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Controlling crystal formation for more efficient and reproducible perovskite solar cells

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Perovskite ($CH_3NH_3PbI_3$) solar cells have been fabricated by a two-step sequential deposition process whereby a PbI_2 film is first spin-coated on a mesoporous TiO_2 film, followed by immersion in CH_3NH_3I (MAI) solution for conversion to perovskite ($PbI_2 + CH_3NH_3I \rightarrow CH_3NH_3PbI_3$). Varying amounts of residual PbI_2 remain in the perovskite active layer due to incomplete conversion. The losses in photocurrent due to the residual PbI_2 result in poor and inconsistent solar cell performance. As the PbI_2 morphology is likely to have a significant effect on the formation and composition of the nanocrystalline perovskite layer, we investigate the PbI_2 film formation via three different processes (thermal drying, solvent extraction and as-deposited) and the effects of these processes on solar cell performance. It is found that the dense, multi-crystal aggregates in thermally dried PbI_2 films hinder MAI penetration and reaction, resulting in approximately 19% residual PbI_2 in the perovskite layer after the conversion process. The residual PbI_2 fraction is significantly reduced to approximately 4% when the PbI_2 film is formed by solvent extraction using dichloromethane (DCM-extraction). The loosely packed disc-like PbI_2 crystals facilitate MAI penetration and reaction. Near 100% conversion to perovskite is achieved when the as-deposited PbI2 film is immersed in MAI solution without any further drying. Perovskite solar cells fabricated from as-deposited PbI_2 films show superior and more consistent performance with an average power conversion efficiency of 14.60 ± 0.55% compared to that of 11.20 ± 3.10% when thermally dried PbI_2 films are used. By optimizing the PbI_2 and perovskite crystal formation process, we have enhanced both the performance and reproducibility of perovskite solar cells. High performance, solution-processed perovskite solar cells are promising candidates for future urban sustainability solutions.

Biography

Siew-Lay Lim received her BE and PhD in Chemical and Biomolecular Engineering from the National University of Singapore, Singapore. She is currently a Research Scientist at the Institute of Materials Research and Engineering, Agency of Science, Technology and Research (A*STAR), Singapore. Her research interests include organic and hybrid electronic materials and devices, such as transistors, photovoltaic cells and LEDs, materials systems and processes for printed electronics and large area printing of functional materials.

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