

Formation, stability and crystallization in two-dimensional perovskites: from nanoplates to 2D/3D interfaces analyzed by *in situ* experiments

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Metal halide perovskite solar cells have reached the recent efficiency breakthrough of 25.6%, higher than silicon polycrystalline photovoltaics. Such fantastic result was only possible due to a precise control and engineering of the morphology, interfaces, defects, and the use of multiple cations in perovskite A-site, as Rb, Cs, MA (methylammonium), FA (formamidinium) and long alkyl cations as phenylethylammonium (PEA). Dimensionality of perovskite materials can be easily controlled by the choice of the cation in the A site, providing structures from zero (0D), one (1D), two (2D) and three-dimensions (3D), amplifying the use of these materials in lighting, lasers and sensors. For tandem perovskite solar cells, a mixture of different anions, as Br and I is also desired to adjust the band gap. Such cocktail of different cations and anions influences not only the structure and dimensionality, but the formation of undesirable phases, halide segregation, defects, etc. They have also a huge impact on device's efficiency and stability.

In this presentation, we will summarize important results using *in situ* experiments to probe the formation of 2D perovskite materials, from nanoplates to micro-sized structures as well 2D/3D interfaces. Dynamics of the formation of these structures and interfaces in solution or solid state, their stability under thermal stress and aggregation, were studied by *in situ* experiments probing the samples with both X-rays and/or visible radiation. For that, we employed time-resolved grazing incidence wide angle X-ray scattering (GIWAXS), small angle X-Ray scattering (SAXS), high-resolution XRD and PL spectroscopy taken at the Brazilian Synchrotron National Laboratory and Lawrence Berkeley National Laboratory.

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