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Low bandgap polymer/polymer, polymer/fullerene phase diagrams: Effect of phase separation on photovoltaic performance

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The photovoltaic technologies can contribute not only to the environmentally friendly renewable energy production but also to the reduction of the carbon dioxide emission associated with fossil fuels and biomass. Specifically, as an emerging photovoltaic technology, we can mention the polymer solar cells based on conjugated polymer/molecule blend materials. These polymer solar cells have received tremendous attention in the past two decades due to their potentials to be environmentally safe, flexible, lightweight, inexpensive, and efficient devices. The most important characteristic of a polymer blend of two (or more) polymers is the phase behavior. Polymer blends (like low molecular weight solvents) can exhibit miscibility or phase separation and various levels of mixing in between the extremes (e.g., partial miscibility). Conjugated polymers are potential materials for photovoltaic applications due to their high absorption coefficient, mechanical flexibility, and solution-based processing for low-cost solar cells. A bulk heterojunction structure made of donor–acceptor composite can lead to high charge transfer and power conversion efficiency. Active layer morphology is a key factor for device performance. The power conversion efficiencies of all-polymer solar cells have been improved up to ~7%. And it is believed that there is still a room for further improvement if we could adjust the energy levels of a semiconducting polymer for harvesting more photon energies. Furthermore, compared with the conventional polymer/fullerene solar cells, all-polymer solar cells can exhibit much better mechanical strength and stability, because the polymer acceptor is not only intrinsically more ductile than the fullerene but also it can be entangled with other polymers within the acceptor domains and at the interface. Hence, the all-polymer solar cells are believed to be better candidates than the polymer/fullerene solar cells, for applications, especially in flexible and portable electronics. My review paper includes: part-I: Conjugated Polymer/Fullerene Phase Diagram (P3HT: PCBM, MDMOPPV: PCBM, MEH-PPV: PCBM), part-II: Conjugated Polymer/Solvent Phase Diagram (P3HT: CB), and part-III: Low Bandgap Polymer/ Fullerene Phase Diagram (PCPDTBT: PCBM) - Correlation of Phase Diagram and Device Performance. A key requirement for efficient charge separation and collection is the formation of interconnected phase-separated domains structured on the sub-20nm length scale. The photoactive layer of organic solar cells consists of a nanoscale blend of electron-donating and electron-accepting organic semiconductors. Controlling the degree of phase separation between these components is crucial to reach efficient solar cells.

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