# Supporting information

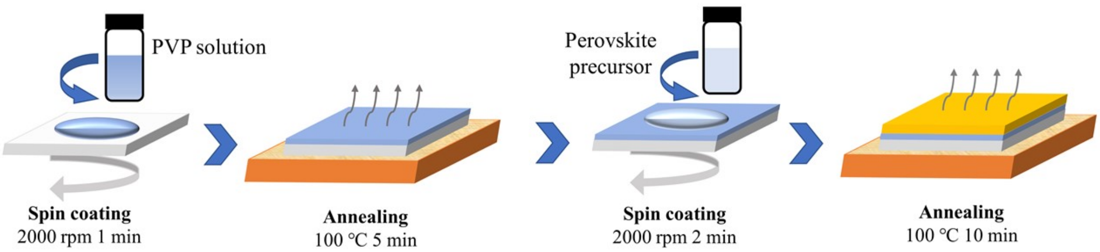


**Fig. S1** The schematic diagram of preparing process of perovskite films.

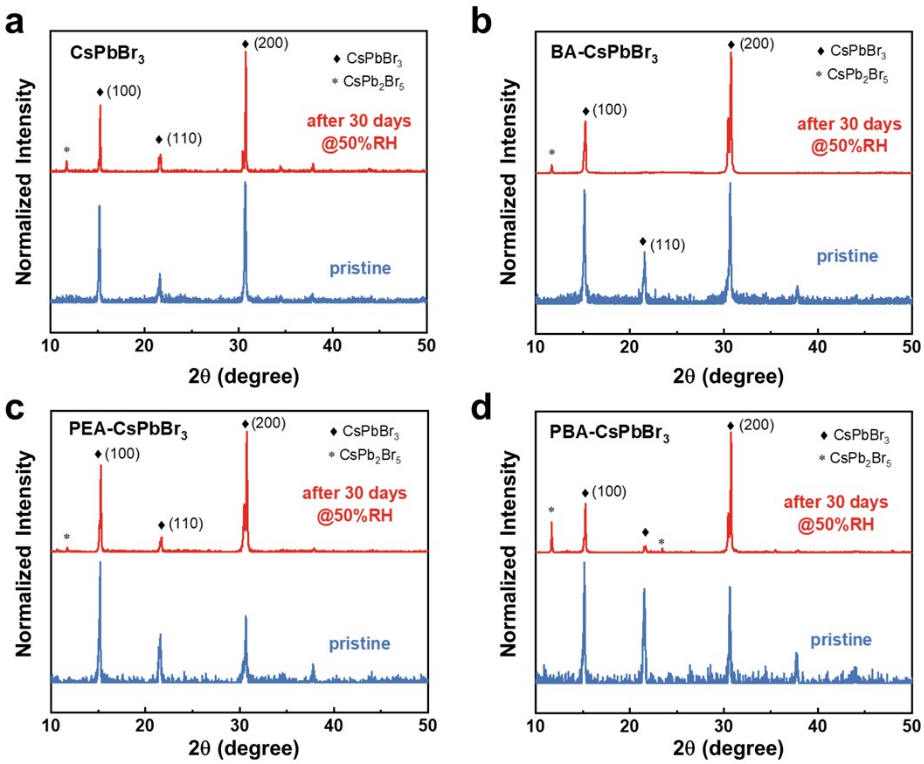


**Fig. S2** XRD patterns of $CsPbBr_3$ films (a), BA-$CsPbBr_3$ films (b), PEA-$CsPbBr_3$ films (c) and PBA-$CsPbBr_3$ films (d) before and after 30 days storage in ambient air (50% RH).

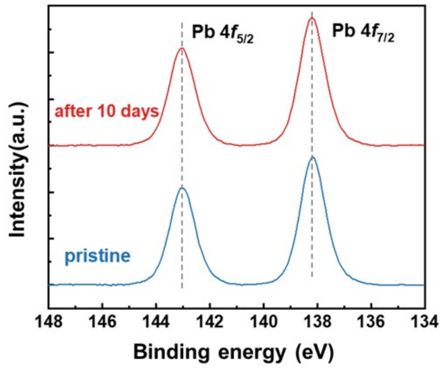


**Fig. S3** XPS Pb 4f core level spectra of OA-$CsPbBr_3$ films before and after storing in ambient air for 10 days. The results show that there is no shift of binding energy in the Pb 4f core level spectra, further confirming the structure stability of OA-CsPbBr3 films.

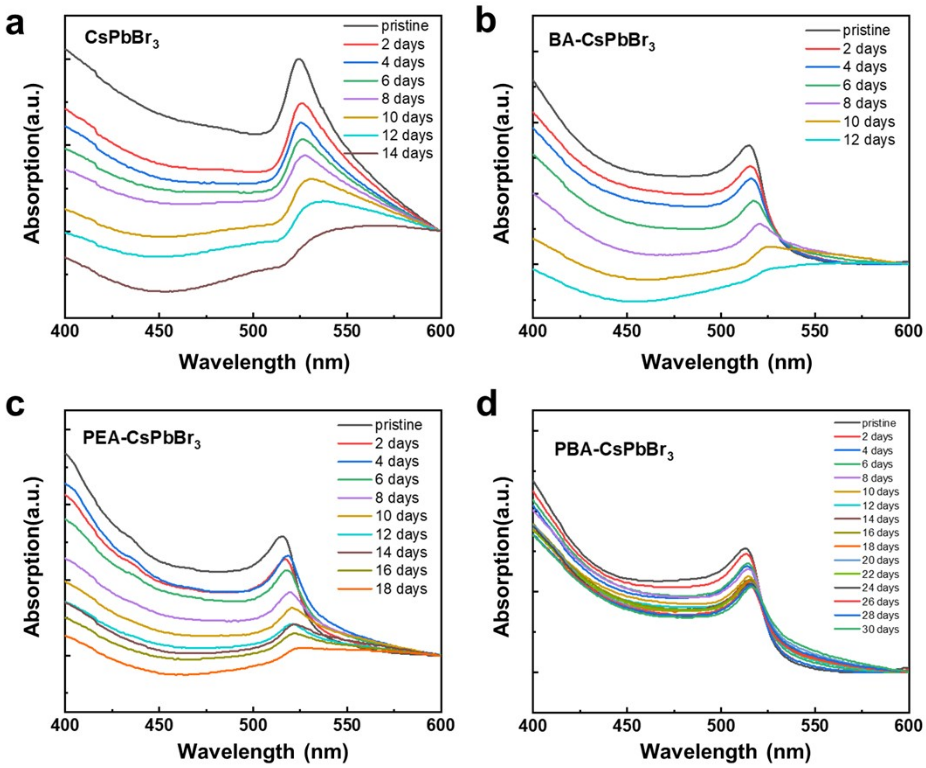


**Fig. S4** The evolution of optical absorption spectra in $CsPbBr_3$ films (a), BA-$CsPbBr_3$ films (b), PEA-$CsPbBr_3$ films (c) and PBA-$CsPbBr_3$ films (d) during long-term storage in ambient air.

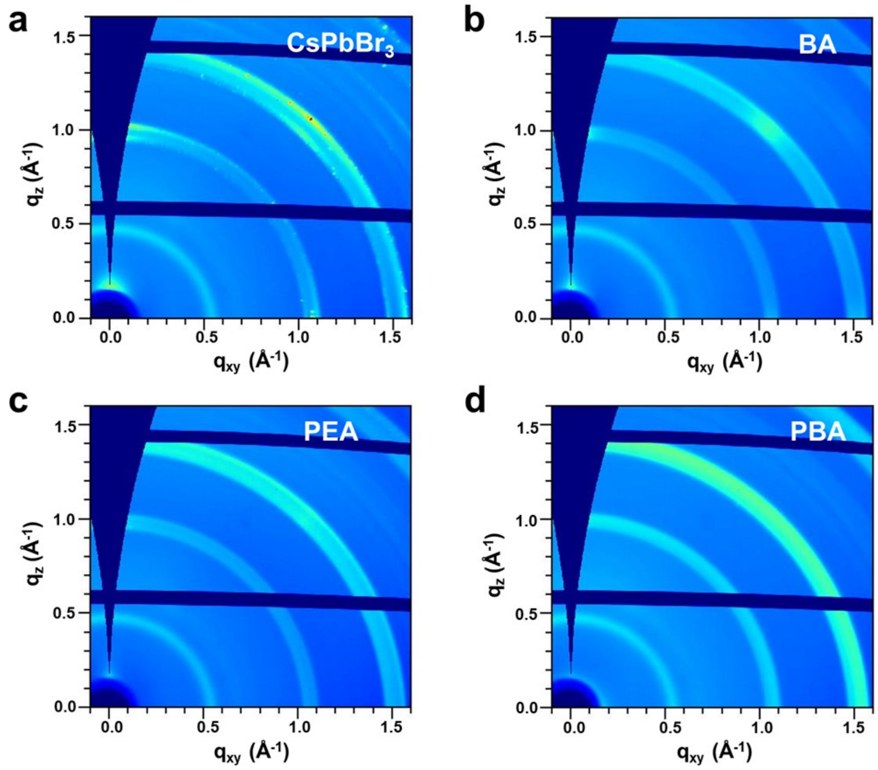


**Fig. S5** GIWAXS patterns of $CsPbBr_3$ film (a), BA-$CsPbBr_3$ film(b), PEA-$CsPbBr_3$ film(c) and PBA-$CsPbBr_3$ film(d).

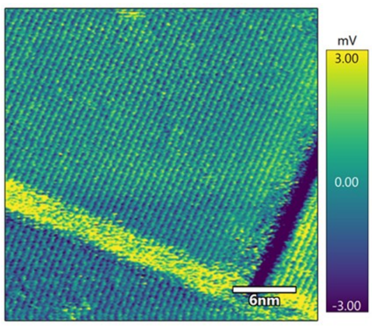


**Fig. S6** The lateral force image of OA-$CsPbBr_3$ film obtained by atomic force microscope.

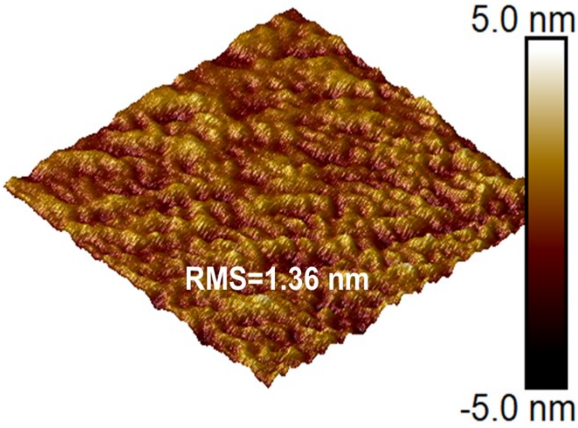


**Fig. S7** The height topography image of OA-$CsPbBr_3$ film obtained from atomic force microscope. The roughness of surface is estimated as 1.36 nm and the scan area of AFM image is 5 μm × 5 μm

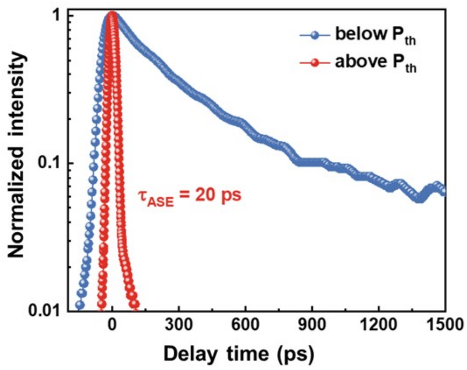


**Fig. S8** Time-resolved PL (TRPL) decay transients of OA-$CsPbBr_3$ film under pump fluences of below and above the threshold.

**Table S1** The element contents on the surfaces of the perovskite films

| | Cs (atomic%) | Pb(atomic%) | Br(atomic%) | N(atomic%) |
|---|---|---|---|---|
| $CsPbBr_3$ | 14.44 | 8.52 | 33.84 | \ |
| BA-$CsPbBr_3$ | 14.96 | 9.11 | 36.07 | 0.05 |
| OA-$CsPbBr_3$ | 13.48 | 9.58 | 39.7 | 0.36 |
| PEA-$CsPbBr_3$ | 16.83 | 10.81 | 44.92 | 0.14 |
| PBA-$CsPbBr_3$ | 8.77 | 6.94 | 44.35 | 0.21 |

**Table S2** ASE performance and stability in ambient air

| Perovskites | Threshold (μJ/cm$^2$) | Stability | Method | Reference |
|---|---|---|---|---|
| $CsPbBr_3$ films | 11.4 | 1000 h | One-step spin coating (MAAc) | [1] |
| $CsPbBr_3$ films | 458 | 2 months | two-step solution method | [2] |
| $MAPbBr_3$ films | 90 | 6000 h | One-step spin coating (MAAc) | [3] |
| PEO-$CsPbBr_3$ films | 176 | 10 months | two-step solution method | [4] |
| $CsPbBr_3$ QDs/PMMA | 7.2 | >7 days | / | [5] |
| $MAPbBr_3$@polymer fibers | 19.9 | 10 days | electrospinning | [6] |
| $CsPbBr_3$ films | 13.7 | 6 months | One-step spin coating (DMSO) | Our work |


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