Influence of Void-Free Perovskite Capping Layer on the Charge Recombination Process in High Performance $CH_3NH_3PbI_3$ Perovskite Solar Cells

Kunwu Fu[1, 2], Christopher T. Nelson[3, 4], Mary Cooper Scott [3, 4], Andrew Minor [3, 4], Nripan Mathews[1, 2, 3*] and Lydia Helena Wong[1, 2*]

1. Energy Research Institute @ NTU (ERI@N), Nanyang Technological University, Research Techno Plaza, 50 Nanyang Drive, 637553, Singapore

2. School of Materials Science and Engineering, Nanyang Technological University, Block N4.1, 50 Nanyang Avenue, 639798, Singapore

3. Singapore-Berkeley Research Initiative for Sustainable Energy, 1 Create Way, 138602, Singapore

4. Molecular Foundry at Lawrence Berkeley National Laboratory, One Cyclotron Rd, NCEM Bldg. 72, University of California Berkeley, California 94720, US

Supplementary Information

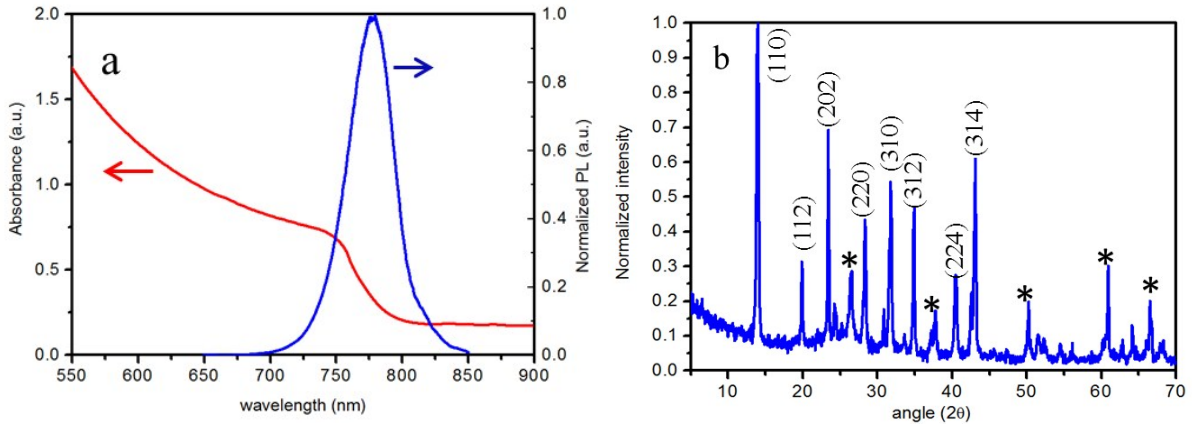

Figure S1 (a) UV-Vis absorbance spectra and normalized PL spectra & (b) normalized XRD pattern of $CH_3NH_3PbI_3$ perovskite film made by single deposition on compact TiO_2 substrate. The XRD peaks from TiO_2 substrate are marked with *. Onset of absorbance and the PL peak match well. XRD pattern shows that $CH_3NH_3PbI_3$ perovskite has tetragonal crystal structure at room temperature

condition and belongs to the I4/mcm crystal structure group with lattice parameter of a = 8.87(1) Å, c = 12.61(1) Å.

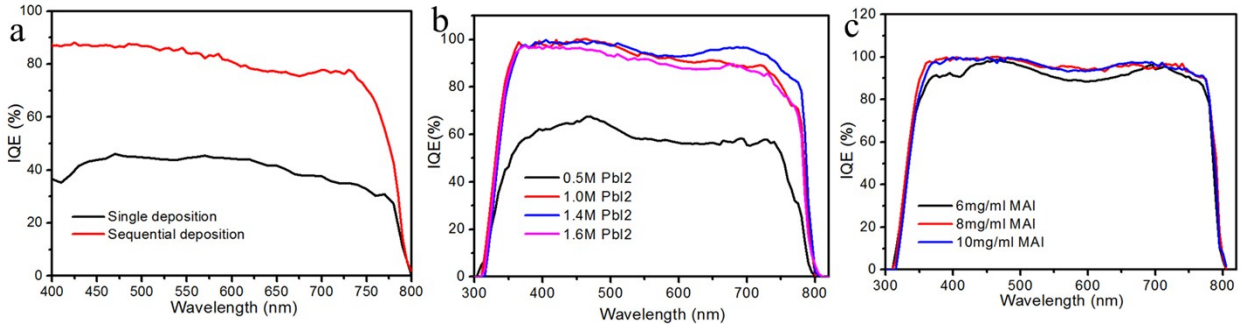

Figure S2 IQE spectra of $CH_3NH_3PbI_3$ perovskite devices fabricated by (a) single deposition and sequential deposition processes, (b) sequential deposition process with different concentration PbI_2 precursor solutions and (c) with different concentration MAI precursor solutions.

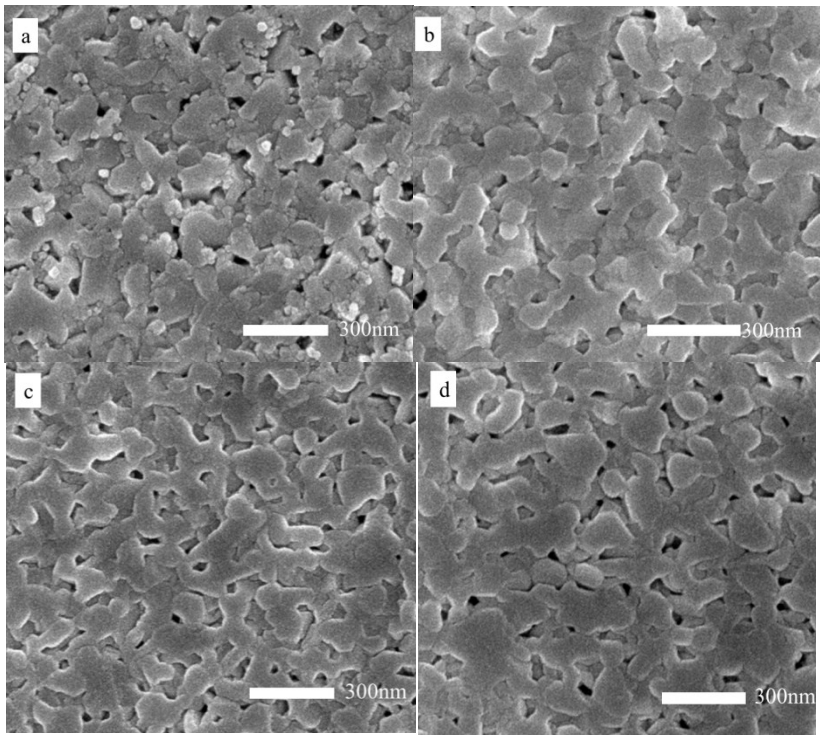

Figure S3 Top surface view SEM images of PbI_2 films produced by spincoating from various precursor solutions: (a) 0.5 M, (b) 1M, (c) 1.4 M and (d) 1.6 M PbI_2 solution.

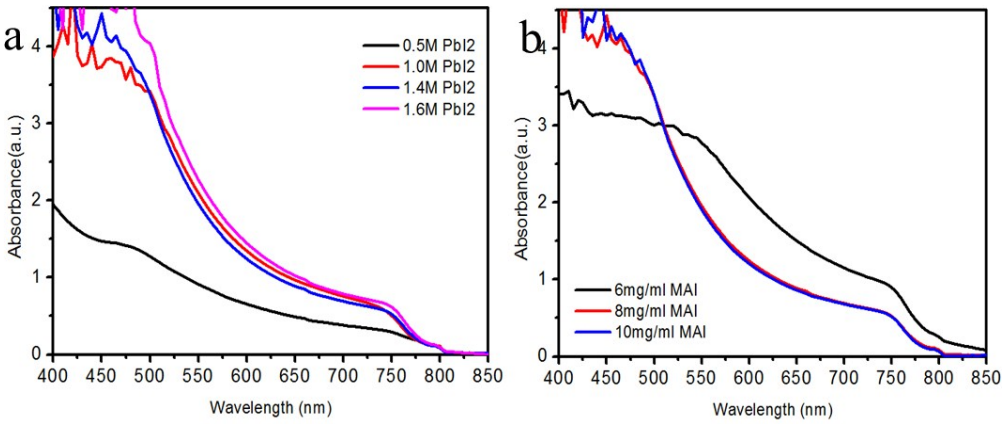

Figure S4 UV-Vis absorbance spectra of $CH_3NH_3PbI_3$ perovskite films on mesoporous TiO_2 substrates by sequential deposition perovskite samples from various (a) PbI_2 and (b) MAI precursor solution with different concentrations.

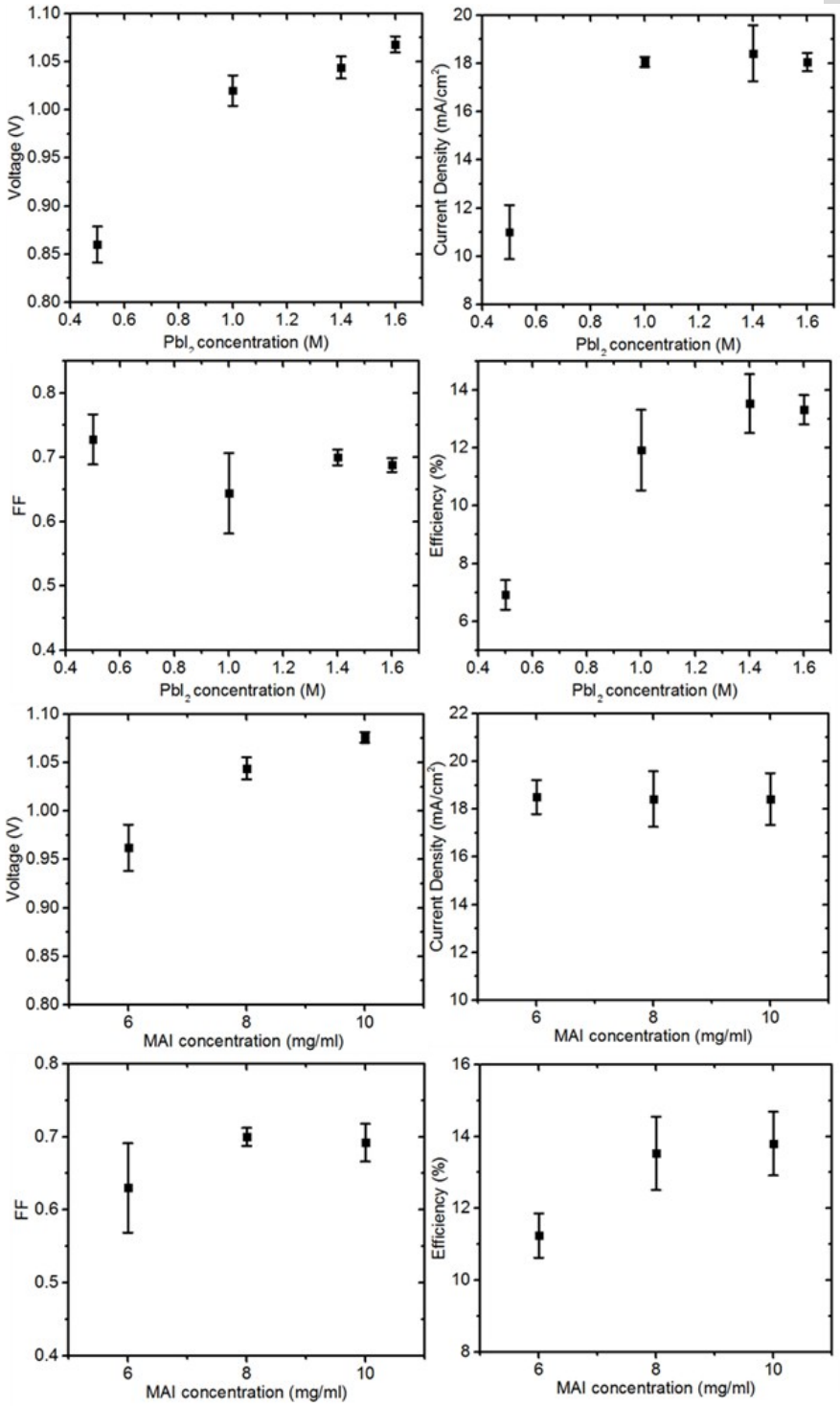

Figure S5 Statistics of mesoscopic perovskite solar cells fabricated with various PbI_2 and MAI precursor concentrations.

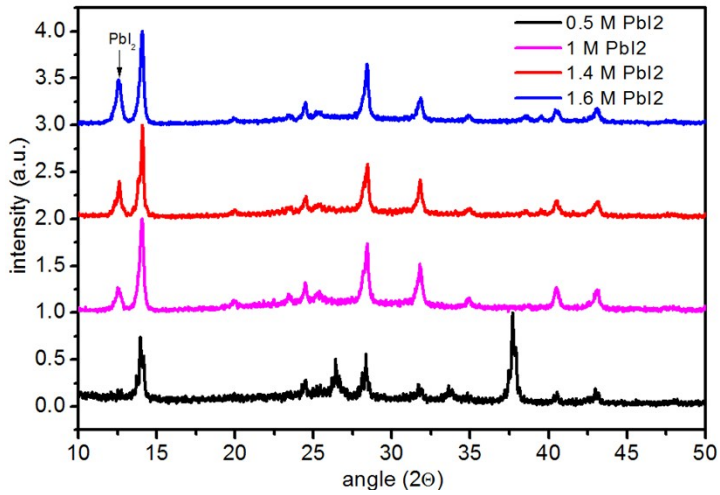

Figure S6 Normalized XRD pattern of $MAPbI_3$ perovskite film produced by sequential deposition from PbI_2 precursor solutions with various concentrations.

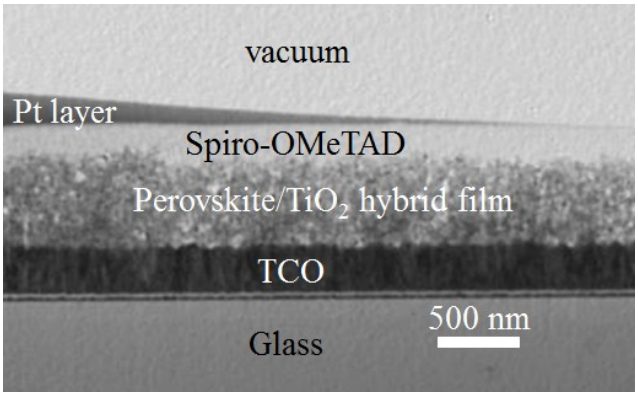

Figure S7 Cross section view of FIB prepared perovskite/mesoporous TiO_2 sample for TEM analysis.

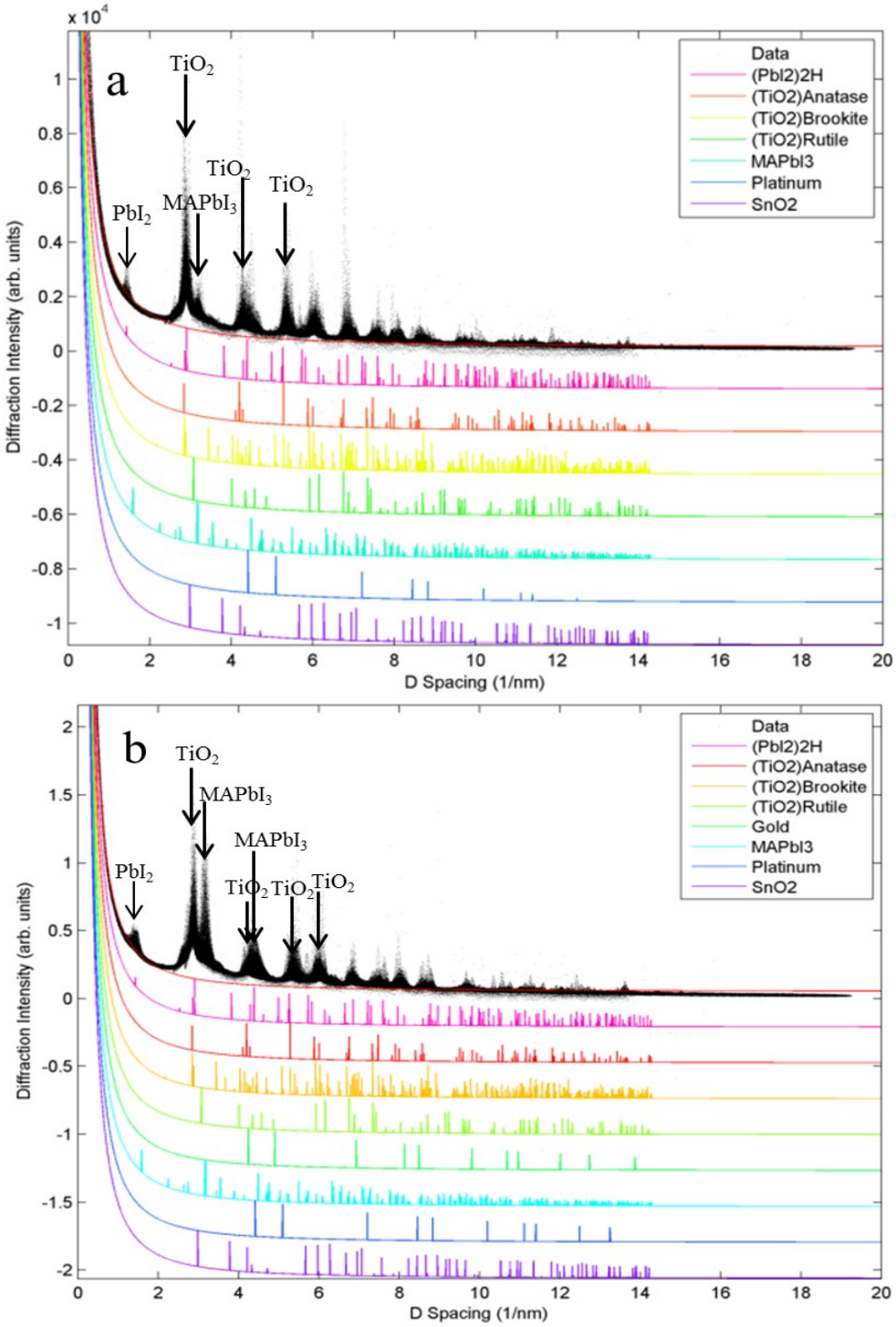

Figure S8 Electron diffraction peak intensity vs. diffraction angle of $CH_3NH_3PbI_3$ perovskite/TiO_2 samples fabricated from single deposition of (a) 40 wt% precursor solution and (b) sequential deposition.