Science Advances

AAAS

advances.sciencemag.org/cgi/content/full/3/11/eaao5616/DC1

Supplementary Materials for

Strained hybrid perovskite thin films and their impact on the intrinsic stability of perovskite solar cells

Jingjing Zhao, Yehao Deng, Haotong Wei, Xiaopeng Zheng, Zhenhua Yu, Yuchuan Shao, Jeffrey E. Shield, Jinsong Huang

Published 17 November 2017, *Sci. Adv.* **3**, eaao5616 (2017)
DOI: 10.1126/sciadv.aao5616

This PDF file includes:

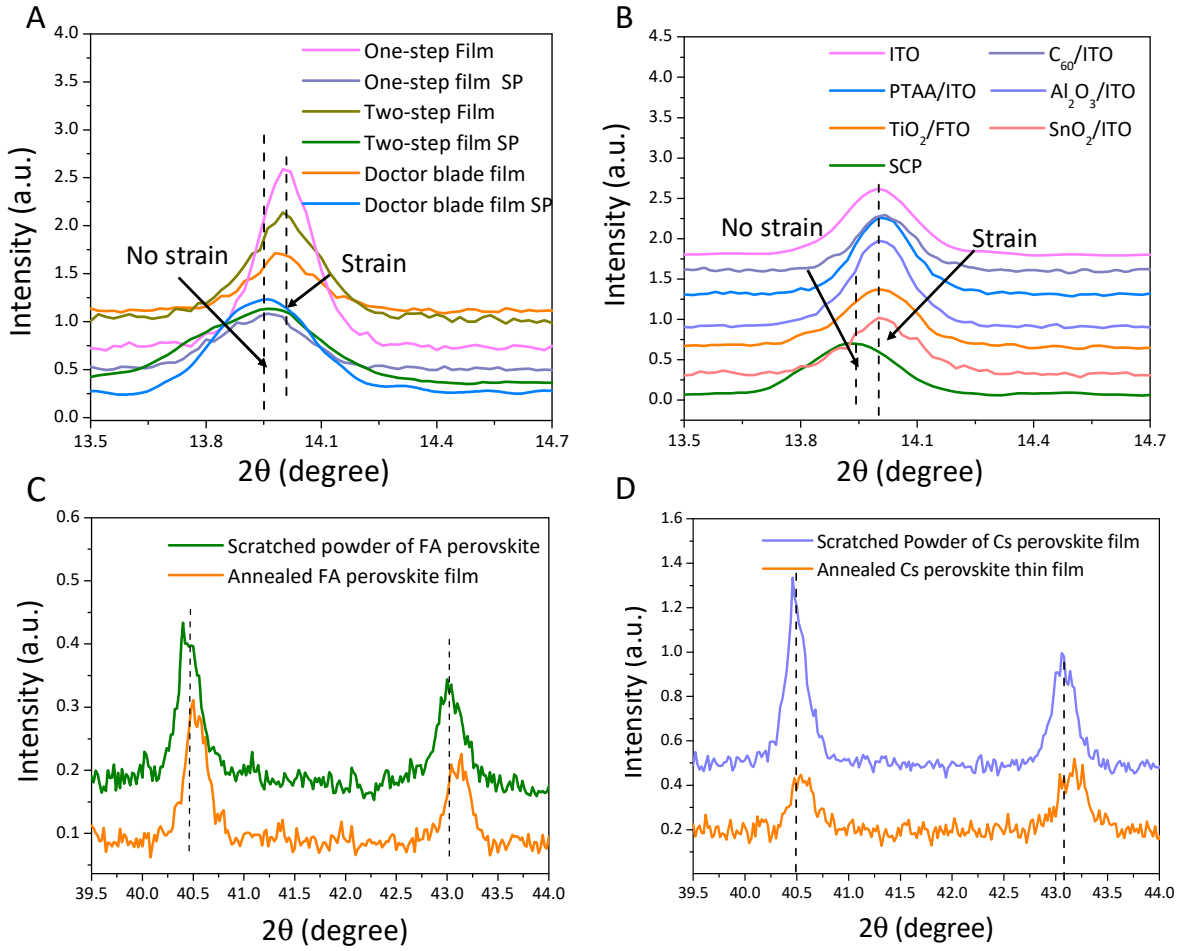

fig. S1. Strain state of $MAPbI_3$ films and scraped powder made by different methods on different substrates and with different compositions. (**A**) Out-of-plane XRD of $MAPbI_3$ film and its corresponding scraped powder (SP) (110) plane made by different methods, including one-step method, two-step method and doctor blading method. (**B**) Out of plane XRD of $MAPbI_3$ single crystal powder (SCP) and films made on different substrates, including ITO/glass, C_{60}/ITO/glass, PTAA/ITO/glass, Al_2O_3/ ITO/glass, TiO_2/FTO/glass and SnO_2/ ITO/glass. (**C**) Out of plane XRD comparison of the annealed film and scraped powder of different perovskites, including FA perovskite ($(FA_{0.85}MA_{0.15})Pb(I_{0.85}Br_{0.15})_3$) and (**D**) Cs perovskite ($Cs_{0.05}(FA_{0.85}MA_{0.15})_{0.95}Pb(I_{0.85}Br_{0.15})_3$).

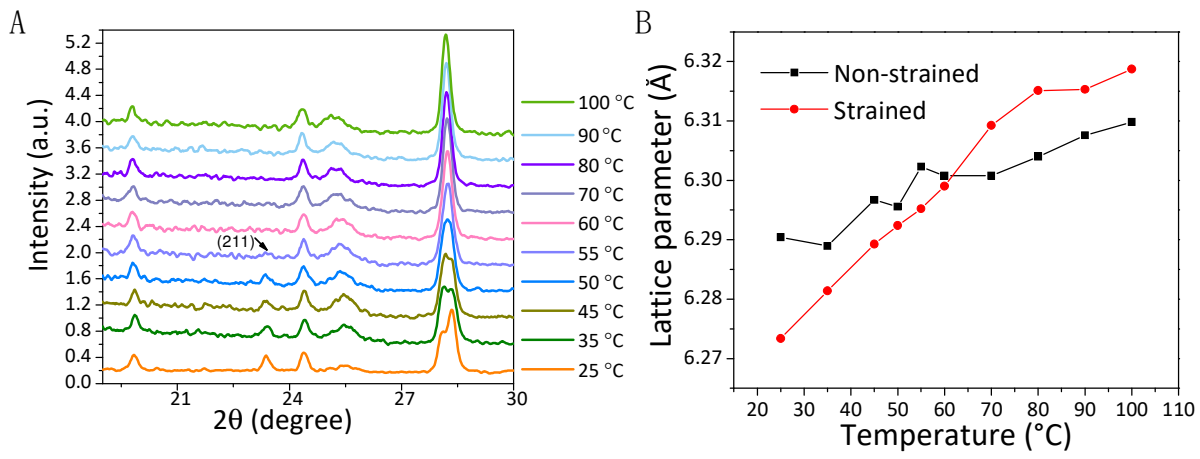

fig. S2. In situ out-of-plane XRD and the calculated lattice parameter of the $MAPbI_3$ powder under different temperatures. (**A**) In-situ out of plane XRD of $MAPbI_3$ power. At 55 ˚C, the (211) peak starts to disappear. (**B**) Lattice parameters of the strained perovskite film and the non-strained perovskite powder. The lattice parameter for tetragonal $MAPbI_3$ is represented by (2a+c)/3.

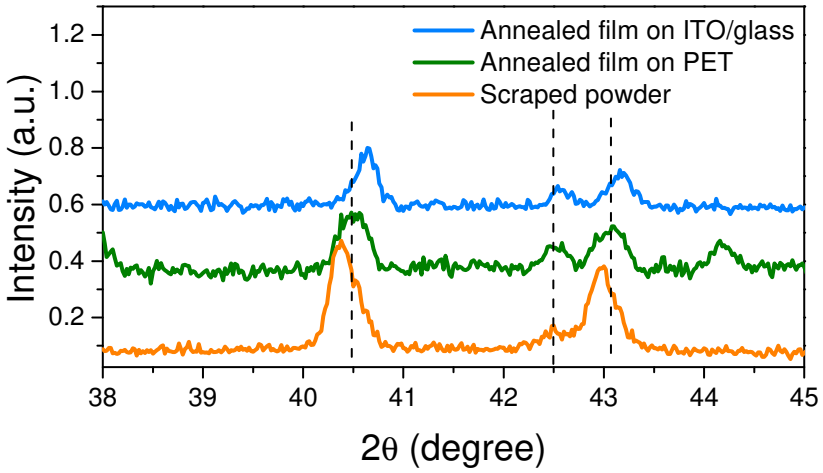

fig. S3. Strain state for $MAPbI_3$ on PET substrate. Out of plane XRD of the $MAPbI_3$ scraped powder, annealed films on ITO/glass and PET substrates.

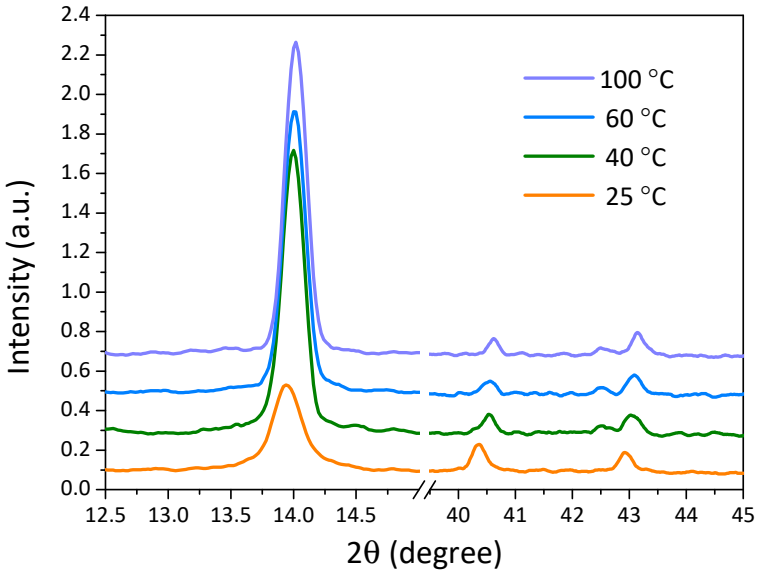

fig. S4. Strain state of $MAPbI_3$ films formed at different temperatures. Out of plane XRD of the $MAPbI_3$ films formed at 25°C, 40°C, 60°C, and 100°C.

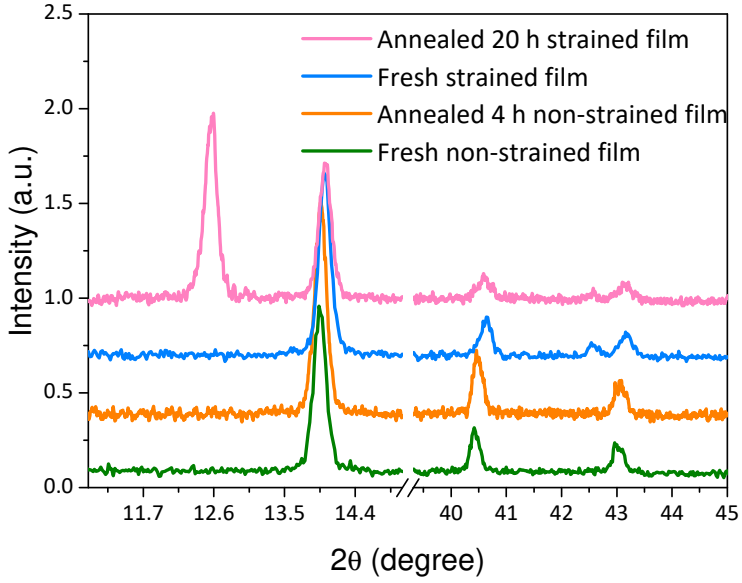

fig. S5. Effect of post-annealing on strain state. Out of plane XRD of the strained and non-strained $MAPbI_3$ films before and after post-annealing.

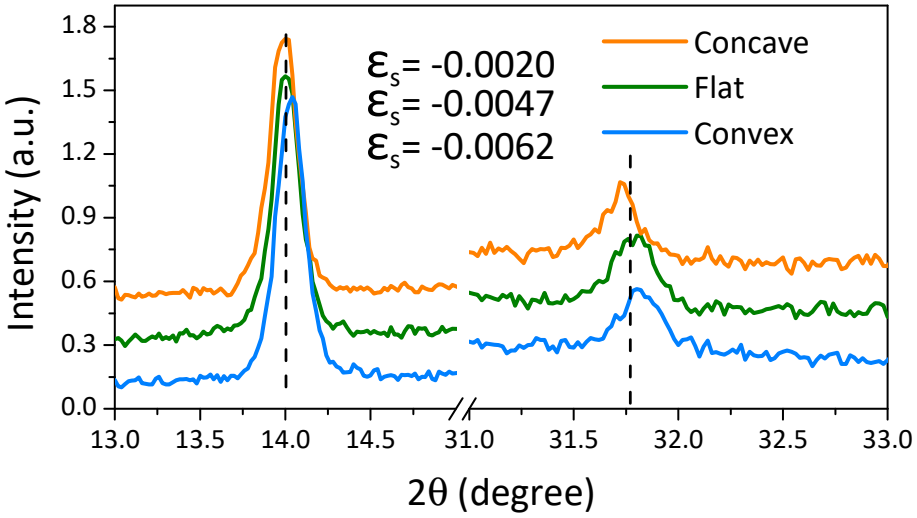

fig. S6. Out-of-plane XRD of the $MAPbI_3$ on a flexible substrate with different bending states. ε_s is calculated by $\varepsilon_s = (d_{strained\ (110)} - d_{non\text{-}strained\ (110)})/d_{non\text{-}strained\ (110)}$ The bending strain applied on the films are ε_b = +0.0023, 0 and –0.0023 for concave, flat and convex films.

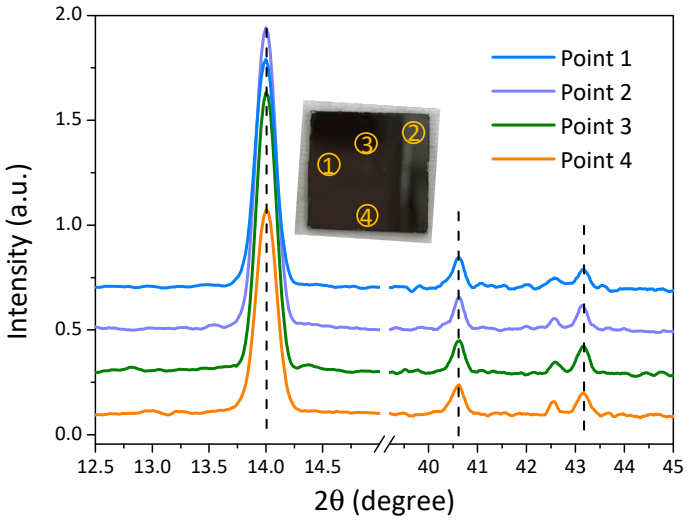

fig. S7. Distribution of strain on the substrate. Out of plane XRD of $MAPbI_3$ film measured at different locations corresponding to the inset picture. Inset: picture of a spin-coated $MAPbI_3$ film.

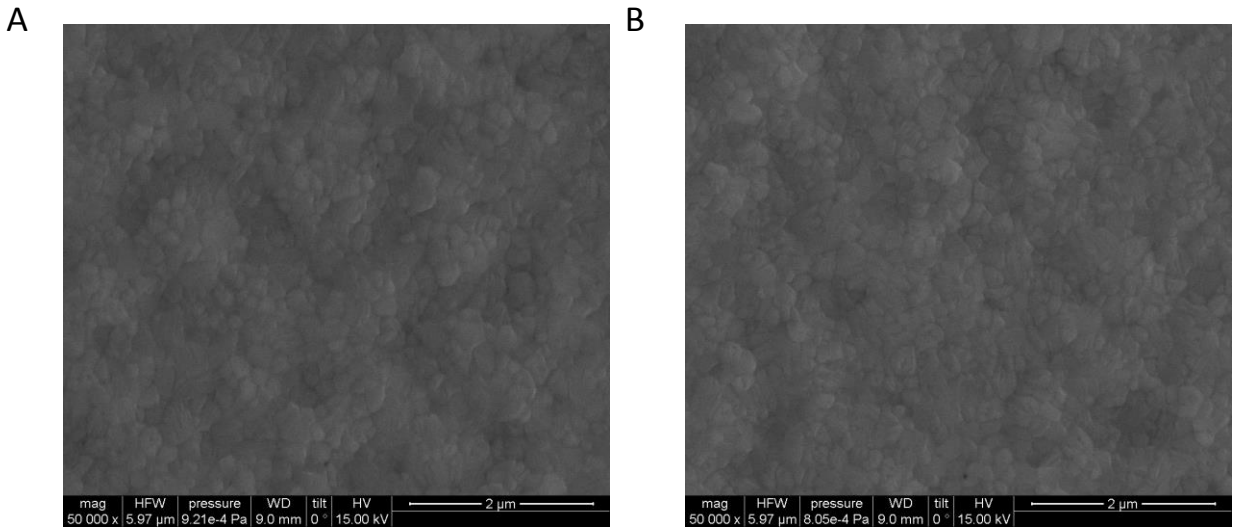

fig. S8. Morphology of $MAPbI_3$ film on PTAA/ITO and PTAA/glass substrates. (**A**) SEM image of perovskite film on PTAA/ITO and (**B**) on PTAA/glass substrates.

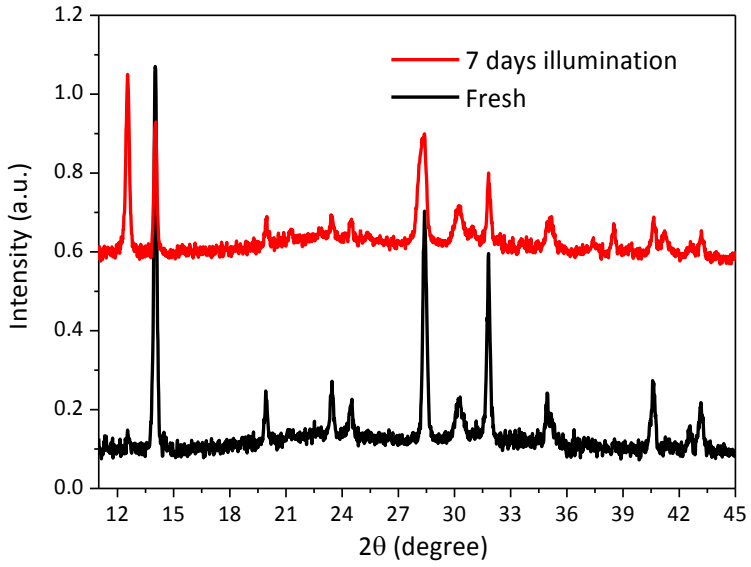

fig. S9. Degradation of strained $MAPbI_3$ film on SnO_2 substrate under illumination. Out of plane XRD of perovskite film on SnO_2/ITO/glass substrate under illumination.