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Grain Quality Engineering for Organic Metal halide Perovskites Using Mixed Anti-Solvent Spraying Treatment

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With the rapid development of organic-inorganic lead halide perovskite photovoltaics, there has been increasing attention paid to the understanding of growth mechanism for controlling the quality of perovskite films.[1, 2] In this study, we propose a mixed anti-solvent treatment by spraying acetonitrile (ACN) added chlorobenzene (CBZ) for the fabrication of high-quality perovskite films. We found that while the lower boiling point ACN preserves the morphology of the perovskite film, it has a significant impact on perovskite crystallization dynamics as shown in Figure 1. While CBZ is responsible for facilitating nucleation, ACN performs two functions. ACN as a weak polarity solvent i) allows the organic salt in the perovskite complex to be re-dissolved for perovskite formation and ii) loosens the DMSO-PbI_2 bond for more rapid perovskite crystallization (confirmed by FTIR measurements of as-deposited films). For the mixed anti-solvent treatment to be successful, an appropriate amount of ACN is the key and the use of spraying to dispense the mixed anti-solvent is crucial. This is due to the more instant and rapid reaction caused by the ACN, which is faster than the spreading the ACN across the substrate by the spinning motion. The resultant film using an appropriate mixed anti-solvent treatment is a pinhole-free high quality of perovskite film (confirmed by SEM) with larger grain and enhanced crystallinity (confirmed by XRD results) compared to CBZ only treatment film. The best solar cell using this mixed anti-solvent treatment with 20% of ACN and 80% of CBZ achieved a PCE of 19.0% due to the reduced recombination (confirmed by PL measurements). This method presents an alternative approach to control the quality of the perovskite film fabricated by the anti-solvent method. Moreover, the method developed in this work is scalable for future large area devices.

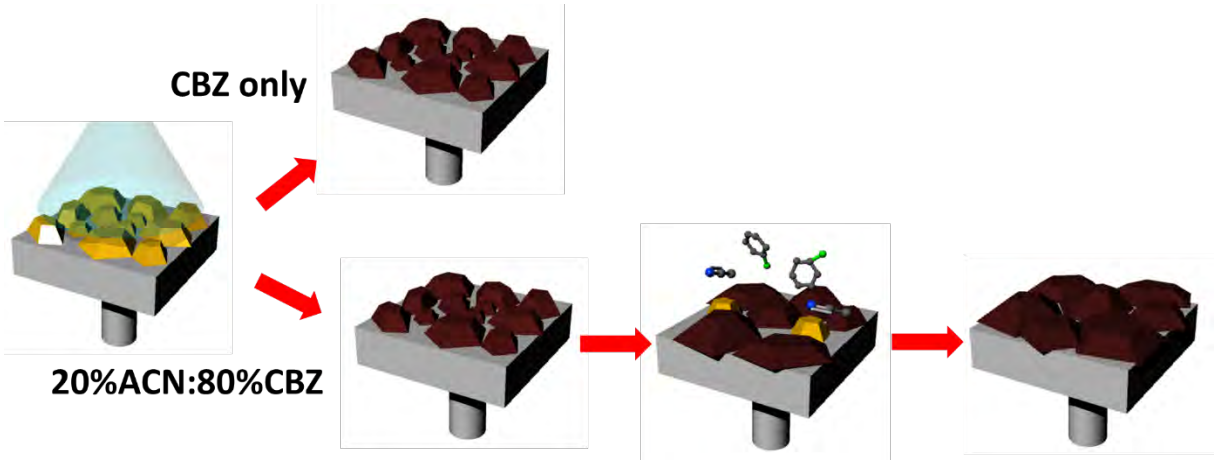

Figure 1. Schematic illustration for nucleation and growth of perovskite film when using CBZ only and a mixture of ACN and CBZ with a ratio of 20:80.

References

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[2] Zhang, M., Wang, Z., Zhou, B. et al., 2018, 'Green Anti-Solvent Processed Planar Perovskite Solar Cells with Efficiency Beyond 19%,' *Sol. RRL*, 2, 1700213