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Supporting Information

Incorporation of Cl in sequentially deposited lead halide perovskite films for highly efficient mesoporous solar cells.

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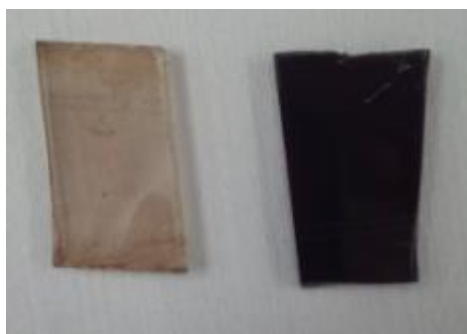
Fig.S1 On the left is the sample with $PbCl_2$ in MAI while the one on the right is that of $PbI_2 + PbCl_2$ in MAI.

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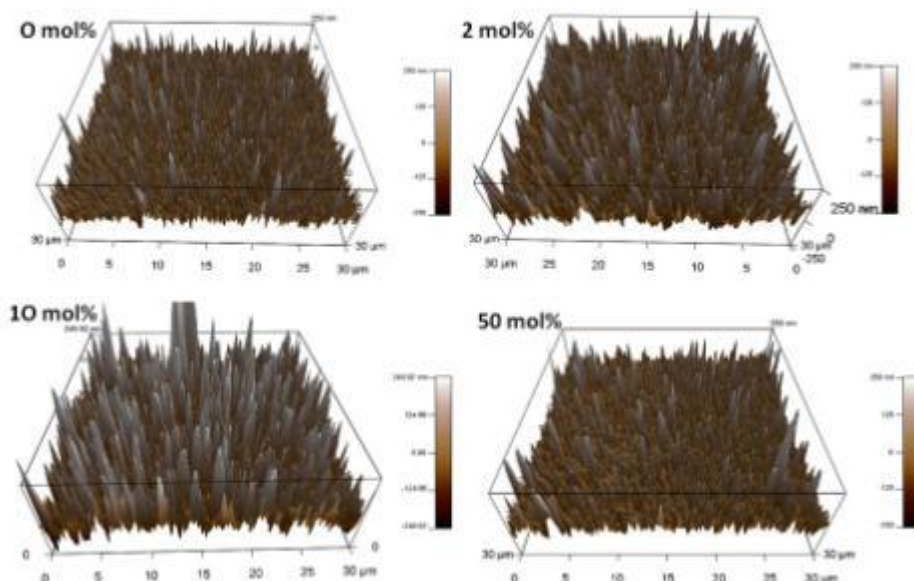
Fig.S2 AFM images illustrating the effect of Cl addition to $CH_3NH_3PbI_3$ on surface roughness of the films.

Supporting Information

Table. S1 Effect of addition of Cl on lattice parameters of perovskite crystal structure

Sample	a (Å)	b (Å)	c (Å)
0 mol % PbCl$_2$	8.8811(7)	8.8811(7)	12.6807(19)
2 mol % PbCl$_2$	8.8859(6)	8.8859(6)	12.6936(18)
50 mol % PbCl$_2$	8.8767(12)	8.8767(12)	12.6910(50)

From the AFM surface roughness characterization it was
5 observed that with increasing concentration of PbCl$_2$, the surface roughness of the sample increased as indicated by the increasing density of sharp peaks in Fig. S2 and Table S1. However for 50 mol % of PbCl$_2$, the surface roughness was measured to be similar to the 0 mol % PbCl$_2$. This could be explained by the
10 vertical growth of all the crystals leading to homogeneous roughness. The increase in the growth of the crystals could be validated from the FESEM cross-section image (Fig. S3).

Table. S2 Effect of addition of Cl on surface roughness of perovskite film

Sample	Surface roughness (nm)
0 mol % PbCl$_2$	52.74
2 mol % PbCl$_2$	70.20
10 mol % PbCl$_2$	97.9
50 mol % PbCl$_2$	53.34

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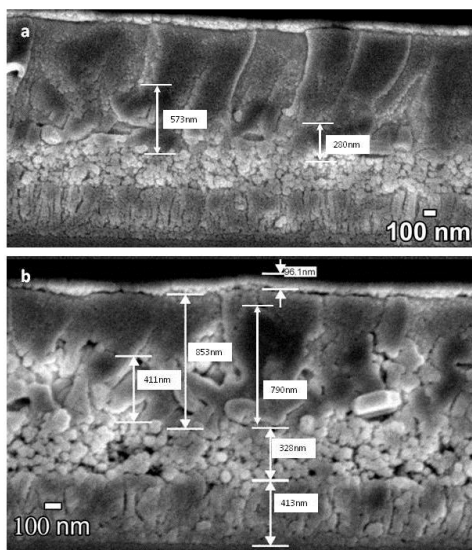
Fig.S3 Cross-section FESEM image illustrating the height of the
20 perovskite layer for 50 mol % of PbCl2 addition.

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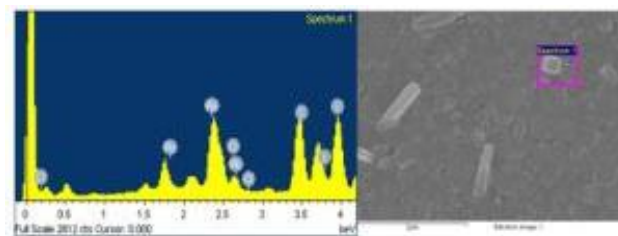
Fig.S4 EDX demonstrating the presence of Cl peaks for 50 mol % PbCl$_2$ addition to methyl ammonium lead iodide.

Table. S3 J-V characteristics of 20 mol % of PbCl$_2$

Sample	J$_{sc}$ (mA/cm^2)	V$_{oc}$ (V)	FF	η (%)
20 mol % PbCl$_2$	18.38	0.98	0.46	8.18

30 From Table. S3, we can observe that for Cl concentration > 10 mol %, the efficiency of the solar cell degrades considerably.
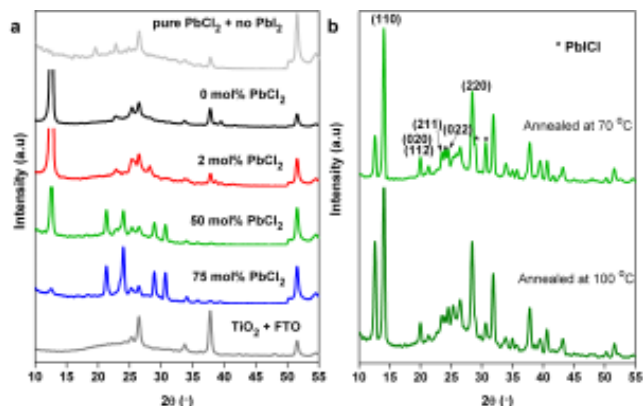
Fig.S5 (a) XRD patterns of the samples after spin-coating PbI$_2$ or (PbI$_2$+PbCl$_2$). **(b)** Comparison of the XRD patterns of CH$_3$NH$_3$PbI$_{3-x}$Cl$_x$
35 (x = 0.05) for different annealing conditions.

It was observed from Fig. S5a, that during the first step of inorganic halide deposition itself for Cl concentrations > 2 mol %, additional peaks were observed. Also the annealing
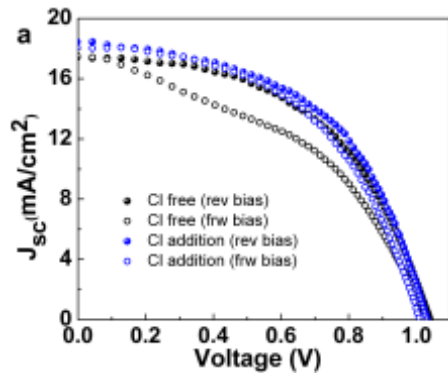40 temperature had no effect on the diffraction patterns as was observed in Fig. S5b.

Fig.S6 Effect of Cl on hysteresis for different scan speeds.

10 Table. S3 Hysteresis Index extracted from data in Fig 5(c&d) for different scan rates.

Delay between points	0 mol % PbCl2	10 mol% PbCl2
0.1 s	0.13	0.02
0.05 s	0.17	0.03