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Improving long-term stability of the $CH_3NH_3PbI_3$ – based solar cells by RT-ALD-Al_2O_3 film

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Since few years, many efforts have been done to keep the initial efficiency of the perovskite solar cells over a long time. The $CH_3NH_3PbI_3$-based solar cells have shown an increased long-term stability against ambient conditions while encapsulating them or covering the perovskite film by a thin Al_2O_3 film. Although the solar cells stability with the Al_2O_3 film could be successfully improved it has not lasted for a long time.

In this paper, we will present that by covering the $CH_3NH_3PbI_3$ film with a room temperature atomic layer deposited Al_2O_3 (RT-ALD-Al_2O_3) [1,2] one cannot only increase the stability, but more interestingly, one can boost the efficiency of solar cells over time. In particular, the Al_2O_3/$CH_3NH_3PbI_3$ interface is characterized using the X-ray Photoemission Spectroscopy (XPS) and Field Emission Scanning Electron Microscopy (FESEM). The efficiency of the Au/Spiro-OMeTAD/(RT-ALD-Al_2O_3)/$CH_3NH_3PbI_3$/PCBM/TiO_2/ITO/glass solar cells are extracted from the current density-voltage (J-V) characteristics measured under AM1.5G light at 100 Wcm^{-2}. As deduced from the XPS and FESEM studies the ALD precursors only clean the perovskite surface from the –OH groups and do not change its composition. Most importantly, the average efficiency of the solar cells containing 9 RT-ALD-Al_2O_3 cycles increases from 9.4 to 10.8 % but without the RT-ALD layer it decreases from 13.6 to 9.6 % while storing both in the same environmental conditions for 355 days. It is supposed that the excitonic states present in the Al_2O_3 film help to maintain the device fill factor on a constant level over a long time.

[1] M. Kot et al., ChemSusChem 9 (2016) 3401.

[2] M. Kot et al., Nucl. Instrum. Methods Phys. Res. B 411 (2017) 49.