MASTER'S THESIS

Thermal diffusion of organic semiconductors determined by scanning photothermal deflection (SPD) technique

Chiu, Ka Lok

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Abstract

Thermal diffusivity (D), measuring how fast heat propagates in a medium, is an important quantity in heat conduction. For a medium with great thermal diffusivity, it will reach thermal equilibrium in shorter time. In the field of solid state materials, thermal diffusivity can give information about the quality and morphology of solid, since D is very sensitive to microstructures. However, studies on the thermal diffusion of organic semiconductors are very scarce.

In this thesis, the thermal diffusion of different classes of photovoltaic polymers and their blends with molecular electron acceptors were studied by scanning photothermal deflection (SPD) technique. The reliability of the technique was confirmed by the good matching between the SPD derived experimental D values and the nominal D values of different reference materials obtained from literatures. To illustrate that determination of thermal diffusivity is a possible method for studying microscopic properties of organic photovoltaic materials, SPD technique was applied to various films of photovoltaic polymers with different crystallinities. It is observed that photovoltaic polymers always possess small D values in the range of 0.3mm^2/s to 2.3mm^2/s. It is also discovered that photovoltaic polymers with more planar molecular structure, stronger π-π stacking and higher crystallinity would possess larger D values. When photovoltaic polymers are blended with small molecular acceptors bulk

heterojunctions (BHJs), the thermal diffusivity is always reduced due to disrupted polycrystalline structure and increase probability of intermolecular phonon transport. However, for all-polymer BHJs with polymeric acceptor, the reduction in thermal diffusivity can be moderate as the proportion of ultrafast intramolecular phonon transport is maintained.

SPD technique was also applied to PBDB-T:(ITIC-M+N2200) ternary BHJs with different ITIC-M to N2200 weight ratio. The thermal diffusivity of the ternary blend increases with the weight percentage of N2200 polymeric acceptor. It is observed that PBDB:(ITIC-M+N2200) ternary photovoltaic devices with enhanced thermal diffusion can possess enhanced photostability. Such enhancement in photostability is attributed to the reduced heat trapping at the area being illuminated due to the improved thermal diffusion.

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