Transient and Steady State Current and Voltage Measurement Development for the Study of Transport and Recombination in Organic Photovoltaics

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Organic photovoltaics are an important subset of the solar cell industry and show promise in applications such as flexible and portable electronics, textiles, and coatings. Optoelectronic methods to measure the collection and evolution of photogenerated charge are crucial to understanding and improving deficiencies in device performance. Our work here extends progress in this area by combining two simple measurements- large perturbation transient photovoltage (LTPV) and impedance spectroscopy. These techniques are employed here to compare the relative populations of mobile and trapped charge carriers at a range of open circuit voltages. Recombination rate and order are also studied over the measured charge carrier density range. We first applied these methods to a well-studied polymer-fullerene pair, P3HT:PC_{61}BM, in a series of devices with varied active layer morphology. We compare variations in film nanoscale morphology and microstructure to variations in charge carrier mobility and the rate of non-geminate recombination. Together, these optoelectronic techniques provide better understanding of the involvement of free-free versus free-trapped recombination and the difference between total population of generated charge and mobile charge carriers. Future studies will be carried out to include other polymer-fullerene pairs. These results may add insight into processing-structure-function relationships for organic photovoltaics.