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Supplementary Information

Surface Passivation of Perovskite by Atomic Layer Deposition: a Mechanism Investigation Enabling Efficient Inverted Planar Solar Cells

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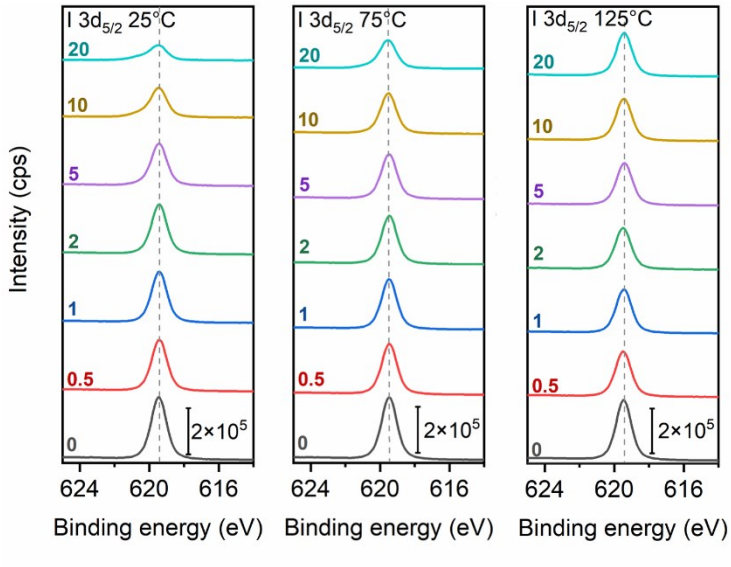

Figure S1 High-resolution XPS core-level spectra of I $3d_{5/2}$ taken from 0 cycles (i.e., initial surface) through 20 cycles of ALD Al_2O_3 on $CH_3NH_3PbI_3$. The deposition temperatures were at 25 °C, 75 °C and 125 °C.

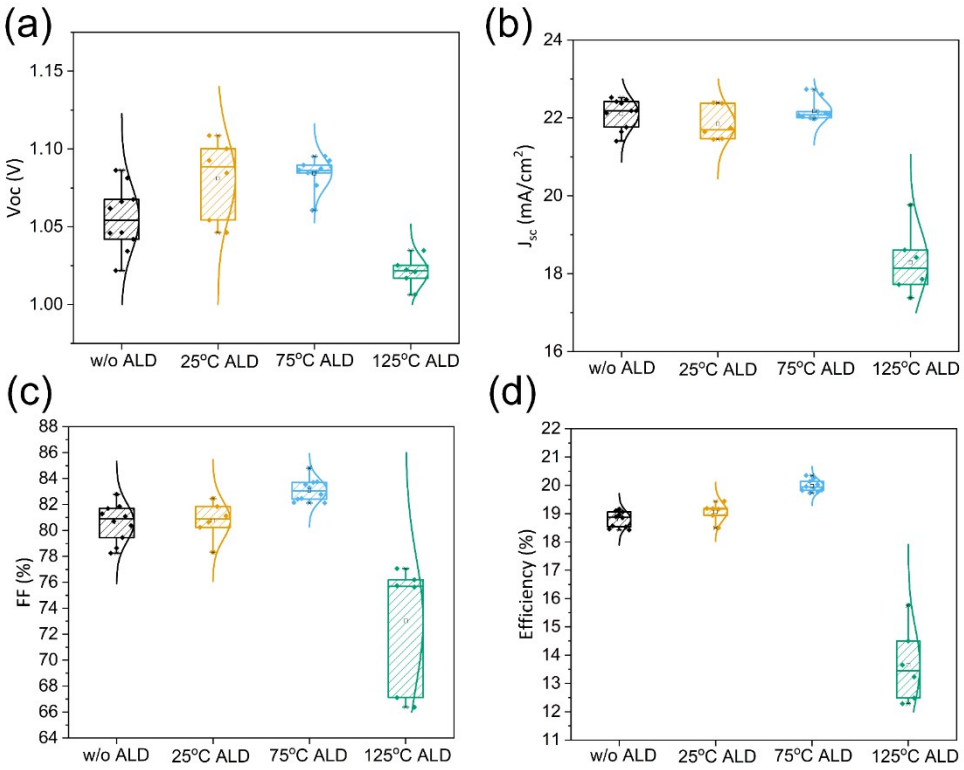

Figure S2 Statistical distributions of open circuit voltage (V_{oc}), short circuit current density (J_{sc}), fill factor (FF), and power conversion efficiency for the perovskite solar cells (PSCs) without ALD and with the ALD Al_2O_3 deposited at 25 °C, 75°C and 125 °C.

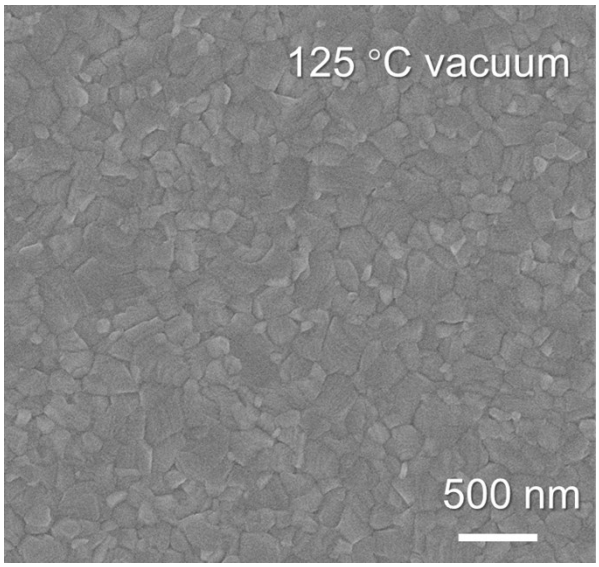

Figure S3 SEM image taken on the $CH_3NH_3PbI_3$ film annealed under vacuum at 125 °C.

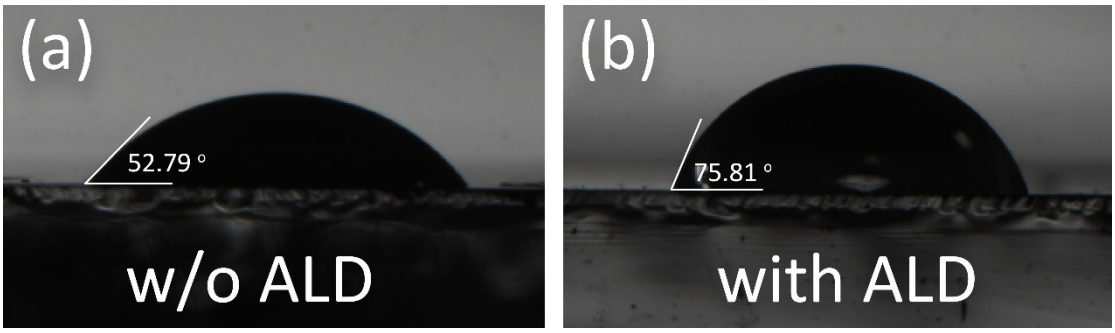

Figure S4 Contact angle measurement for the $MAPbI_3$ film (a) without ALD-Al_2O_3 and (b) with 10 cycle ALD-Al_2O_3 at 75 ^oC.

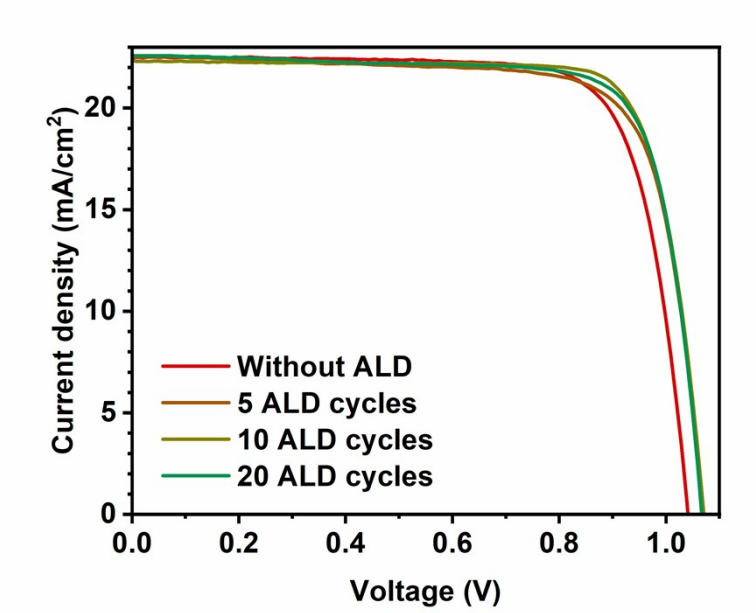

Figure S5 Curves of current density versus voltage for the PSCs without ALD (red) and with 5- (brown), 10- (dark yellow), and 20-cycle (green) ALD Al_2O_3 deposited at 75 °C.

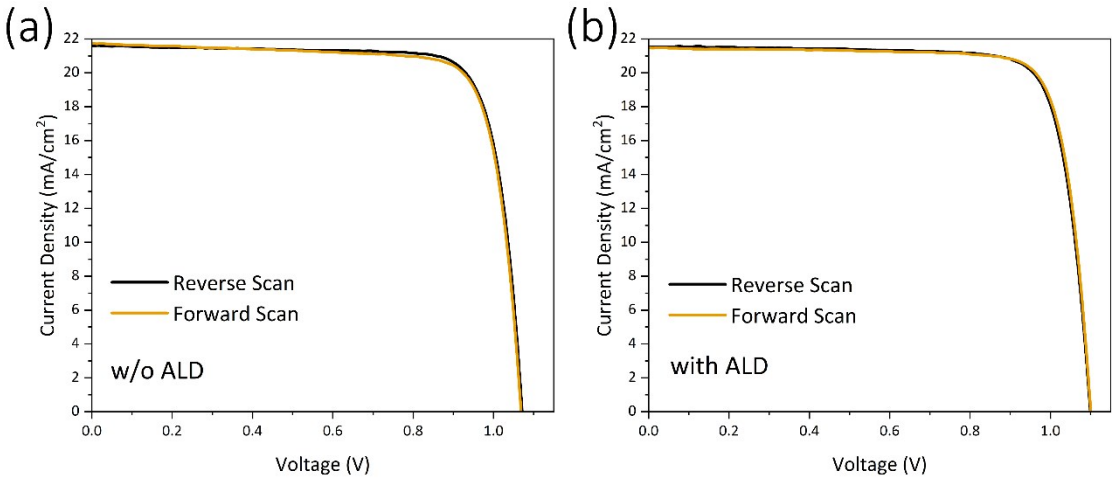

Figure S6 The reverse and forward scan J-V curves for the PSCs (a) without ALD-Al_2O_3 and (b) with 10 cycle ALD-Al_2O_3 at 75 ^oC.

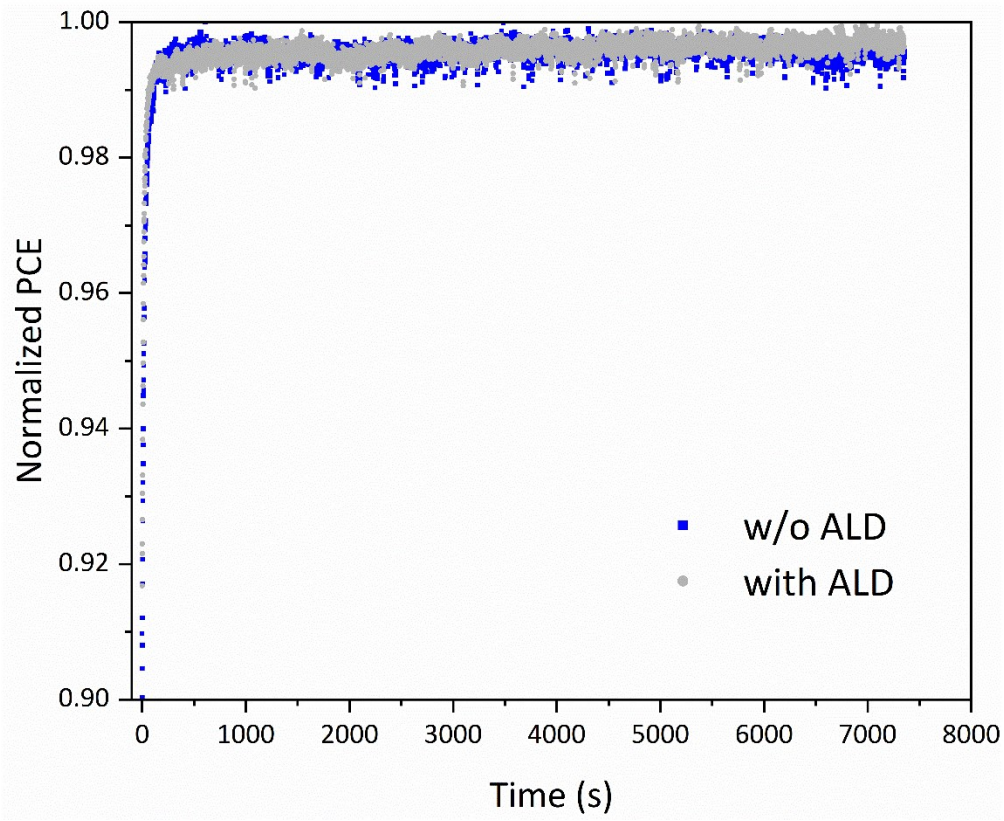

Figure S7 The maximum power point tracking measurement for the PSCs without and with 10 cycle ALD-Al_2O_3 at 75 ^oC.

Table S1 Fitted decay times of PSCs with and without ALD Al_2O_3 from time-resolved photoluminescence spectra. “Glass side” means that the incident light came from the glass side, and the “air side” means that the incident light came from the PVK side (PVK sample) or the Al_2O_3 side (PVK/Al_2O_3 sample).

Sample	τ_1 (ns)	A_1	τ_2 (ns)	A_2	τ_{ave} (ns)
PVK-air side	5.72	0.72	29.52	0.24	20.88
PVK/Al_2O_3-air side	9.10	0.45	84.30	0.29	73.39
PVK-Glass side	7.55	0.67	61.62	0.28	49.42
PVK/Al_2O_3-Glass side	8.86	0.53	89.52	0.29	77.52