Probing Photoexcitation Dynamics in Organic Photovoltaic Materials by Ultrafast Broadband Photoluminescence Spectroscopy

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Understanding the photophysics processes in organic photovoltaic (OPV) is critically important for the development of new materials and the design of device structures. Time resolved spectroscopy has contributed to probe photoexcitation dynamics in OPV, giving insights of the mechanisms of photocurrent generation. For example, we have applied temperature-dependent transient absorption spectroscopy (TA) to qualitative and quantitative analysis the spatial distribution of charge pairs in polymer solar cells [1]. It highlights the correlation between free charges and long-range charge separation within the thermalization time scale.

As the primary photoexcitation species in organic semiconductors, singlet excitons play a key role in OPV. With selectivity and high sensitivity, time-resolved photoluminescence (TRPL) can provide rich information of exciton dynamics. However, in contrast to TA, TRPL is more challenging to obtain ultrafast time resolution and broadband detection simultaneously.
We first use optical Kerr gate to track the spectral evolution with sub-picosecond time resolution in OPV [2]. This work reveals the generation of ultrafast charge carrier via excitation delocalization in P3HT: fullerene blends.

To overcome the limitations of conventional TRPL methods, for example, fluorescence upconversion and Kerr gate, we developed a new technique, transient grating PL spectroscopy (TGPLS) [3]. This method has been used to address several OPV related topics including ultrafast torsional relaxation, ultrafast energy transfer [4] and singlet exciton fission [5]. Combining high spectral resolution, sub-picosecond time resolution and extremely low background, TGPLS provides an exciting opportunity to advance our knowledge of photoexcitation processes in OPV.

References

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