STM Emission Spectroscopy on Organic Solar Cell

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Organic thin film solar cells (OSCs) are expected to be light-weighted, flexible, design friendly and cost efficient. Thus, it gathers attention in the development of sustainable energy sources. To maximize the active region for photoelectric conversion, a number of OSCs have complex bulk-hetero junction (BHJ) structures, where the interface between *p*-type and *n*-type semiconductor regions is heavily corrugated during the self-organizing phase separation. In an OSC device, the organic film with BHJ structure is sandwiched by a metal electrode and a transparent electrode. Thus, such nanoscale variations are not observable by an external measurement. To understand the nanoscale variation, however, is crucial for further improvement of conversion efficiency of OSC devices.

To investigate such nanoscale variation of efficiency in OSCs, we applied scanning tunneling microscopy light emission spectroscopy (STM-LES) on a naked OSC thin film without the metal electrode. In our experiment, instead of the planar metal electrode, STM metal tip works as the metal electrode. To investigate local power conversion efficiency, we correct photoelectrons by the STM tip. In addition to the conversion efficiency, we also investigate *inverse*-conversion efficiency of OSCs locally by injecting electrons from the STM tip and holes from bottom transparent planar electrode, i.e. light emission due to the recombination of electrons and holes in the OSC active layer. With STM apparatus, we regulate injection current during measurement. With the STM emission spectroscopy, we expected to visualize carrier recombination center in the OSCs.

Fig. 1 shows a surface topography of a BHJ-type OSC made of P3HT:PCBM. Fig. 2 and Fig. 3 are the light emission intensity map and photocurrent map corresponding to the region imaged in Fig. 1. As shown, nanoscale distributions of emission intensity and photocurrent are clearly observed by our system. In the Presentation, we introduce that nanoscale light-emitting property with light emission intensity and the relationship with photocurrent.

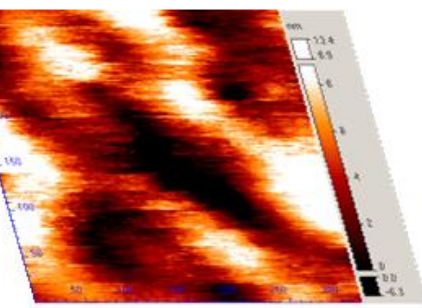

Fig.1: STM topography (350 nm x 350 nm)

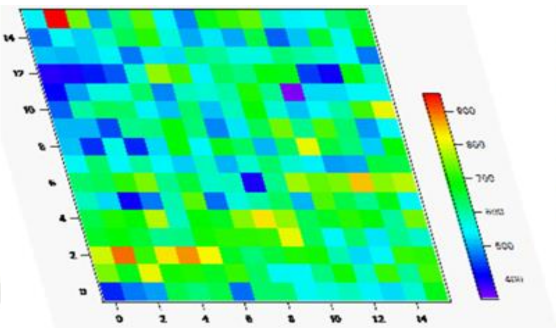

Fig.2: Light emission intensity on P3HT:PCBM OSC.

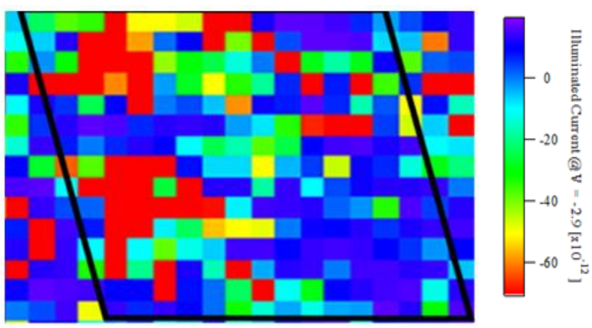

Fig.3: Photocurrent on P3HT:PCBM OSC.