Supporting Information

Composition-dependent photoluminescence intensity and prolonged recombination lifetime of perovskite CH₃NH₃PbBr_{3-x}Cl_x films

Meng Zhang, Hua Yu, Miaoqiang Lyu, Qiong Wang, Jung-Ho Yun, Lianzhou Wang*

Nanomaterials Centre, School of Chemical Engineering and AIBN, The University of Queensland, St Lucia, Qld 4072, Australia. Email: <u>l.wang@uq.edu.au</u>

Sample preparation

Methylammonium bromide (MABr) was synthesized before preparing perovskite precursor solutions. Hydrobromic acid (18 mL, 48 wt.% in water, Sigma-Aldrich) and methylamine (20 mL, 33% in ethanol, Sigma-Aldrich) were mixed in 100 ml anhydrous ethanol and stirred in a glass bottle with ice bath. After stirring at 0 $^{\circ}$ C for 2 h, the resulting solution was evaporated at 50 $^{\circ}$ C by a rotary evaporator. The product of MABr powder was washed with diethyl ether for at least 3 times and dried in a vacuum oven over night. The MAPbBr_{3-x}Cl_x perovskite precursor solutions were prepared by dissolving (2M, 1.5M, 1M, 0.75M) CH₃NH₃Br and 0.25M PbCl₂ (Sigma-Aldrich) in N,N-Dimethylformamide (anhydrous, Sigma-Aldrich) and sonicated at 60°C for 30 min.

In order to get a more reliable comparison for the samples, a thick (~1.5 μ m) insulating mesoporous Al₂O₃ layer was chosen as the scaffold of the perovskite film. The mesoporous Al₂O₃ layer was deposited by spin-coating the suspension of 20 wt. % Al₂O₃ (< 50nm) in isopropanol (Sigma-Aldrich) at 2000 rpm for 15s on a glass substrate. The perovskite layer was spin-coated onto Al₂O₃ layer at 2000 rpm for 30s and followed by heating at 100 ^oC for 1 min using a hot plate.

Characterizations

X-ray diffraction (XRD) data was obtained from a Bruker Advanced X-ray diffractometer (40 kV and 30 mA) with Cu K α 1 (λ = 0.15406 nm) radiation. Cross-sectional morphology image were taken using a scanning electron microscope (SEM, JEOL 7001). Visible light absorbance spectra of solutions were measured by Jasco V-650 spectrophotometer with an integrating sphere. The photoluminescence (PL) measurements were conducted with a fluorescence spectrometer (FLS 920, Edinburgh Instruments Ltd) at room temperature. The emission spectra and lifetime were measured by exciting the samples with a light beam from 450 W Xe lamp at 400 nm and nanosecond flash laser beam at 377 nm, respectively.

Figures



Fig. S1. XRD patterns of the Al₂O₃ precoated glass substrate.



Fig. S2. Light absorption spectra of MAPbBr_{3-x}Cl_x samples.



Fig. S3. PL emission spectra of $MAPbI_{3-x}Br_x$, inset: Enlarged view for $MAPbI_2Br$ and $MAPbIBr_2$.



Fig. S4. XRD patterns of the fresh $MAPbI_3$ film: black for day 1 and red for day 2.