

## Orientation effect of organic semiconducting polymer revealed using Photo-Electron Emission Microscopy (PEEM)

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### 1 Introduction

High degrees of molecular orientation play an important role in the improvement of the carrier density in organic semiconductors. However, generally films consist of a mixture of regions with different orientation direction. In this study, we have investigated the orientation effect of organic semiconducting polymers containing sulfur atoms by Photo-Electron Emission Microscopy (PEEM) combined with linearly polarized synchrotron at the S 1s near-edge X-ray-absorption fine-structure (NEXAFS) region.

### 2 Experiment

Microscopic images were recorded with STAIB PEEM 350-10R system installed at BL27A station. X-ray incidence angle was 30° (glancing incidence) to the surface. Electrons emitted from the surface are magnified and projected onto a phosphor screen. Images were accumulated in a CCD as a function of photon energies. Intensities were normalized by values at the pre-edge region and divided by the edge-jump. We have prepared thin films of poly(3-hexylthiophene) blended with [6,6]-phenyl-C61-butyric acid methyl ester (P3HT : PCBM) on Si wafers by the solution process.

### 3 Results and Discussion

Figure 1(a) shows a PEEM image for the blend film measured with UV lamp. The spherical aggregates have been reported to be attributed to PCBM. Figure 1(b) shows an image measured with the S 1s excitation (~2473.1 eV). Five representative regions-of-interest (ROI: A to E) are depicted. Regions of A and C were chosen as bright parts. Zone B was selected as a dark one. Positions of D and E are brilliant spots.

Figure 2 shows integrated intensities for the five regions as a function of photon energies at the S 1s edge regime, i.e., NEXAFS. Figure 2 also shows the S 1s - NEXAFS spectra for thick films of P3HT [1]; Ref. 1 reports that polymer main chains tend to parallel the surface. Peak 1 can be assigned to S 1s → σ\* (polymer chain direction) [1]. If the intensity of peak 1 becomes weak under the glancing incidence, it means polymer chains tend to parallel the surface. Careful inspection indicates that the NEXAFS spectra for A, B, and C are similar to the spectrum for P3HT film measured at 30°, meaning the parallel orientation of polymer chain in these regions. In contrast, as for D and E, the intensities of peak 1 are stronger than those observed for A, B, and C, suggesting that polymer chains tend to perpendicular the

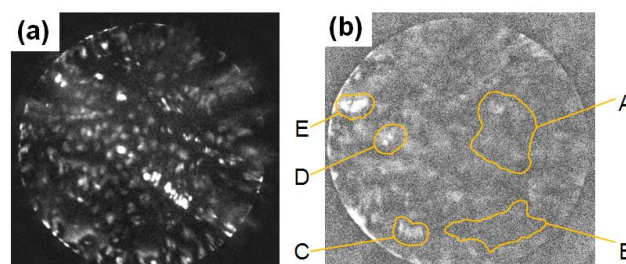


Fig. 1 (a) PEEM image (F.O.V.~120μm) for P3HT:PCBM blend film measured with Hg-UV excitation. (b) Image (F.O.V.~60μm) measured with the S 1s excitation.

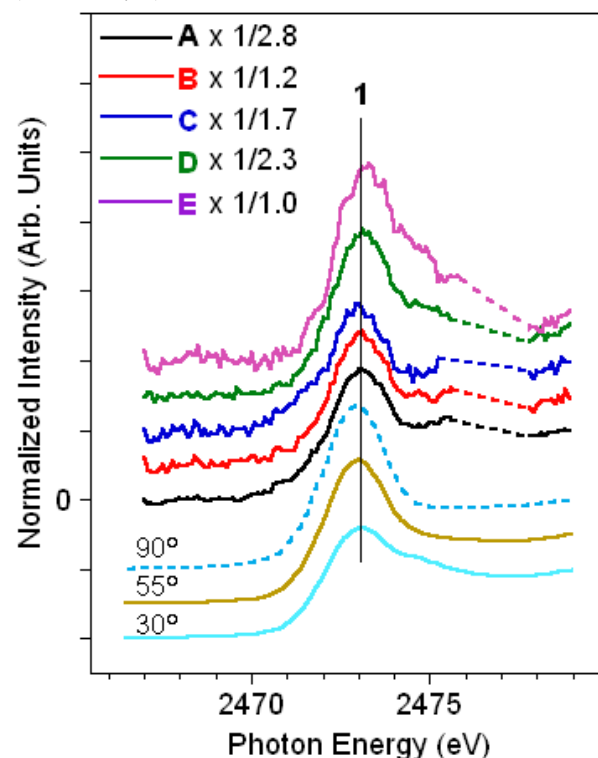


Fig. 2 Photon energy dependences of intensities for regions of A to E. Also shown are the S 1s - NEXAFS spectra for P3HT thick films measured at 30°, 55°, and 90° [1].

surface. In conclusion, it was found that PEEM with polarized synchrotron can be a powerful tool that gives information of molecular orientation in nano-meter scale.

### Reference

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