Laser-combined STM study on organic solar cell

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Solar-power-conversion efficiency of the organic-bulk-heterojunction (BHJ) solar cell is largely governed by the nanoscale morphology of their active layer region. Therefore, simultaneous measurement of photoelectrical property and nanoscale morphology is crucial for optimizing their performance. In this study, we used "light modulated scanning tunneling spectroscopy" [1,2] to investigate the nanoscale photoelectrical property of a BHJ solar cell. This technique reveals local current-voltage characteristics of sample under illuminated and dark conditions with a nanoscale spatial resolution. A prototypical PCBM/MDMO-PPV BHJ solar cell was used for a sample.

Samples were prepared in the following procedures. First, a p-type buffer layer was formed on an ITO/glass substrate by spin-casting PEDOT/PSS solution. After annealing the sample at 410K in air, an active layer, which consist of PCBM : MDMO-PPV (= 4:1) mixed solution, was spin-casted in N_2 filled glovebox under the dark condition. STM measurements were performed under ultrahigh vacuum at room temperature. An electrochemically etched W wire was used for the STM tip.

Figure 1 shows a surface topography of the active layer region. The bright areas correspond to PCBM clusters whose sizes are 200~300 nm in diameter. The MDMO-PPV layer covers underneath flat regions surrounding the PCBM clusters. Figure 2 shows a corresponding dark current image obtained under a reversely biased condition (Vs = -3.7V). Due to the rectification of the p-n junction formed between PCBM and MDMO-PPV areas, no dark current flowed in PCBM areas. In contrast, a photocurrent image under zero bias condition (Fig. 3) shows a large photocurrent in PCBM areas, which corresponds to the amount of carriers generated by the charge separation of excitons at the interface of MDMO-PPV/PCBM. The photocurrent variation observed in PCBM clusters indicates a microscopic variation in performance of a solar cell caused by nanostructures.

[1] O. Takeuchi, S. Yoshida and H. Shigekawa, Appl. Phys. Lett. 84, 3463 (2004).
[2] S. Yoshida et al., Phys. Rev. Lett. 98, 026802 (2007).

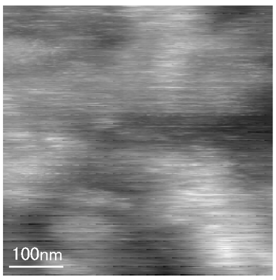

Fig. 1 STM image obtained for Vt=4.0V and Is=150pA.

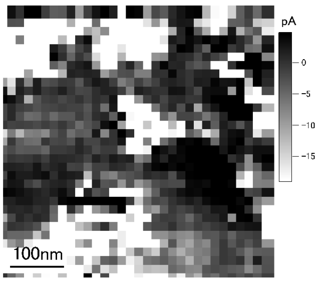

Fig. 2 Dark current mapping for Vs= -3.7V.

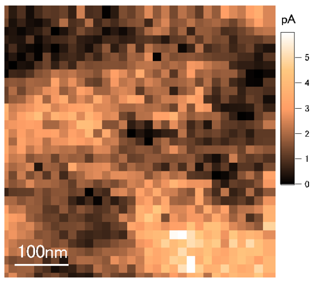

Fig. 3 Photocurrent mapping for Vs = 0V.