A Novel Cryo-controlled Growth Technique for High Performance Organometal Halide Perovskite Solar Cells

Annie Ng,[1] Zhiwei Ren,[2] Qian Shen,[2] Sin Hang Cheung,[3] Aleksandra B. Djurišić,[4] Shu Kong Su,[3] Gang Li,[2] and Charles Surya[5]

[1] *Department of Electrical and Computer Engineering, School of Engineering, Nazarbayev University, Astana, Kazakhstan*
[2] *Department of Electronic and Information Engineering, the Hong Kong Polytechnic University, Hong Kong SAR*
[3] *Department of Physics, Hong Kong Baptist University, Hong Kong SAR*
[4] *Department of Physics, the University of Hong Kong, Pokfulam, Hong Kong SAR*
[5] *School of Engineering, Nazarbayev University, Astana, Kazakhstan*

E-mail: *charles.surya@nu.edu.kz*

The recent trend of the high-performance perovskite solar cell (PSC) is based on multi-component perovskite materials. The reproducible perovskite growth techniques are crucial for acquiring mixed halide perovskite films with precise stoichiometry, desirable morphology, and low defect density. Nowadays, solvent engineering techniques involving the formation of Lewis acid-base adduct in precursor films and application of anti-solvent dripping process are the mainstream for preparing solution based mixed halide perovskites. However, there are a number of limitations associated with using anti-solvent techniques to prepare large-scale samples. The morphology of the perovskite films is significantly affected by many factors such as the anti-solvent dripping time, volume and location on the samples. Furthermore, the anti-solvent technique commonly works together with the spin-coating process and it would be difficult to apply to other large-scale solution processing techniques.

A novel cryo-controlled growth technique is demonstrated to grow mixed halide perovskite for PSCs. The abrupt decrease in the ambient temperature results in a supersaturation condition in as-cast precursor films, leading to form uniform nucleation sites for subsequent crystal growth. A blow dry process is introduced subsequently to facilitate the removal of residual solvents from the films before thermal annealing. Our proposed strategies can effectively retard the pre-mature crystallization of the perovskites and, thereby, decoupling the nucleation and crystallization phases. This material growth approach can be applied to different types of mixed halide perovskites, ensuring excellent uniformity of the nucleation layers and, subsequently, higher quality perovskite films. Power conversion efficiency (PCE) of 21.4% with a fill factor of 80% for the champion PSC can be achieved by using the proposed perovskite growth technique without incorporation of anti-solvent.