Hybrid Perovskites for Photovoltaics: challenges and opportunities

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Abstract

It is undoubted that organic-inorganic hybrid perovskites have been representing a scientific breakthrough in the photovoltaic field since 2009 when they were applied to replace photoactive dyes in hybrid solar cells. Further development has been highly boosted by a large and enthusiastic effort of the worldwide scientific community to improve the response to sun light. The current certified maximum efficiency is 23.7%. The exceptionality of this class of materials resides in their soft nature. The long diffusion lengths of the photo-generated carriers, the wide absorption range, the direct and tunable bandgap are mainstays. It is equally true that the low structural stability of the hybrid perovskites, primary $MAPbI_3$, risks to severely retard their wide-range applications in low cost/high yield devices. A large effort is consequently needed to frame the instability sources and degradation mechanisms in relationship with the operation conditions, including temperature, illumination, humidity, contaminants and boundary materials in the final architecture. One of the most used strategies is this perspective is the changing or mixing different cations, (MA^+, FA^+ and Cs^+) to improve the lattice stability. Although the overall scenario is brighter than years ago, reliable and long-lasting solutions to avoid back-reaction of perovskites to the starting organic and inorganic components and indeed to extend cell durability are under spotlight. For the market uptake, moreover, device architectures, to be produced via simple and sequential steps, being free of contaminants and at low environmental impact, are warmly encouraged to catch the interest of investors. A critical analysis of the available data indicates that degradation under ambient conditions is a defect-generation process that is highly localized on surfaces and interfaces, while it is further enhanced above the tetragonal-cubic transition at ∼54 °C. Within this context, we discuss the conservative role of N_2 and propose strategies for the emergence of industrially viable hybrid photovoltaics. The paper will thus frame strengths and weaknesses of hybrid perovskites for next-generation photovoltaics in view of their extended use and dissemination in daily life.