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Improving the Efficiency and Stability of Organolead Halide Perovskite Solar Cells through Atomic, Microstructural, and Interfacial Engineering

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Abstract

Two of the most pressing issues facing humanity now and for the foreseeable future are the increasing global energy demand and environmental conservation. Solar energy offers a rich opportunity to turn our energy supply to an abundant, renewable source. Commercial silicon-based solar cells have achieved power conversion efficiencies (PCE) of 20-25%, though there is a constant push to decrease the cost of production. One emerging photovoltaic technology with potential future commercialization is the hybrid organometal halide perovskite solar cell (PSC). With its seminal paper published in 2009, the PSC has grown in PCE from under 4% to over 22% in under a decade. The absorber layer is composed of perovskite structure ABX_3 material, where traditionally the A site is comprised of an organic cation such as methylammonium, the B site is a large post-transition metal cation such as lead, and the X site is composed of halides or a mixture of halides normally including iodide. These materials offer high absorption and tunable direct bandgaps, long carrier lifetimes and diffusion lengths, defect tolerance, low temperature facile processing, and low cost. However, they have been historically plagued by instability in the presence of high humidity, heat, and UV light, and exhibit *J-V* hysteresis, indicating non-ideality in electronic transport and detrimental ionic migration, but offering insight into mechanisms of decreased PCE and degradation. Before PSCs can be commercialized, these issues must be addressed. This talk will review recent literature illuminating routes to increased stability and PCE of the perovskite materials at three perspectives: the atomic, the microstructural, and the interfacial scales. Topics will include a theoretical summary of the electronic structure of PSCs, cationic and anionic substitutions, crystalline and morphological control, and surface passivation and interface engineering.