting layer (HCL) by spin-coating method. The HCL may influence the arrangement of the active layer due to its interfacial interaction. Many studies have shown that the device performance is related to the morphology of the active layer. In this study, the poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) and Sulfonated poly(diphenylamine) (SPDPA) were used as HCLs, respectively. The molecular structures of PEDOT:PSS and SPDPA are shown in Fig. 1. The synchrotron grazing-incidence X-ray diffraction (GI-XRD) was used to detect the morophology of the active layers, which were deposited onto different HCLs. The GI-XRD measurements were carried out with synchrotron radiation at 17B1 baseline.

The synchrotron grazing-incidence X-ray diffraction (GI-XRD) measurement was employed to reveal the film structure. Here, the grazing incidence was fixed at a very small angle in order to conduct the measurements at the same thicknesses. Figure 2 shows XRD patterns for the crystalline structures of P3HT:PCBM films on both PEDOT and SPDPA substrates. The high intensities found for both (100) and (200) reflection peaks belong to P3HT with prevailing a-axis orientation, indicating that the main (side) chain is parallel (perpendicular) to the substrate. We also found that the film structure on SPDPA appears more ordered than that on PEDOT:PSS, which can be explained as follows. For a pure P3HT film, specially on a substrate having strong polar groups, P3HT tends to be repelled by the polar groups due to the overlap of their electron clouds so the assembled P3HT molecules are inclined to lay on the substrate with their side chains in the orientation perpendicular to the substrate.[1] Earlier reports indicated that P3HT with PCBM can exhibit a more evident molecular orientation in the a-axis direction.[2] Together with the fact that SPDPA has a strong polarity and can assist P3HT:PCBM molecules in the a-axis orientation, P3HT:PCBM assembly near the interface is guided by SPDPA, forming a more ordered structure. As these assembled molecules pile up layer-by-layer, they become susceptible to being self-organized into a highly ordered lamellar structure. The performance of the whole active layer can be enhanced by increased crystallinity. The detailed discussion can bo found in our previous work.[3]

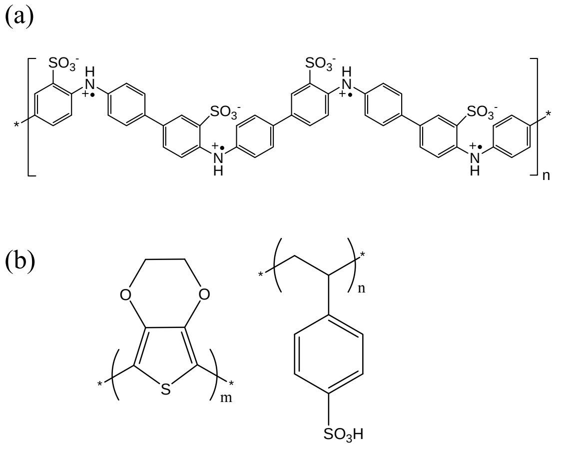

Fig. 1: The molecular structures of (a) SPDPA ; (b). PEDOT:PSS

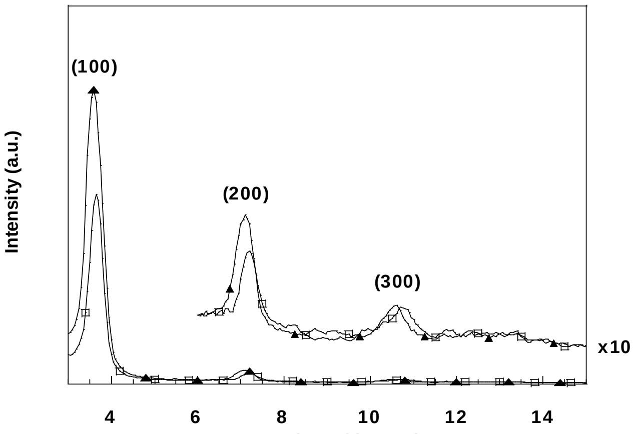

Fig. 2: GI-XRD spectra of P3HT:PCBM slow-grown film onto ITO/PEDOT: PSS (□) and ITO/SPDPA (▲) substrates.

References

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