Perovskite solar panel fabrication

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Two organolead halide perovskite nanocrystals, $CH_3NH_3PbBr_3$ and ...

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Although perovskite solar cells (PSCs) are promising next generation photovoltaics, the production of PSCs might be hampered by complex and inefficient procedures. This Review outlines important advances in materials and methods for the cost-effective manufacturing of PSCs, including precursor synthesis, selection criteria for precursors based on chemistry, additive engineering, and deposition techniques. The goal of these technologies is not only to improve the performance and stability of PSCs, but also to significantly reduce their manufacturing costs. These advances are critical to the commercialization of PSCs, in terms of making them viable and cost-effective.

In this review, we aim to explore the important advancements in materials and methods for the cost-effective fabrication of PSCs based on efficient conventional ink components, including cost-effective precursor synthesis and selection criteria, additive engineering, and deposition techniques. Furthermore, we investigate the challenges faced in this field and explore potential directions for future research and development. By understanding the principles and latest advancements in PSC fabrication, we can provide practical guidelines for cost-effective fabrication procedures.

Precursor selection18,67,68,69 and additive engineering41,53,70,71,72 are crucial steps for the fabrication of PSCs since they affect the crystallization kinetics36,73, film morphology, and quality41,65, thereby ultimately influencing the photovoltaic performance of the devices71,74,75. Therefore, careful consideration of these factors is essential for eventually achieving the cost-effective fabrication of PSCs.

Additive engineering is another effective method for enhancing the properties of perovskite films41,53,70,71,72, which may significantly affect crystallization kinetics, film quality, and the stability of the perovskite material34,89. A wide range of additives, including solvents, functional additives, dopants and interface engineering, have been explored for this purpose32,90.

It should be emphasized that the additive engineering discussed above can be extended not only to the preparation of Sn-Pb perovskites but also to other types of perovskites in general, such as Pb-free, wide-bandgap, and 2-dimensional (2D) perovskites. However, due to space constraints, we do not go into details again in this review.

Additionally, stabilizing the a-phase FAPbI3 involves the incorporation of doped ions such as MA+, Cs+, and Br- into the perovskite lattice. However, this can increase lattice microstrain and bandgap as well. To mitigate these effects, introducing 3.8% methylenediammonium dichloride (MDACl2) was introduced in the FA-based perovskite precursor, where the larger methylenediammonium (MDA2+) can enter the lattice, compensating the Cs+-induced microstrains (Fig. 4b). This method yields perovskites with near-intrinsic bandgaps109 and reduced strain105, enhancing efficiency and thermal stability. Notably, the device maintains a PCE above 90% after heat treatment at 150 ?C for 20 h, with a certified PCE of 24.4%.

The aforementioned large cation doping might be limited to use in general due to unwanted low dimensional phase formation. Consequently, it is crucial to further investigate efficient interstitial doping techniques that utilize low dopant concentrations to avoid microstrain. For instance, our study on doping role of cations in suppressing iodide migration shows that trivalent neodymium cations (Nd3+) are more effective than monovalent Na+ at 0.45% and bivalent dopants Ca2+ at 0.25% (Fig. 4c)106. Importantly, the optimal doping concentration of Nd3+ was just 0.08%, which was sufficient to minimize microstrain and maintain perovskite phase stability while suppressing ion migration.

Thickness control of the interlayer is hard to control with the traditional precursor solution and spin-coating technique. A method of growing uniform 2D layers on the 3D perovskite layer was reported by adjusting donor number and dielectric constant of solvents for the 2D layer deposition115. As shown in Fig. 5d, polar aprotic solvents with dielectric constant higher than 30 and donor number ranging ~10-20 kcal/mol were found to be appropriate because they dissolve 2D materials but not 3D underneath layer. Among the studied solvents, acetonitrile (MeCN) was found to be the most suitable solvent to make uniform 2D layer on the 3D perovskite film.

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