High Efficiency Organic Solar Cells: Controlling Film Morphology

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Organic photovoltaics offer the promise of a solution-processable, low cost, scalable alternative energy technology; however remain impractical due to limited power conversion efficiency. Integral to improving efficiency is controlling the three dimensional self-assembly of electron donor and acceptor materials into interpenetrating percolating phases of a bulk heterojunction. Recently we have developed a materials system in which the efficiency is highly tunable through processing. Structural characterization via high resolution transmission electron microscopy reveals small changes in processing conditions lead to significant changes in film structure. Specifically, thermal annealing and solvent additives results in the appearance of well-defined, wire-like crystalline donor domains and subsequently large improvements in device efficiency. Single crystal diffraction experiments of the donor material provide detailed information on the solid state molecular orientation and packing within the wires and thereby provide unprecedented molecular-level insight. Detailed device characterization helps elucidate structure-property relationships, which should be applicable for designing the next generation of energy conversion materials and devices.