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Large-Area Film Fabrication for Perovskite Solar Cell via Scalable Thermal-Assisted and Meniscus-Guided Bar Coating

Authors : Gizachew Belay Adugna

Abstract : Scalable and cost-effective device fabrication techniques are urgent to commercialize the perovskite solar cells (PSCs) for the next photovoltaic (PV) technology. Herein, large-area films of perovskite and hole-transporting materials (HTMs) were developed via a rapid and scalable thermal-assisting bar-coating process in the open air. High-quality and large crystalline grains of $MAPbI_3$ with homogenous morphology and thickness were obtained on a large-area (10 cm×10 cm) solution-sheared mp-TiO_2/c-TiO_2/FTO substrate. Encouraging photovoltaic performance of 19.02% was achieved for devices fabricated from the bar-coated perovskite film compared to that from the small-scale spin-coated film (17.27%) with 2,2′,7,7′-tetrakis-(N,N-di-p-methoxyphenylamine)-9,9′-spirobifluorene (spiro-OMeTAD) as an HTM whereas a higher power conversion efficiency of 19.89% with improved device stability was achieved by capping a fluorinated (HYC-2) HTM as an alternative to the traditional spiro-OMeTAD. The fluorinated exhibited better molecular packing in the HTM film and deeper HOMO level compared to the nonfluorinated counterpart; thus, improved hole mobility and overall charge extraction in the device were demonstrated. Furthermore, excellent film processability and an impressive PCE of 18.52% were achieved in the large area bar-coated HYC-2 prepared sequentially on the perovskite underlayer in the open atmosphere, compared to the bar-coated spiro-OMeTAD/perovskite (17.51%). This all-solution approach demonstrated the feasibility of high-quality films on a large-area substrate for PSCs, which is a vital step toward industrial-scale PV production.

Keywords : perovskite solar cells, hole transporting materials, up-scaling process, power conversion efficiency
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