

Photophysics of organic and perovskite based solar cells tracked by ultrafast spectroscopy

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Ultrafast transient spectroscopy is a vital tool to investigate the photophysical processes taking place in energy harvesting materials. In particular, the findings provide valuable insights into the efficiency limiting processes in solar cells. The focus of this talk will be on solution-processed metal-halide perovskite solar cells as they have received immense attention in the field of photovoltaic research due to their outstanding power conversion efficiency, which has surpassed 26% in a relatively short time. Understanding carrier losses at metal halide perovskite/charge transport layer interfaces is a pre-requisite to bring the efficiency closer to the Shockley-Queisser limit. Interfacial recombination can to some extent be accessed through time resolved techniques, however identifying this is often a challenge due to the complexity associated to the interpretation and modelling of the extracted charge carrier transients.

Our approach is to utilize complementary transient spectroscopic techniques, namely transient absorption spectroscopy and transient photoluminescence spectroscopy, not only to unravel the processes limiting the solar cell's short circuit density and the open circuit voltage but also to evaluate different charge recombination channels and extraction. Herein, we focus on spectroscopic studies on the photoactive layer and the respective stacks containing the hole transport layers. Several different hole transport materials (PTAA, NiO_x, and 4PACz) are adjacent to the photoactive layer. We report on challenges faced during performing complementary spectroscopic techniques and interpretation of the extracted transients. Specifically, differentiation between photophysical processes such as charge extraction and interfacial charge recombination.

In addition, charge generation in non-fullerene acceptor (NFA) based organic solar cells (OSCs) have gained prodigious attention, and with this the critical role of the energetics at the donor/acceptor interface. Ionization energy (IE), upon optical excitation, drives the Foerster energy transfer from donor to acceptor and subsequently hole transfer (from acceptor to donor), prerequisite that the low bandgap component is the emitter in the organic photoactive blend. In this regime, the correlation between the cells internal quantum efficiency (IQE) and the photoluminescence quenching efficiency (PLQE) with the donor/acceptor offset is critical for this charge generation channel.