Elucidating the long-range charge carrier mobility in metal halide perovskite thin films

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Abstract

Many different characterisation methods have been employed for assessing the optoelectronic properties (i.e. long charge carrier diffusion lengths, high radiative efficiency and charge carrier mobility) of metal halide perovskites. It is important to understand the long-range charge transport within the metal halide perovskite, and if these properties change in different carrier density regimes, or through different methods of processing the films. Despite many benefits of advanced spectroscopic techniques (non-contact and reproducible optical pump terahertz probe), these measurements are not sensitive to long-range charge conduction in metal halide perovskites. Measurements on this length scale using transient methods, mobilities are often estimated assuming an initial charge carrier population following an optical excitation pulse. For nanosecond to millisecond transient methods, such as microwave conductivity, an accurate determination of the carrier mobility is hindered by both early-time recombination and the branching ratio of excitons to free-carriers. This is overcome by only measuring under very low excitation densities, but these are often different to the conditions relevant to an operating solar cell. The present talk will highlight an advanced optical and electrical transient in-plane photo-conductivity methodology, and accurately estimated the internal free-carrier density during photo-excitation, accounting for both early-time recombination and exciton-to-free-carrier branching ratios. With this method we can determine the long-range charge carrier mobility in metal halide perovskites, to be invariant over many orders of magnitude of charge density. We also demonstrate that the processing method of perovskite layer has a strong influence on the long-range mobilities. In addition to metal halide perovskites, we expect our methodology to be especially useful for polycrystalline and nanostructured semiconductor materials, where the long-range mobility is expected to vary considerably in comparison to the short-range mobility, such as quantum dots, carbon materials, semiconducting organic molecules and metal oxides.

Keywords: *long-range, charge carrier mobility, metal halide perovskite, photophysics, optoelectronic devices*

References

[1] J. Lim et. al., Energy Environ. Sci., 2019, 12, 169

Biography

Jongchul Lim obtained his Ph.D degree from POSTECH under supervision of Prof. Taiho Park. He is currently working as a Post-doctoral research associate under Prof. Henry J. Snaith at University of Oxford. Current research interest: photophysics and optoelectronic of devices with organic-inorganic hybrid materials.