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Ambient-air-solution-processed efficient and highly stable perovskite solar cells based on $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x\text{-NiO}$ composite with $\text{Al}_2\text{O}_3/\text{NiO}$ interfacial engineering

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Abstract

The poor air-stability and reproducibility of perovskite solar cells (PSCs) have prevented the practical applications of the devices that can withstand sustained operation under ambient air conditions. Here, we report all-ambient-air-solution-processed PSCs based on $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$ -NiO composite film with inserting $\text{Al}_2\text{O}_3/\text{NiO}$ at the TiO_2 /perovskite interface in a cell configuration of FTO/c- TiO_2 /mp- TiO_2 / $\text{Al}_2\text{O}_3/\text{NiO}/\text{MAPbI}_{3-x}\text{Cl}_x$ -NiO/spiro-OMeTAD/Au. The interface engineering with $\text{Al}_2\text{O}_3/\text{NiO}$ not only improves crystalline quality of perovskite films and enhances charge transport, but also effectively suppresses carrier recombination. This composite-based interface engineering PSCs showed a high power conversion efficiency (*PCE*) of 18.14 % and excellent reproducibility with average 16-18 % *PCE* for 35 devices. More importantly, the devices without encapsulation showed a significant enhancement in long-term air-stability; the device photovoltaic parameters stabilized after 20 days and sustained its stability over 210 days with retaining ~100% of its original V_{oc} , ~94% of J_{sc} , ~91% of *FF* and ~86% of *PCE* in an ambient environment.

Keywords: Perovskite solar cells; $\text{MAPbI}_{3-x}\text{Cl}_x$ -NiO composite; Interfacial engineering; reproducibility; Air stability

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