ARTICLE

## Supplementary information



Fig. S1. Experimental set-up used for Raman-photocurrent-photoluminescence mapping



**Fig. S2. (a)** Pbl<sub>2</sub> film thickness as a function of concentration. **(b)** Raman spectra of Pbl<sub>2</sub> thin films on glass with different thicknesses. **(c)** Pbl<sub>2</sub> Raman intensity integrated between 80 cm<sup>-1</sup> and 140 cm<sup>-1</sup> as a function of film thickness. The dotted line is a polynomial fit of experimental data.



**Fig. S3.** (a) Typical J-V curves of perovskite solar cells with structure glass/ITO/NiO<sub>x</sub>/CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub>/PCBM/BCP/Ag using stoichiometric or 5% PbI<sub>2</sub> excess perovskite solution. (b) statistical power conversion efficiency data for 10 different devices having stoichiometric or 5% PbI<sub>2</sub> excess perovskite.



**Fig. S4.** Raman spectra of MAPbl<sub>3</sub> films on ITO/glass substrates prepared with different amounts of Pbl<sub>2</sub> excess. Each spectrum is an average of 200 data points measured using laser power of 0.15 mW for 10 s.



**Fig. S5.** high and low magnification SEM top-view images of perovskite films degraded with (a-b) 0.03 mW laser power for 120 s and (c-d) 0.3 mW laser power for 120 s in air, with corresponding Energy Dispersive Spectroscopy (EDS) measurements taken at various locations along the degraded spot (b and d).