In-situ Morphology Study of Organic Photovoltaics with Real Time X-ray Scattering using a Roll-to-roll Coater

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Performance of organic photovoltaics (OPVs) is extremely sensitive to the morphology of the bulk heterojunction (BHJ) active layer, which can be greatly impacted by the processing methods and conditions. It is not surprising that the optimized processing conditions for spin coating usually cannot be directly transferred to roll-to-roll (R2R) coating for mass volume production. In order to bridge the gap between laboratory scale and industrial scale development of OPV materials and processes for better materials design and morphology control, in-depth understanding of the morphology evolution of organic semiconductors is highly demanded. We have developed a R2R coater designed to be portable and adaptable so that it allows in-situ x-ray scattering during the R2R coating process on synchrotron beamlines. Multi-length scale morphology evolution information was obtained by implement this portable coater with different grazing-incidence scattering geometries, i.e. molecular packing and crystallization through wide-angle (GIWAXS) and phase separation through small-angle scattering (GISAXS). We have investigated the drying process and BHJ morphology evolution of the OPV blend systems based on either small molecule or polymeric donor and acceptor materials as a function of processing conditions. Exciting findings on processing-morphology-performance relation will be discussed for these model systems, and the knowledge is expected to greatly advance the understanding of morphology control of solution processed organic materials at scale, which is expect to benefit relevant broader polymer research fields as well.