Spatial Distribution of P3HT:PCBM Organic Photo Voltaic Propety Using Multistep LM-STS

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The organic photovoltaic (OPV) device is one of the most attractive solar cells because of its desirable properties, i.e. cost efficient, resource saving, lightweight and mechanically flexible. OPV cells fabricated by spin coating often have so-called "bulk-heterojunction (BHJ) structure", in which the p-type and n-type molecular regions are phase separated by a sharp but complicated interface, to increase the volume of the active layer and the efficiency of exciton separation. This structure is inhomogeneous at the nanometer scale, so the performance of the device such as power conversion efficiency also becomes non-uniform. To improve the performance of such devices, it is important to understand how the local device performance is determined by the non-uniform local structure.

In an actual device, OPV layer is sandwiched by two planar electrodes and its local photoelectrical performances are inaccessible. So we removed the metal electrode from a BHJ OPV cell made of poly(3-hexylthiophene)(P3HT) and1-(3-methoxycarbonyl) propyl-1-phenyl[6,6]C61 (PCBM) solar cell and observed the naked OPV layer by ‘‘light modulated scanning tunneling spectroscopy’’ (LM-STS) to investigate its nanoscale photoelectrical property, where the STM tip works as an alternative metal electrode. To extract electrons from a OPV cell efficiently, the work function of the metal electrode should be low. In this study, we deposited magnesium on tungsten probe in am ultrahigh vacuum to lower the work function of the probe.

Figure 1 shows the result. In the topography, some granular structure with ~1μm dimension can be identified. These grains are the P3HT nanocrystals, which is covered by the amorphous P3HT:PCBM composite layer. When illuminated by green laser (532 nm), photocarriers are generated at the interface of P3HT crystal and P3HT:PCBM composite. Since a negative sample bias voltage assists collection of photoelectrons by the STM tip, the photocurrent mapping at high negative bias voltage, I_{ph} represents the spatial variation of carrier separation efficiency. As seen in the figure, I_{ph} differs on different grain and also varies on a same grain. In this manner, we can visualize the spatial distribution of local performance of OPV cells with LM-STS. At the presentation, we discuss the physical origin of the distribution in terms of the inhomogeneous sample structure and composition.

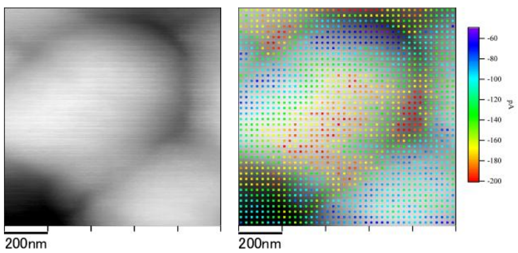

Fig. 1: STM topography obtained for Vt = 2.0 V, Is = 30 pA (left) and photocurrent mapping for V= -2.7V (right).