Nanoscale correlative imaging of halide perovskite solar cells

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Perovskite (ABX_3) solar cells have been identified as one of the top 10 future technologies by the World Economic Forum. However, device optimization occurred faster than the detailed understanding of the device operation and the properties of the perovskite semiconductor. In order to improve perovskite solar cells and to gain insight into the fabulous optoelectronic properties of this material, in-depth characterization is necessary. Compositional engineering by mixing A cations and X anions was one of the successful strategies to improve perovskite solar cells but it was rapidly noticed that many phases, from macroscale down to nanoscale, can co-exist. These secondary phases are potentially hampering stability and device performance, thus need to be correctly identified and characterized.

Helium Ion Microscopy - Secondary Ion Mass Spectrometry (HIM-SIMS) is a recently developed technique by Wirtz et al. [1-3] allowing for high-sensitivity and high-lateral-resolution elemental imaging down to < 20nm. This increased resolution compared to the state of art SIMS equipment is ideal for correlative morphology-elemental imaging of the typical grain structure and grain boundaries of polycrystalline thin films [4,5].

Here, we present elemental mapping of Cs^+, Pb^+, I^-, Br^- as well as organic cation distribution in complex mixed perovskite formulations. It is revealed that the ionic distribution within perovskite layers yielding high efficient solar cells is not homogenous at the nanoscale. By providing nanoscale analysis of the grain composition and the grain boundaries, we are able to discuss the origin and the consequences of the non-homogenous ionic distribution.

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