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Unexpected Morphological Traits of Bulk Heterojunction Organic Solar Cells with Exceptional Power Conversion Efficiencies JOHN TUMBLESTON, BRIAN COLLINS, North Carolina State University, ANDREW STUART, University of North Carolina, ZHE LI, Monash University, HONGPING YAN, North Carolina State University, CHRISTOPHER MCNEILL, Monash University, WEI YOU, University of North Carolina, HARALD ADE, North Carolina State University — The synthesis of new polymers for polymer/fullerene bulk heterojunction solar cells has boosted the power conversion efficiency (PCE) of these devices to levels now exceeding 5%. Even with these advancements in efficiency, relatively little is known of the morphological characteristics of the active layer including domain size and purity, material crystallization and orientation, and miscibility of the bulk heterojunction components. Herein, we employ a suite of soft and hard x-ray scattering and microscopy techniques to probe defining traits of the morphology for the high-performing polymers, poly[4,8-(3-butylnonyl)benzo[1,2-b:4,5-b']dithiophene-*alt*-2-(2-butyloctyl)-5,6-difluoro-2H-benzo[d][1,2,3]triazole] (BnDT-FTAZ) and thieno[3,4-b]thiophene-*alt*-benzodithiophene (PTB7) blended with phenyl-C61-butyric acid methyl ester ($PC_{61}BM$) and $PC_{71}BM$, respectively. PCEs of 7.4% for BnDT-FTAZ and 5.3% for PTB7 based solar cells are achieved when processing methods result in smaller, more mixed polymer/fullerene phases where non-zero miscibility is measured for each system. Furthermore, the polymers do not strongly crystallize in the active layer and average domain sizes larger than 50 nm are noted for both systems.

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