Supporting information

Extremely robust gas quenching deposition of halide perovskites on top of hydrophobic hole transport materials for inverted (p-i-n) solar cells by targeting the precursor wetting issue.

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AUTHOR CONTRIBUTIONS

‡ K.O.B. and J.H. contributed equally to this work.

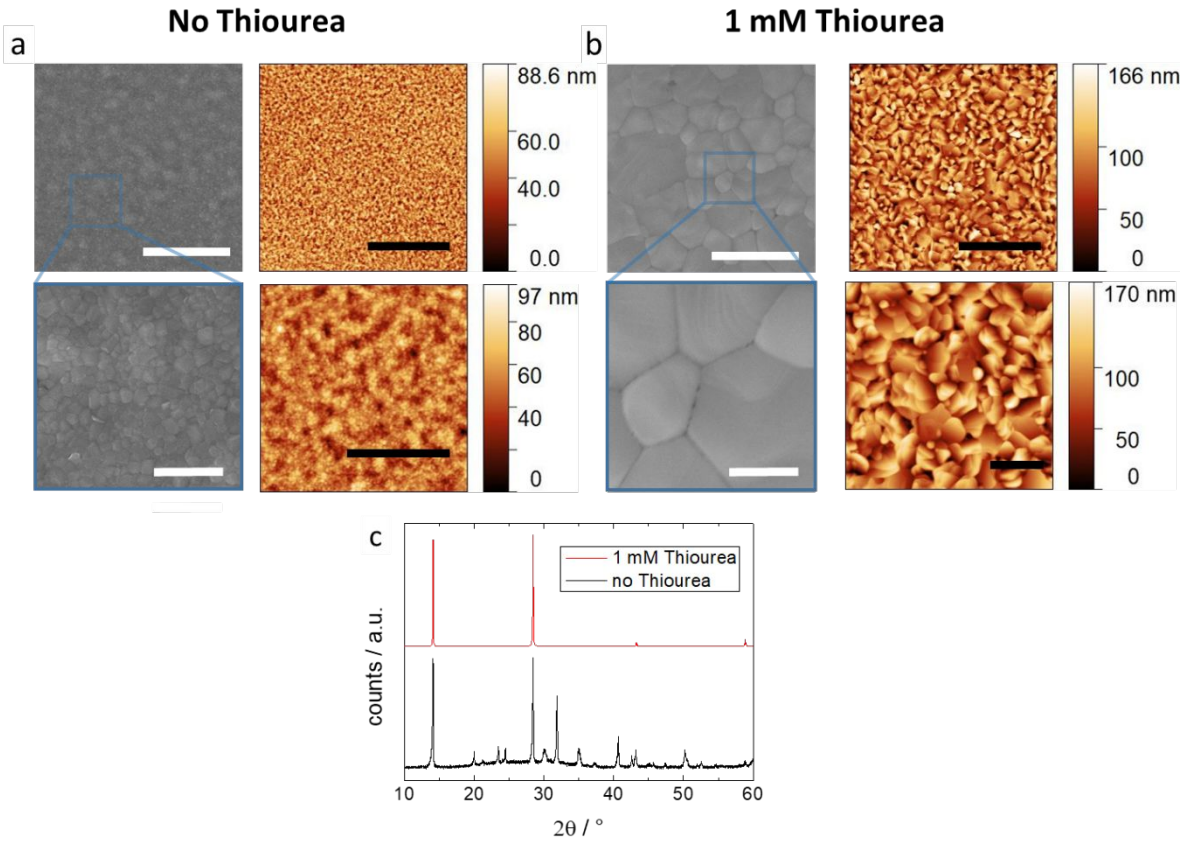


Figure S1: SEM and AFM images of perovskite surface without (a) and with 0.1 M Thiourea per ml precursor solution (b) as well as respectove XRD diffractograms (c). The bars for SEM images represent 5 µm (top) and 1 µm (bottom). Bars in AFM images are 20 µm (top) and 5 µm (bottom). Average lateral crystal sizes are (determined by edge detection on AFM images) ~ 200 nm without and ~ 900 nm with the use of Thiourea as additive.

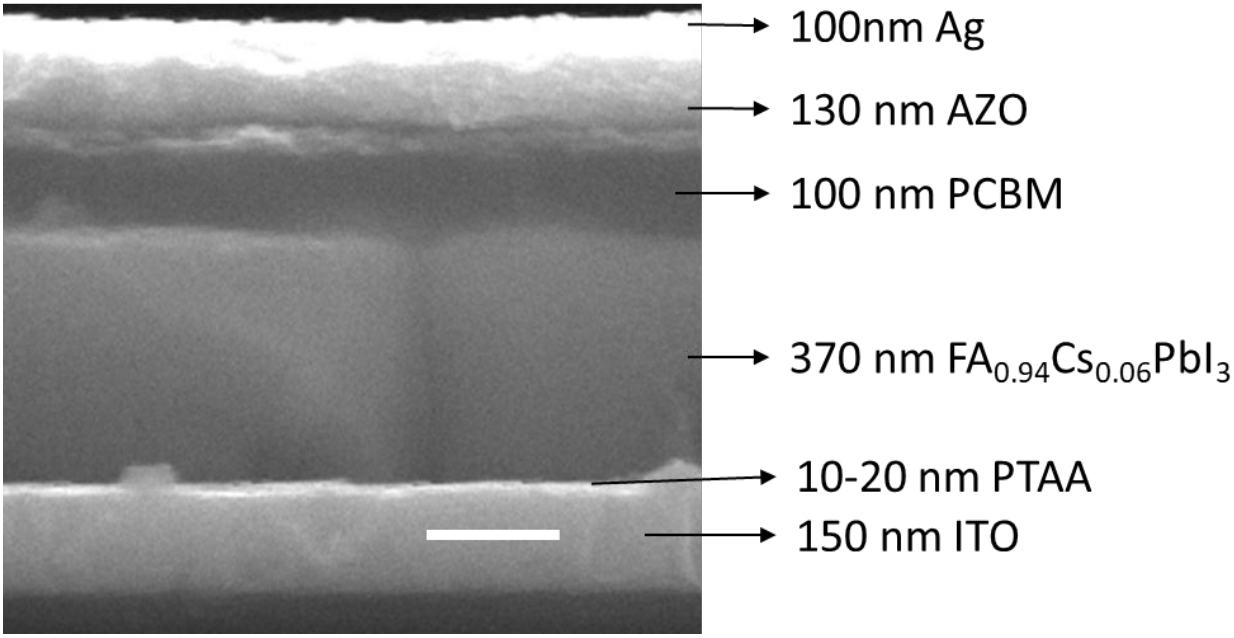
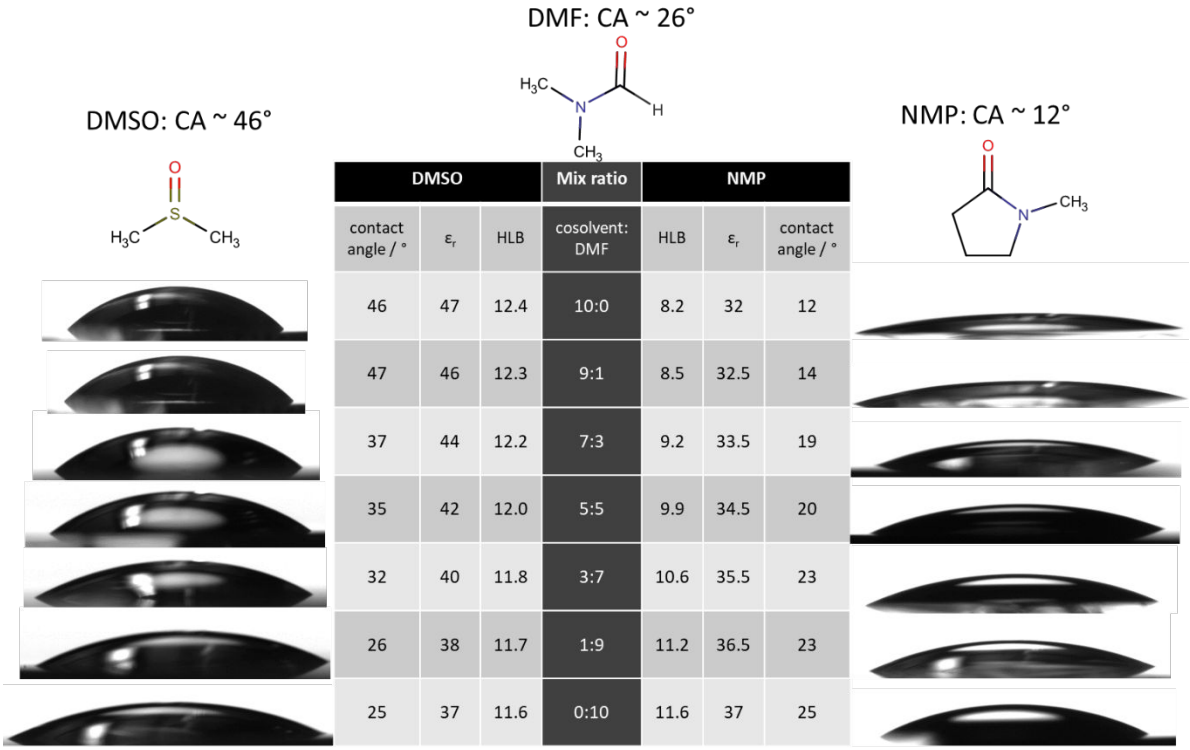


Figure S2: cross sectional SEM image and derived thicknesses of the respective layers of a $FA_{0.94}Cs_{0.06}PbI3$ solar cell stack. The white bar resembles 200 nm.



DMSO			Mix ratio	NMP		
contact angle / °	ε_r	HLB	cosolvent: DMF	HLB	ε_r	contact angle / °
46	47	12.4	10:0	8.2	32	12
47	46	12.3	9:1	8.5	32.5	14
37	44	12.2	7:3	9.2	33.5	19
35	42	12.0	5:5	9.9	34.5	20
32	40	11.8	3:7	10.6	35.5	23
26	38	11.7	1:9	11.2	36.5	23
25	37	11.6	0:10	11.6	37	25

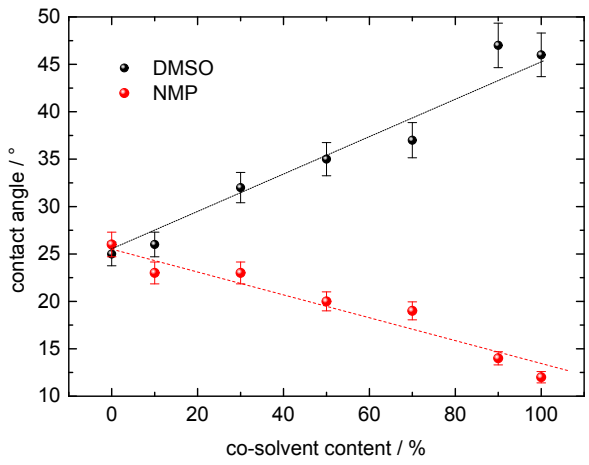


Figure S3: Contact angle measurements of DMF:DMSO and DMF:NMP mixtures on PTAA (top: tabular, bottom: graphical) including calculated permittivity and HLB values of the mixtures. Dashed lines are a guide to the eye to visualize the proposed linear behavior.

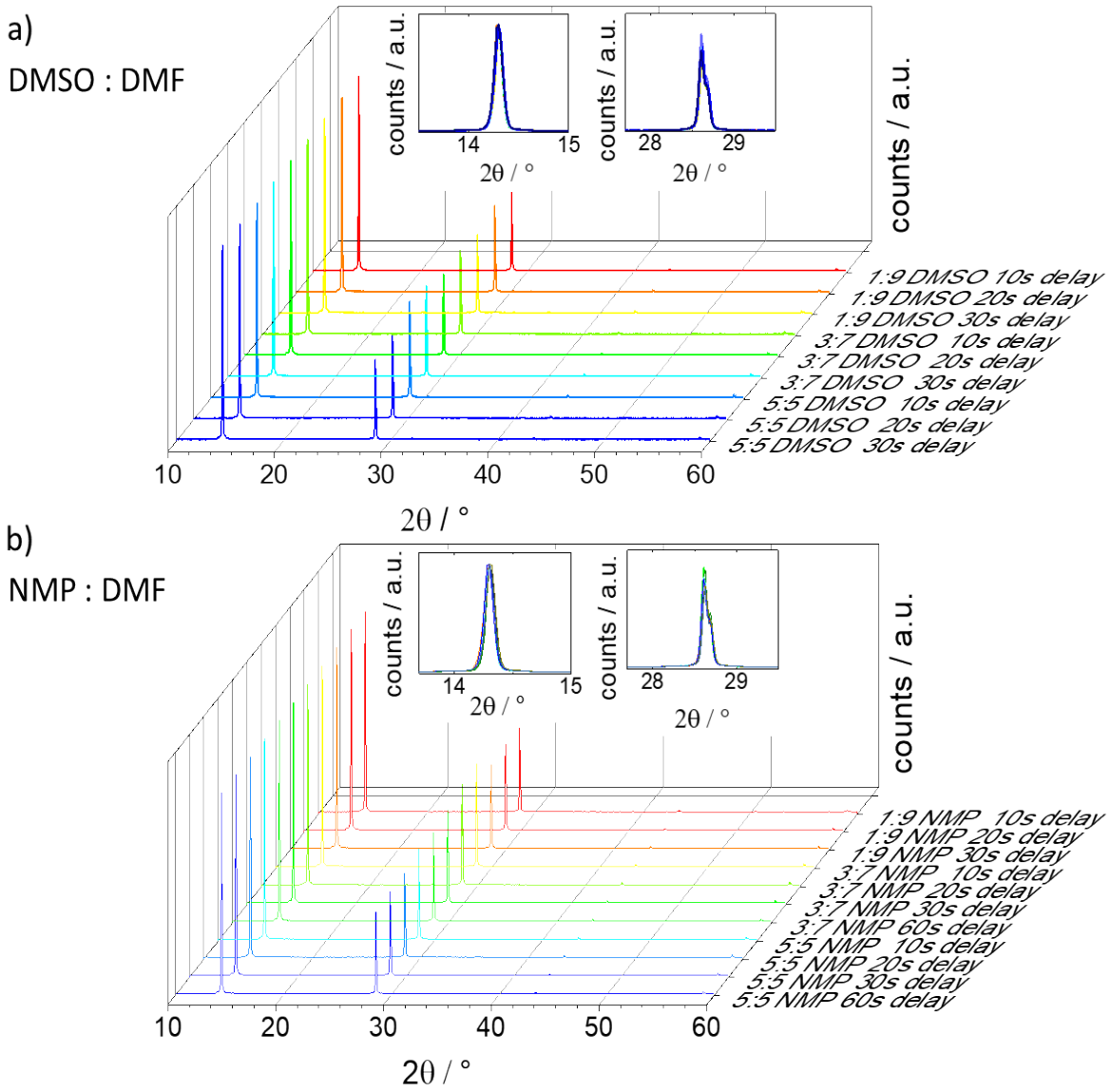


Figure S4: XRD diffractograms of $MAPbI_3$ layers fabricated with diffrent co-solvent : solvent ratio and processing timing utilizing DMSO (a) and NMP (b) as co-solvent. Insets are magnified views of the 110 and 220 tetragonal peak.

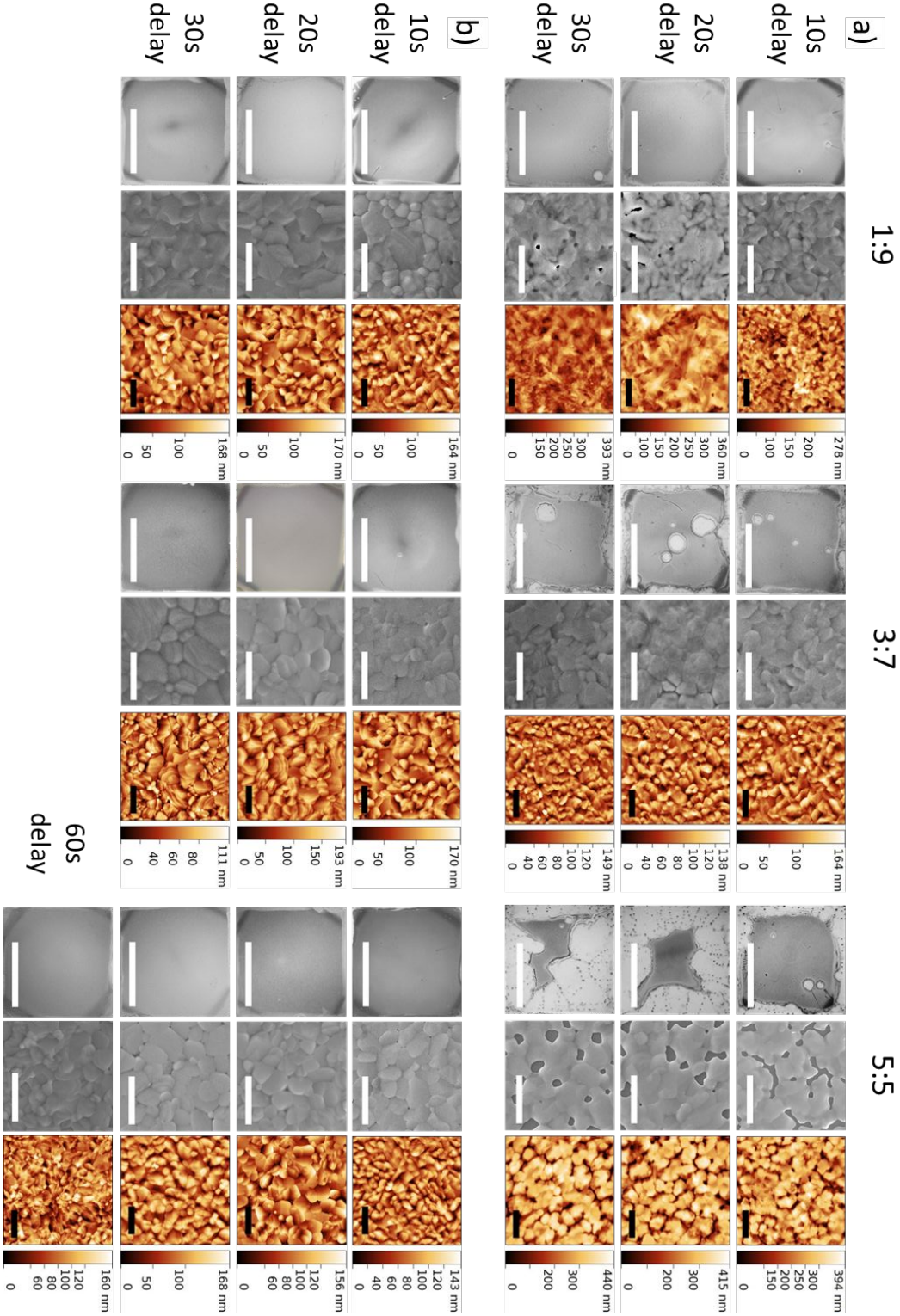


Figure S5: microscope, SEM and AFM images of perovskite layers prepared on PTAA layers with diffrent co-solvent:solvent ratios and varied quenching delay times for DMSO (a) and NMP (b)

Table S1: Mean grain sizes derived from watershade algorithm (AFM images Figure S4) and surface coverage of perovskite layers (microscope images Figure S4) prepared on PTAA layers with different co-solvent:solvent ratios and varied quenching delay times for DMSO and NMP co-solvent.

	quenching delay / s	mean grain size / µm | surface coverage					
Solvent:co-solvent ratio		1:9		3:7		5:5	
DMSO	10	0.9	>99 %	1.01	95 %	0.99	77 %
	20	0.74	>99 %	0.97	85 %	1.08	32 %
	30	0.56	97 %	0.84	81 %	1.13	25 %
NMP	10	0.95	>99 %	0.95	>99 %	0.91	>99 %
	20	1.04	>99 %	1.19	>99 %	1.04	>99 %
	30	0.99	>99 %	1.08	>99 %	0.92	>99 %

DMF

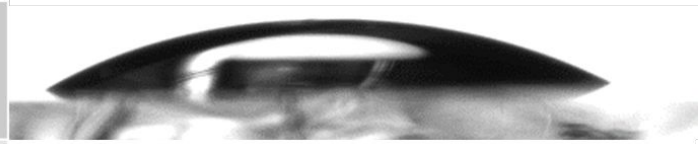
Iteration	Contact angle	
1	29	
2	28	
3	29	

Figure S6: contact angle development of pure DMF during drying process.

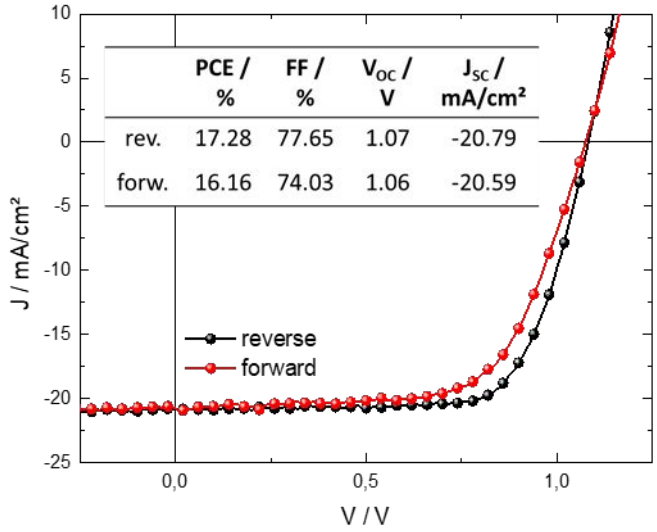


Figure S7: J-V scan and solar cell characteristics of the champion cell with DMSO co-solvent in 1:9 DMSO : DMF ratio and 10 s quenching delay time.

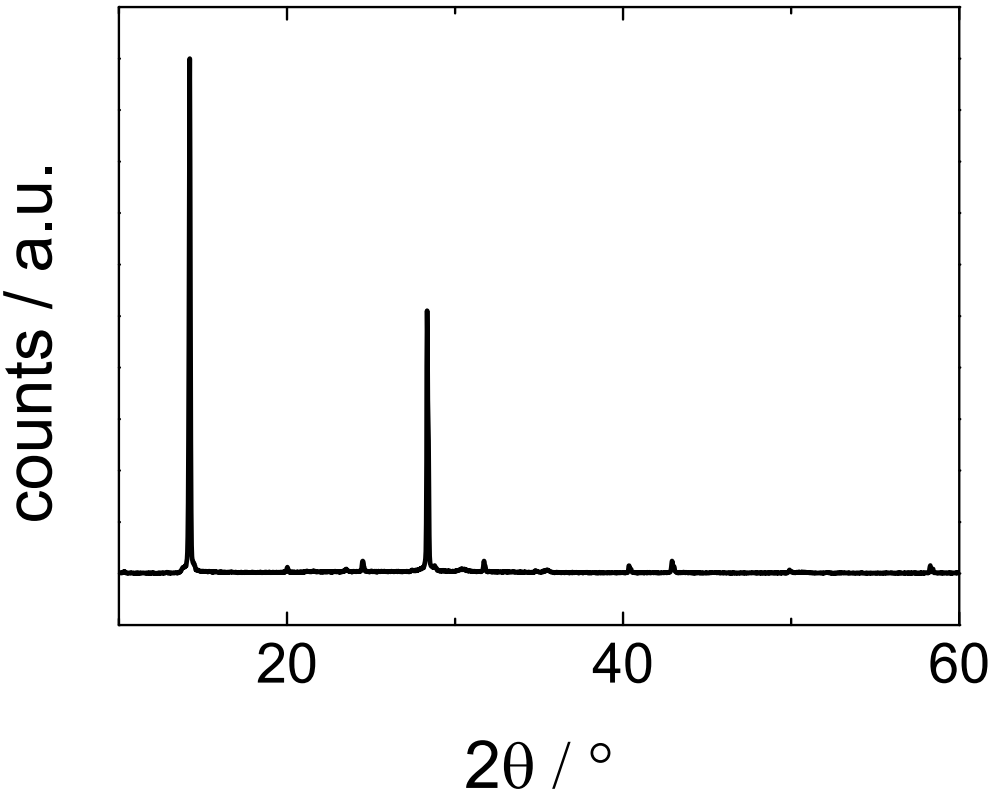


Figure S8: XRD diffractogram of $FA_{0.94}Cs_{0.06}PbI_3$ on top of PTAA with 3:7 NMP : DMF

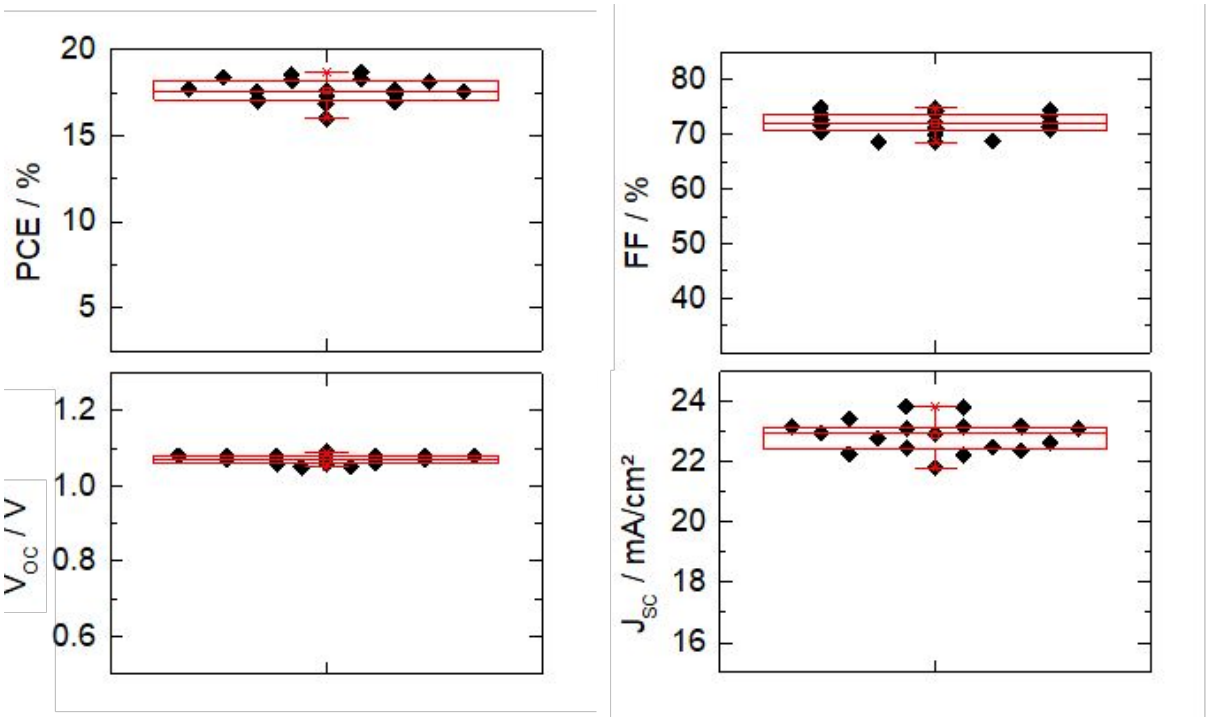


Figure S9: Box chart diagram for $FA_{0.94}Cs_{0.06}PbI_3$ solar cells with 3:7 NMP : DMF co-solvent : solvent ratio at a quenching delay of 30 s. 18 cells were measured.