Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Light induced Degradation in Mixed-Halide Perovskites

Supporting Information

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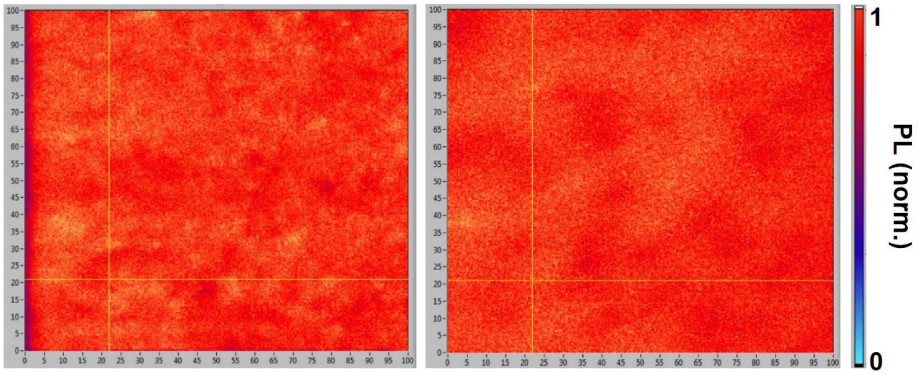


Figure S1. The PL mapping images of $MAPbI_1Br_2$ and $MAPbI_2Br_1$ films excited by 407 nm laser. The measured PL for $MAPbI_1Br_2$ is 650 nm and for $MAPbI_2Br_1$ is 690 nm,

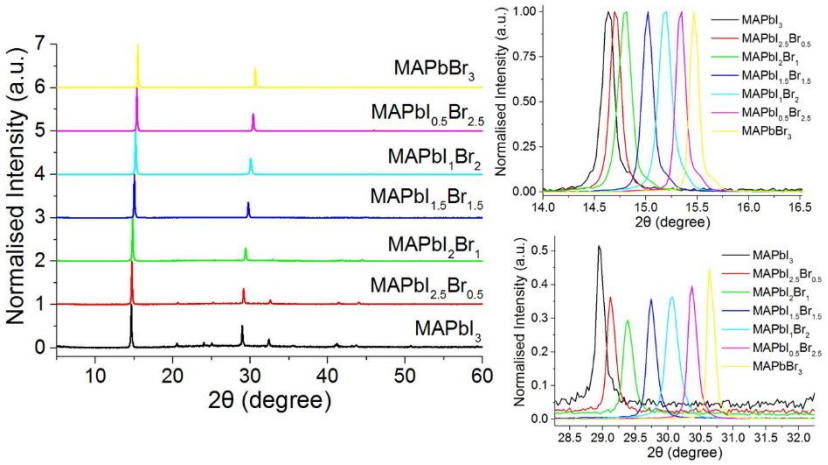


Figure S2. The XRD patterns of the freshly prepared $MAPbI_{3-x}Br_x$ films (x = 0.5, 1.0, 1.5, 2.0, 2.5).

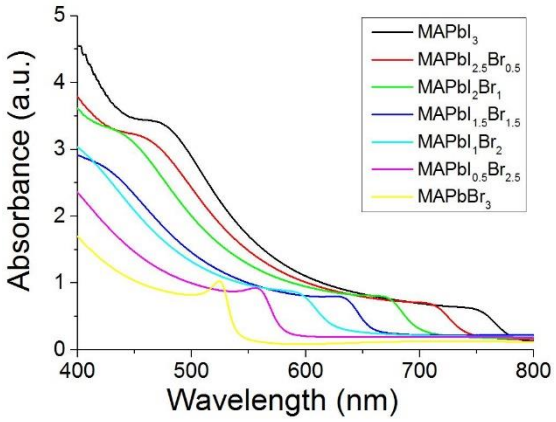


Figure S3. The absorbance spectra of the freshly prepared $MAPbI_{3-x}Br_x$ films (x = 0.5, 1.0, 1.5, 2.0, 2.5).

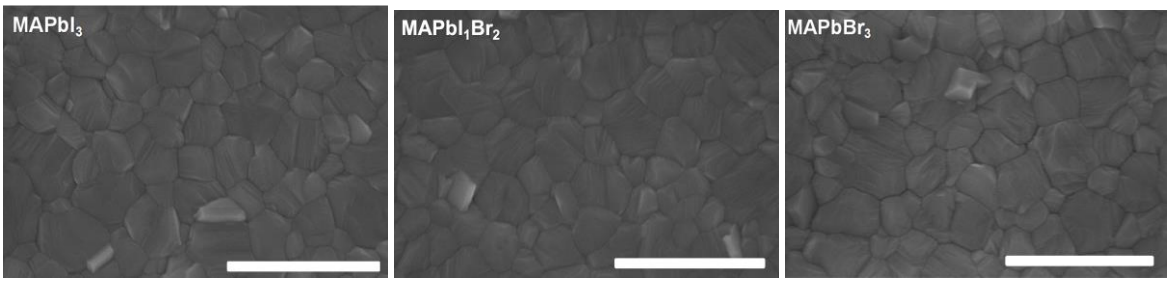


Figure S4. The SEM images of $MAPbI_3$ (left) $MAPbI_1Br_2$ (middle) $MAPbBr_3$ (right). The scare bar indicates 1 μm.

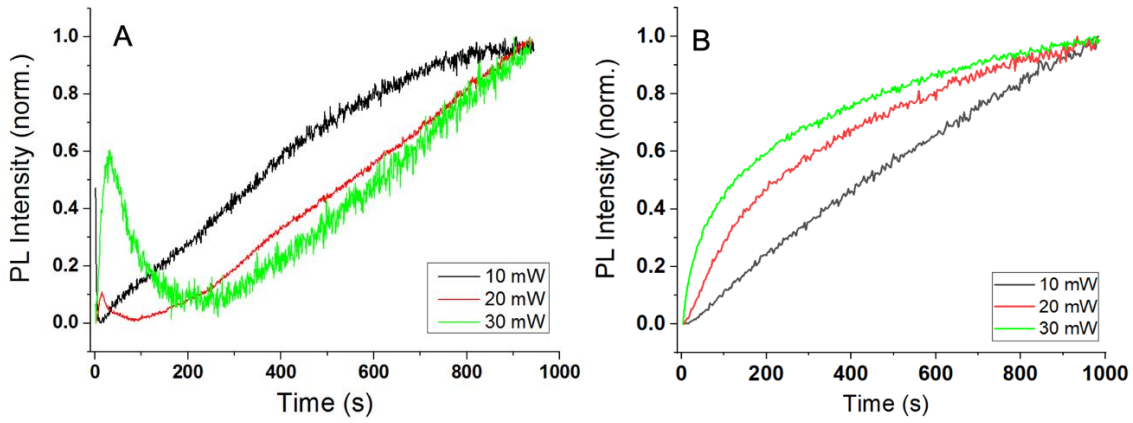


Figure S5. Change in PL intensity at 530 nm for $MAPbBr_3$ films under continuous 407 nm laser illumination in the air (a) and nitrogen environment (b).

Table S1. The Raman peak frequency for the studied $MAPbI_3Br_{3-x}$ single crystals. All unit in cm^{-1}.

	C-N rocking	C–N stretching	C-N rocking	asym. CH_3 bending	sym. CH_3 bending	asym. NH_3^+ bending
$MAPbI_3$	908	958	1240	1421	1465	1579
$MAPbI_1Br_2$	914	963	1246	1425	1472	1585
$MAPbBr_3$	917	966	1248	1427	1476	1588

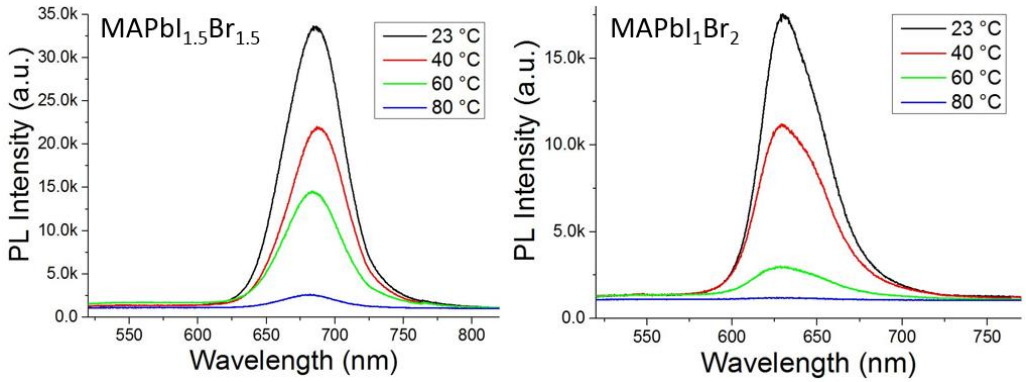


Figure S6. High temperature induced PL quenching for perovskite films in the open air. No peak was found at 530 nm.

Table S2. The unit conversion from laser power (mW) to the intensity (W/cm^2) used in this study.

Laser power (mW)	0.1	1	5	10	20	40	60
Laser intensity (W/cm^2)	0.45	4.5	22	44	88	180	270

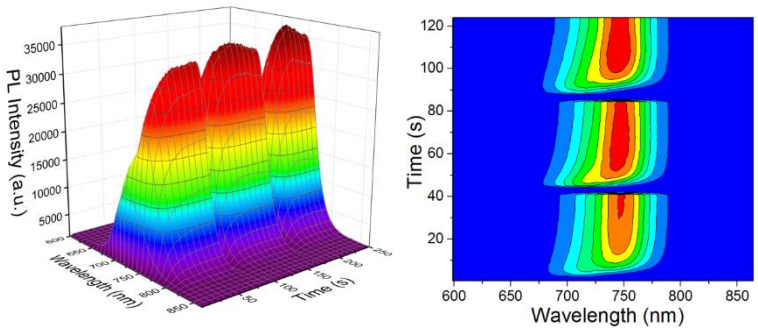


Figure S7. The reversible phase segregation of $MAPbI_2Br_1$ film under 1 mW 407 nm laser illumination. Laser was blocked for 20 min between each cycle. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

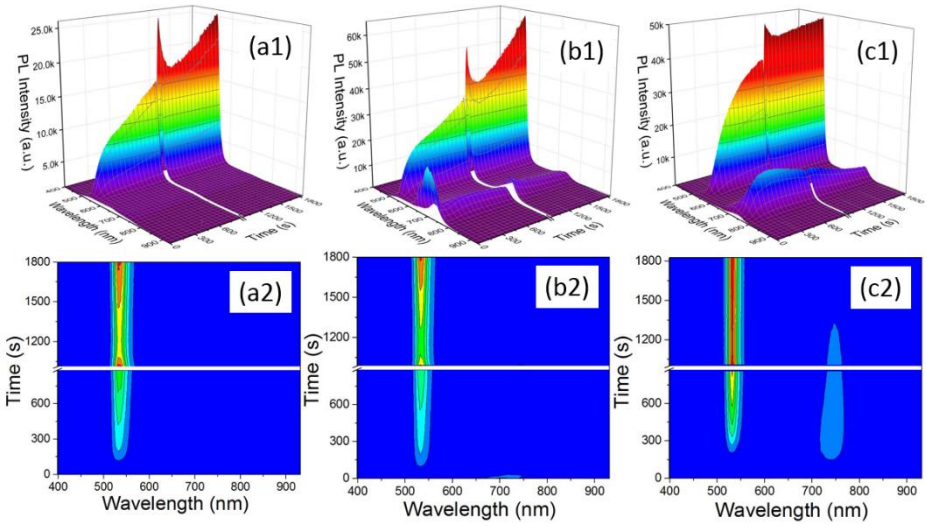


Figure S8. The irreversible phase degradation of $MAPBI_{0.5}Br_{2.5}$ (a), $MAPBI_1Br_2$ (b) and $MAPBI_{1.5}Br_{1.5}$ (c) films under 40 mW 407 nm laser illumination. Laser was blocked for 20 min between each cycle. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

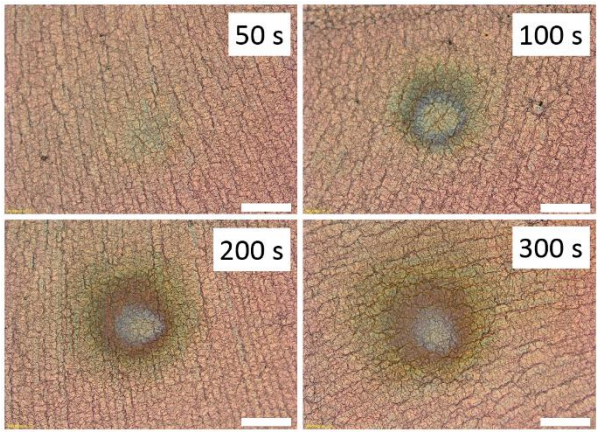
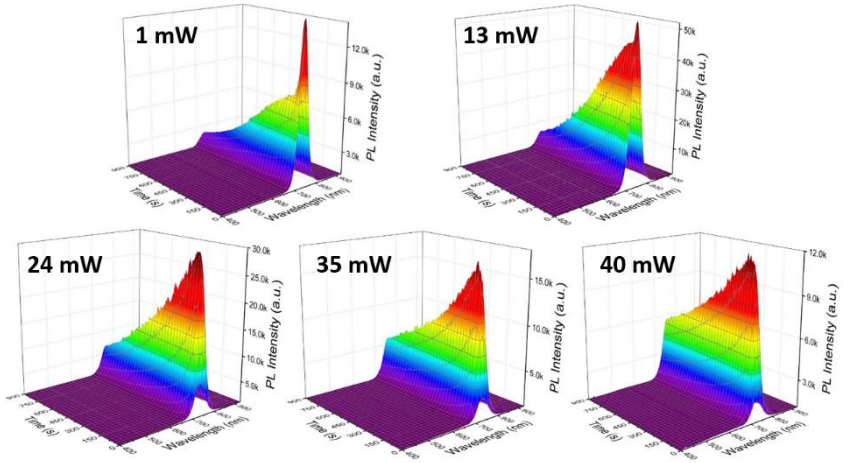


Figure S9. The reflection-mode microscopic images of the time-dependent morphology change of $MAPbI_1Br_2$ film under 20 mW 407 nm laser. All the scale bars indicate 200 µm. We identified the core size of the damaged spot is ~150 um. The appearance of the dark colour surrounding the core is possibly due to light scattering or local heating induced by strong laser.



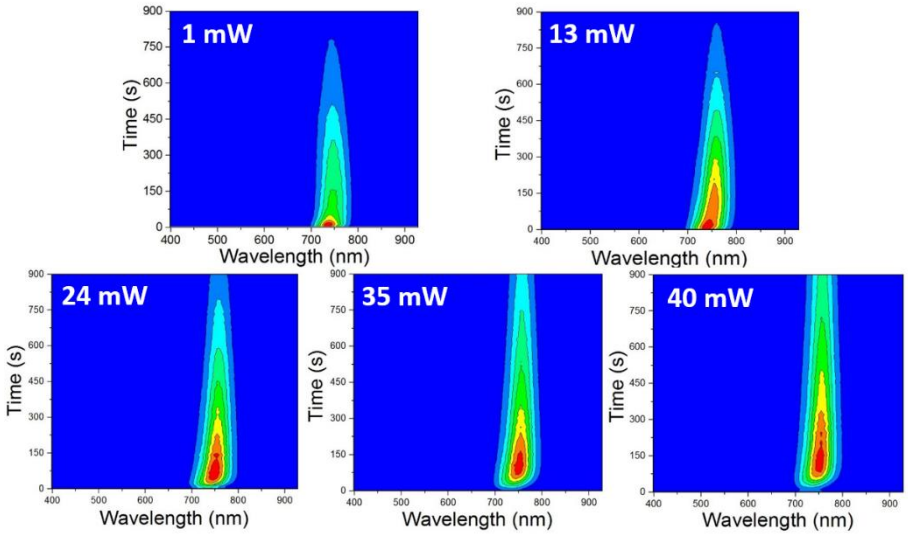


Figure S10. PL spectra of $MAPbI_{2.5}Br_{0.5}$ film as a function of laser power (407 nm) over 900 s. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

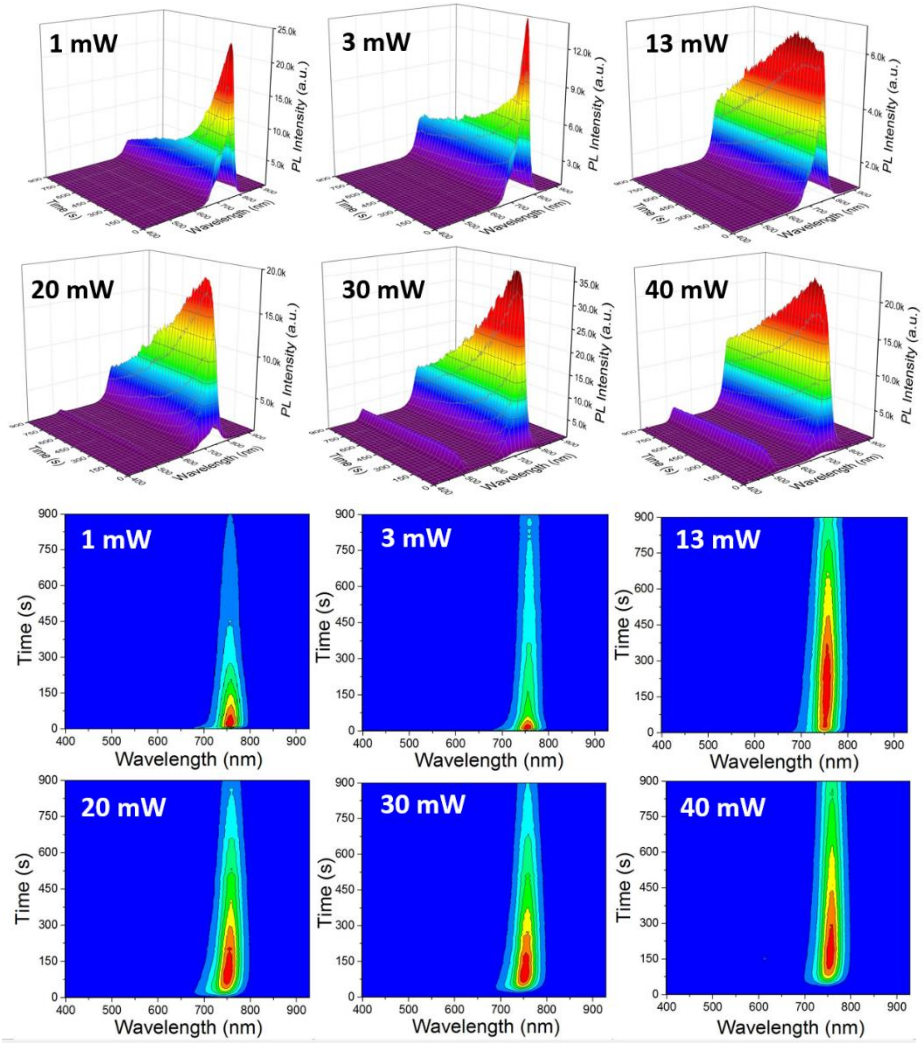


Figure S11. PL spectra of $MAPbI_2Br_1$ film as a function of laser power (407 nm) during 900 s. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

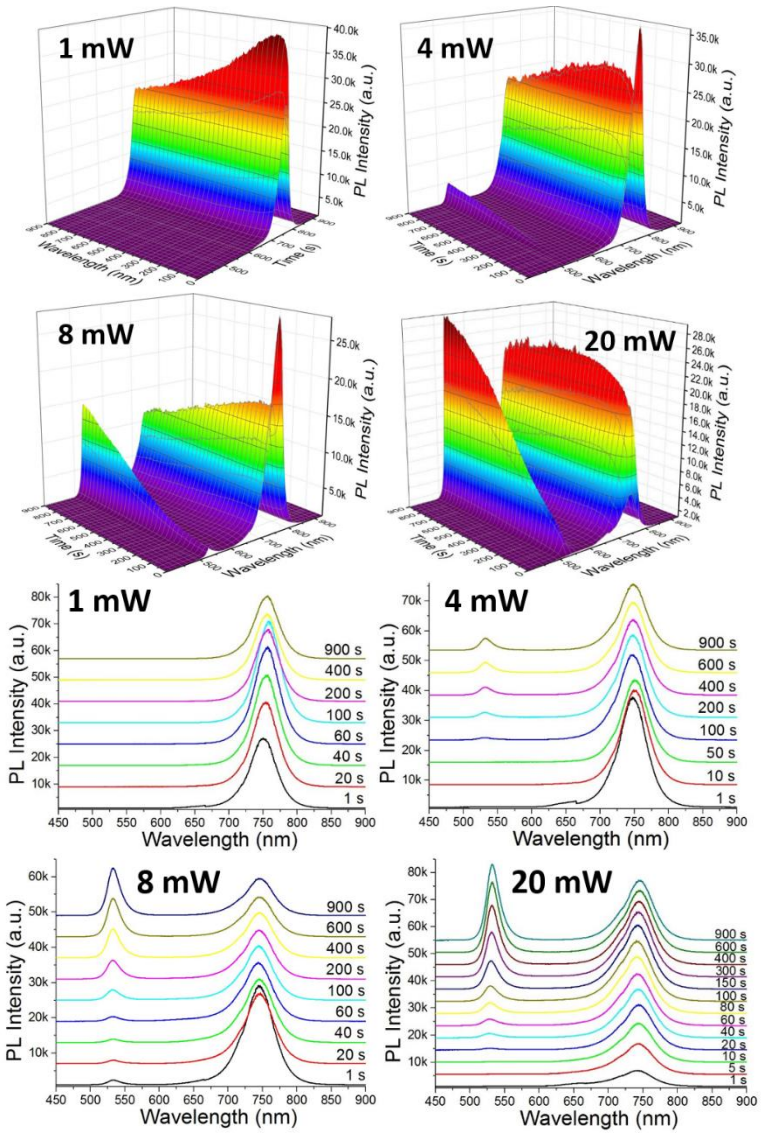


Figure S12. PL spectra of $MAPbI_{1.5}Br_{1.5}$ film as a function of laser power (407 nm) over 900 s. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

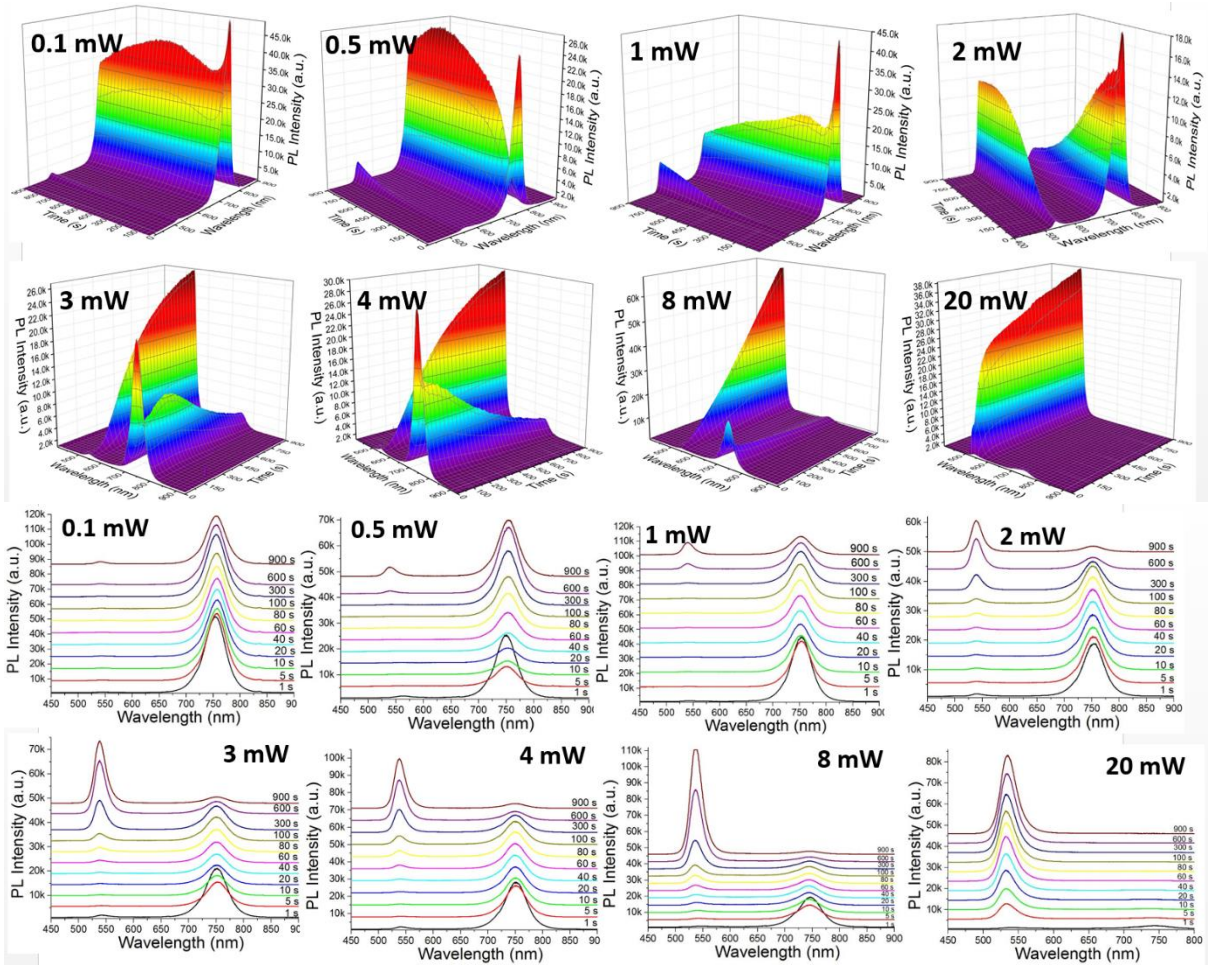


Figure S13. PL spectra of $MAPbI_{0.5}Br_{2.5}$ film as a function of laser power (407 nm) during 900 s. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

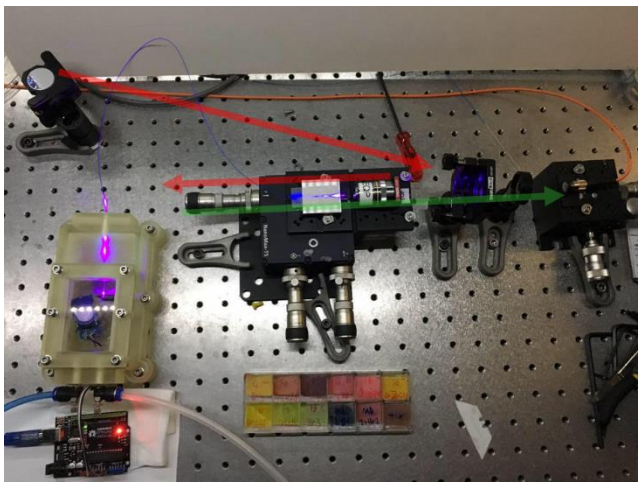


Figure S14. The home-built chamber for O_2 controlling experiment. The Oxygen level was controlled through adjusting the gas flow of pure nitrogen and dry air. Red arrow in the picture indicating the incoming 407 nm light for film excitation and green arrow shows the excited PL transmitted backwards to the spectrometer.

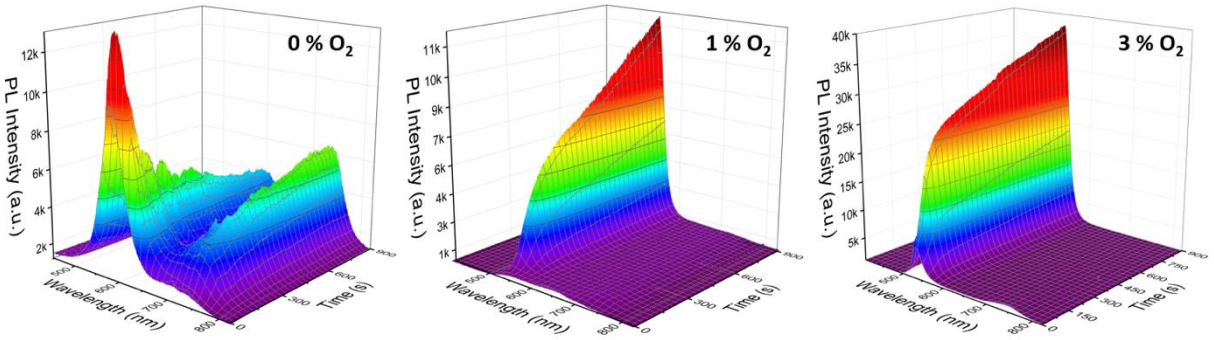


Figure S15. The evolving PL spectra during the 900 s continuous 20 mW laser illumination at different oxygen concentrations for $MAPbI_{0.5}Br_{2.5}$ films. Samples are measured under ambient condition (22 °C, 40 ± 5% RH).

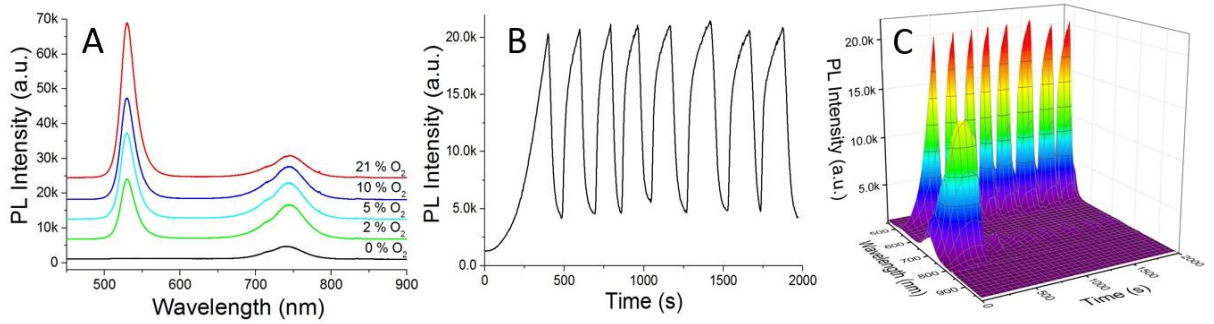


Figure S16. PL emission of $MAPbI_{1.5}Br_{1.5}$ film as a function of oxygen concentration after 900 s illumination by 20 mW 407 nm laser (a). Spectral evolution of oxygen-dependent PL of degraded $MAPbI_{1.5}Br_{1.5}$ film at 530 nm as a function of time in a 1 % oxygen and full nitrogen alternative environment (b), and (c) is the corresponding three-dimensional image indicating the peak position at 530 nm.

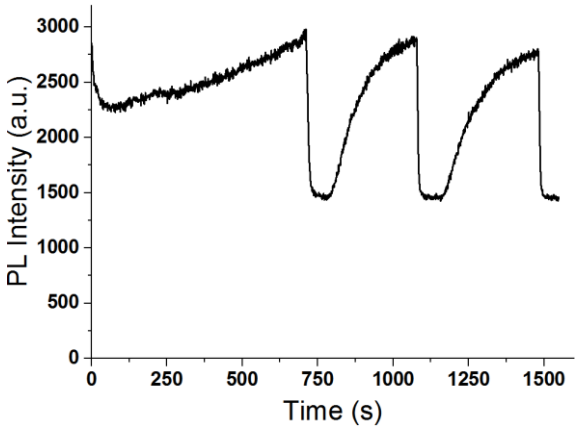


Figure S17. PL Spectral evolution of oxygen-dependent PL of degraded $MAPbBr_3$ film at 530 nm as a function of time in a 1 % oxygen and full nitrogen alternative environment. Film is under illumination by 20 mW 407 nm laser.

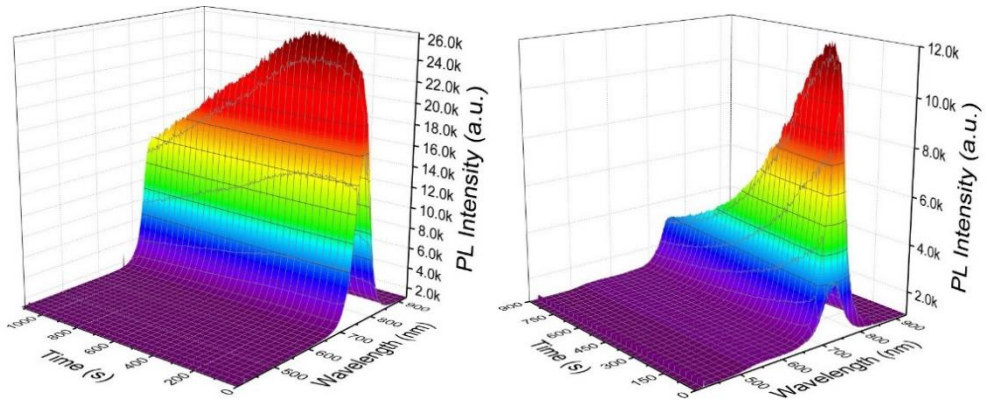


Figure S18. PL spectra of the encapsulated $MAPbI_1Br_2$ (left) and $MAPbI_2Br_1$ (right) film under 20 mW laser power (407 nm) illumination during 900 s. No peak was found at 530 nm.

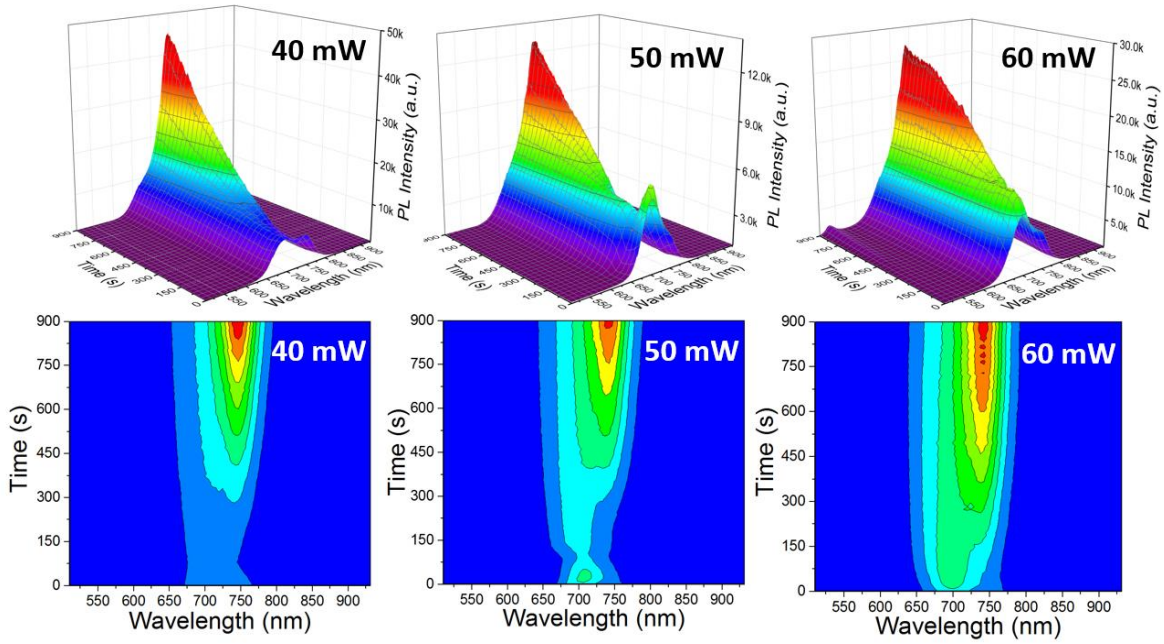


Figure S19. PL spectra of $MAPbI_1Br_2$ perovskite film as a function of laser power (488 nm) during 900 s at ambient conditions.

Supporting references

1. M. Xiao, F. Huang, W. Huang, Y. Dkhissi, Y. Zhu, J. Etheridge, A. Gray-Weale, U. Bach, Y. Cheng and L. Spiccia, *Angew. Chem. Int. Ed.*, **2014**, *53*, 9898.

2. S. Ruan, J. Lu, N. Pai, H. Ebendorff-Heidepriem, Y.-B. Cheng, Y. Ruan and C. R. McNeill, *J. Mater. Chem. C*, 2018, **6**, 6988-6995