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FLASH INFRARED ANNEALING FOR SOLUTION PROCESSED PEROVSKITE SOLAR CELLS

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Organic–inorganic perovskites have demonstrated an impressive potential for the design of the next generation of solar cells. Perovskite Solar Cells (PSCs) are currently considered for scaling up and commercialization. However, many of the lab-scale preparation methods are difficult to scale up or environmentally unfriendly. The highest efficient PSCs are currently prepared using the antisolvent method, which utilizes a significant amount of an organic solvent to induce perovskite crystallization in a thin film. An antisolvent-free method is presented in this dissertation, based on rapid thermal annealing, which allows preparing methylammonium lead iodide (MAPbI3) PSCs with a record stabilized power conversion efficiency of 18.3%. With an irradiation time of fewer than 2 s, the so-called Flash Infrared Annealing (FIRA) method enables the coating of glass and plastic substrates with pinhole-free perovskite films that exhibit micrometer-size crystalline domains. This work discusses the FIRA-induced crystallization mechanism and unveils the main parameters controlling the film morphology. The replacement of the antisolvent method and the larger crystalline domains resulting from flash annealing make FIRA a highly promising method for the scale up of PSC manufacture.

One strategy to improve long-term stability is to replace the thermally unstable organic cations with inorganic cations that compress the perovskite lattice. Here, for the first time, pulsed infrared light is used to drive the crystallization of inorganic mixed halide CsPbIxBr(3−x) perovskite films, resulting in solar cells with a power conversion efficiency that exceeds 10%. By varying the iodide–bromine ratio systematically, it is found that to keep the inorganic perovskite black phase stable at room temperature, the iodine content needs to be limited to lower than 60% – bromine content higher than 40%. This finding revises previous reports claiming stable compositions with high iodine contents, which is systematically exploited to reduce the perovskite bandgap with the aim to enlarge the light absorption spectra and thus to boost the device efficiency. It is demonstrated that the newly defined stable compositional range enables devices that retain 90% of the efficiency after stressing the perovskite at 200 °C for 1 h. This result demonstrates that inorganic halide perovskites are stable materials for high-temperature applications such as concentrated photovoltaics. Furthermore, this dissertation shows that the FIRA synthesis of perovskite thin films has the potential for the industrial commercialization of PSCs

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