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Organic devices. New perspectives provided from soft x-ray characterization

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Organic semiconductors are continuing to receive significant interest for application in photovoltaic cells, field-effect transistors and light-emitting diodes. Conjugated polymers in particular offer the convenience of solution processibility with the flexibility of materials design afforded by synthetic chemistry. One of the disadvantages of conjugated polymers is the complexity of their film structure that, while key for understanding and optimizing device performance, is difficult to characterize. Here I will present new insights into the structure of films based on conjugated polymers using synchrotron-based soft x-ray techniques. By exploiting molecular resonances near the carbon K-edge, soft x-ray techniques such as x-ray spectromicroscopy and resonant soft x-ray scattering afford enhanced material contrast with high spatial resolution. This enhanced material specificity has been exploited to reveal the complex, hierarchical structure of conjugated polymer blends used in polymer solar cells. Furthermore, we have recently demonstrated a significant degree of miscibility of fullerene derivatives used in high-efficiency polymer/fullerene blends calling into question the assumed paradigm of phase-separated, pure phases. The polarized nature of synchrotron radiation can also be exploited to probe local molecular orientation and order using soft x-rays. This facilitates mapping of domain orientation and molecular order important for understanding charge transport in polycrystalline polymer films used in field-effect transistors.