Defects in Perovskite Solar Cells

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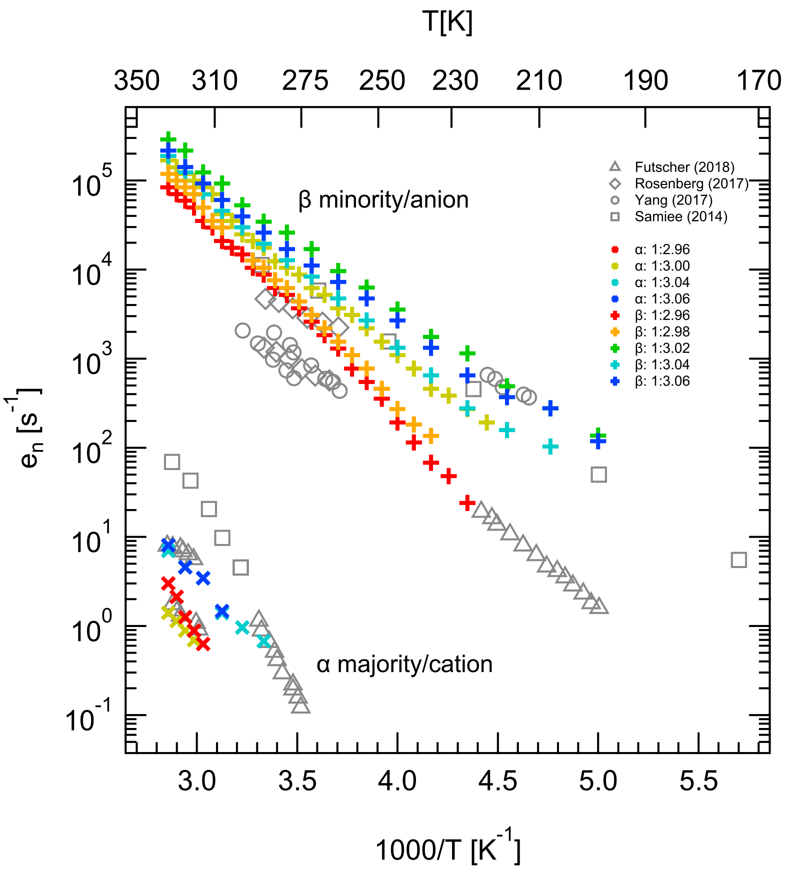
The perovskites used for photovoltaics are fascinating materials, showing very high performance for solution-processed thin film solar cells. While this class of semiconductors seems to have a high tolerance for defects, their role in performance, optoelectronic properties and long-term stability is not clear yet.

We want to contribute to this discussion. Here, I present recent work on the defect spectroscopy on methylammonium (MA) lead halide perovskites, which were processed with minute changes of the stoichiometry. Details about the processing as well as the optoelectronic and energetic characterisation can be found in a recent publication by the Vaynzof group.[1] As the methods used for the defect spectroscopy, deep level transient spectroscopy and impedance spectroscopy, cannot a priori distinguish between electrons/holes and ions in these mixed conductors, we define the term *defect* broadly to cover both electronic traps and, e.g., ionic vacancies. We extract the activation energies (we do not have direct access to the formation energies) from the emission rates. An example, here plotted in Arrhenius representation typical for the „classical“ defect spectroscopy, is shown below.



In the stoichiometry varied MA lead halide solar cells, we were able to distinguish two states, β and α. For comparison, some emission rates from the literature are shown, for different perovskite systems: MA lead halide,[2] single crystalline $MAPbBr_3$,[3] α-phase formamidinium PbI_3 (containing some $MAPbBr_3$),[4] and MA PbI_xCl_{1-x}.[5] We expect a lively discussion on our results.

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[1] P. Fassl et al. (2018) Energy Environ. Sci. 11, 3380

[2] M. Futscher et al. (2018) arXiv:1801.08519

[3] J. W. Rosenberg et al. (2017) J. Appl. Phys. 122, 145701

[4] W. S. Yang et al. (2017) Science 356, 1376

[5] M. Samiee et al. (2014) Appl. Phys. Lett. 105, 153502