REAL-TIME X-RAY DIFFRACTION ANALYSIS FOR SOLVENT VAPOR ANNEALING PROCESS OF SMALL-MOLECULE/FULLERENE FILMS

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Organic photovoltaics (OPVs) using small-molecule donor materials have been attracting much attention, where the power conversion efficiencies higher than 10% are reported using thiophene-based molecule (DRCN5T)$^{[1]}$. Thermal annealing (TA) and solvent vapor annealing (SVA) are important technique to achieve high performance OPVs because improvement of the crystallinity, improvement of the domain size, and optimization of film morphology, which provide the improvement of short circuit current ($J_{sc}$) and fill factor, can be achieved. The mechanism of the morphology transformation is important research topic and detail of the annealing process should be investigated in detail in order to develop the practical fabrication process and novel organic-semiconductor materials. In this study, we conducted real-time X-ray diffraction analysis during the SVA process of DRCNST/PC$_{61}$BM mixed films by means of synchrotron radiation facility (SPring-8).

The mixed film of DRCNST/PC$_{61}$BM was fabricated and after the TA treatment, the SVA process using chloroform (CF) was analysed. The measurement chamber was specially designed to analyze grazing incident X-ray diffraction (GIXD) and optical absorption spectra simultaneously (Fig. (a)). The low-angle shift of the diffraction peak ($q_z = 0.34$ Å$^{-1}$) indicating (100) diffraction of DRCNST (side chain order) was observed 200 s after the CF injection, which means the increase of the distance of side-chain direction (Fig. (b)). Then the optical-absorption intensity at 550 nm, 610 nm, and 690 nm was increased, which indicates the enhancement of the interaction between the molecules (Fig. (c)). On the other hand, the decrease of the distance of side-chain direction and decrease of optical absorption for the above 3 peaks were observed. We found the change of film structure not only for the injection of the solvent but also for the desorption of the solvent. The importance of the control of the desorption process of the solvent is suggested.