## **Supporting Information**

## Stress-induced stabilization of photoactive FAPbI<sub>3</sub> phase in ambient conditions without using an additive approach

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**Figure S1:** Schematic of Perovskite solar cells (a) Device architecture, and (b) Energy-Band diagram of the device. The energy band positions have been taken from various references.<sup>1-5</sup>

**Table S1:** Systematic exploration of solvent ratio and anti-solvent selection in conjunction with Two and Three-Step spin coating parameters for the deposition of Perovskite Films on both SnO<sub>2</sub>-coated FTO substrates and Glass substrates.

Note: The per	ovskite Films form	ned under RH	= 20-28%,	Temperature =	24-30 °C.
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Solvent	FAI: PbI <sub>2</sub> Molar Ratio	Anti-solvent	Annealing Temperature (° <sup>C</sup> )	Formation of <b>α</b> -FAPbI <sub>3</sub> With spin coating parameters
DMF:	1.5 M	Chlorobenzene	150-170	2-step; N
DMSO (9:1)	1 M 0.7 M	Toluene		3-step; N
		Ethyl Acetate		
DMF:	1.5 M	Chlorobenzene	150-170	2-step; N
DMSO (4:1)	1 M 0.7 M	Toluene Ethyl Acetate		3-step; N

DMF:	1.5 M	Chlorobenzene	150-170	2-step; N
DMSO (3:1)	1 M 0.7 M	Toluene Ethyl Acetate		3-step; Y only with 0.7M ratio of FAI: PbI <sub>2</sub> but not with Ethyl Acetate

N: Perovskite film not formed; Y: Perovskite film formed.

**Table S2:** Optimization of spin coating parameters, anti-solvent dripping duration, anti-solvent volume, and annealing temperature for the precision fabrication of Perovskite Films on Glass substrates and SnO<sub>2</sub>-coated FTO substrates.

Spin coating Steps	Spin coating parameters	Anti- solvent Dripping	Anti-solvent	Temper ature (° <sup>C</sup> )	Formation of α-FAPbI <sub>3</sub>
		During the deposition process			
2-step	1200 rpm, 15 sec	15 <sup>th</sup> sec of	Chlorobenzene	150-170	Not formed
	5000 rpm, 30 sec	step	(250-300µL)		
2-step	1200 rpm, 15 sec	15 <sup>th</sup> sec of	Toluene	150-170	Not formed
	5000 rpm, 30 sec	step	(250-300µL)		
3-step	500 rpm, 5sec	Ending of	Chlorobenzene	150-170	Very poor-quality film
	3500 rpm, 5 sec	step	(250-300µL)		Ionned
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	Ending of	Toluene	150-170	Poor quality film formed
	3500 rpm, 5 sec	step	(250-300µL)		
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	During	Toluene	150-170	Poor quality film formed
	3500 rpm, 5 sec	n of 3 <sup>rd</sup>	(250-300µL)		from previous one
	5000 rpm, 30 sec	step			
3-step	500 rpm, 5sec	Starting of	Toluene	150-170	Poor quality film formed
	3500 rpm, 5 sec	und step	(250-300µL)		from previous one
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	7 <sup>th</sup> sec of	Toluene	150-170	Poor quality film formed
	3500 rpm, 5 sec	third step	(250-300µL)		from previous one
2 atom	5000 rpm, 30 sec	12th case of	Taluara	150 170	Door quality film fame 1
o-step	300 rpm, 3sec	third step	Ioiuene	130-170	but slide improvement

	3500 rpm, 5 sec		(250-300µL)		from previous one
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	15 <sup>th</sup> sec of	Toluene	150-170	Good quality film formed
	3500 rpm, 5 sec	third step	(250-300µL)		
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	15 <sup>th</sup> sec of	Toluene	150-170	Good quality film formed
	3500 rpm, 5 sec	third step	(250µL)		slide improvement from previous one
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	15 <sup>th</sup> sec of	Toluene	150	Very Good quality film
	3500 rpm, 5 sec	the third step	(250µL)		formed
	5000 rpm, 30 sec				
3-step	500 rpm, 5sec	18 <sup>th</sup> sec of	Toluene	150	Very poor-quality film
	3500 rpm, 5 sec	the third step	(250µL)		formed
	5000 rpm, 30 sec				



**Figure S2:** Phase transformation images from intermediate to FAPbI<sub>3</sub> phase with different time intervals after reaching 150 °C.

**Table S3:** Theoretical stress calculation at various temperatures, while perovskite solution temperature was constant at  $70^{\circ}$ C.

$\left  \frac{E_P}{1-v_P} \right $	$\alpha_s - \alpha_p$	$\alpha_g - \alpha_P$	Substrate Temperatur	$\Delta T$	Stress in Sample S1	Stress in Sample S2
			e (°C)		(MPa)	(MPa)
			30	+40	+63.43	+6.34
			40	+30	+47.57	+4.75
15.857	10 <sup>-5</sup> K <sup>-1</sup>	10 <sup>-4</sup> K <sup>-1</sup>	50	+20	+31.71	+3.17
GPa			60	+10	+15.85	+1.58
			70	0	0	0
			80	-10	-15.85	-1.58
					(Compressive	(Compressive
					stress)	stress)

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										Sam	ple			
Mater	rial H K	L	Wave	length	2Theta	Poisson	Young	S1	1/2 S2	Arx				
FAP	0 0 1 3 0 0 1		Cu_K	a1	14.100	0.300	111000	-2.703E-	6 1.171E	-5 1.0	00			
Measured: Peak Evaluation Method: Stress Model:										Pse	udo-Hydro:			
25-No	v-2022				Slidin	g Gravity				Norr	mal		-/	- <u>+</u> -/-
					( 10, 2	20, 30, 40, 5	0, 60, 70, 8	0)		Norma	I:			
										1408	8.7 <u>+</u> 174.0			
Phi:0.0	Phi:0.0	Phi	0.0 🚦	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0 🔤	Phi:0.0	Phi: 45.0	Phi:45.0	Phi:45.0	Phi:45.0
Psi:0.0 Omega:7.00	Psi:5.6 Omega:7.00	Psi: Ome	11.1 ga:7.00	Psi:16.7 Omega:7.00	Psi:22.2 Omega:7.0	Psi:27.8 0. Omega:7.00	Psi:33.3 Omega:7.00	Psi:38.9 Omega:7.00	Psi:44.4 Omega:7.00	Psi:50.0 Omega:7.00	Psi:0.0 Omega:7.00	Psi:5.6 Omega:7.00	Psi:11.1 Omega:7.00	Psi:16.7
100				193			12.11					1205	1. A. B. B.	Star St
			1											
		1		S.O						-	100			
														100
		a.			2.0							2000		22.2.2
Phi:45.0 Psi:22.2	Phi:45.0 Psi:27.8	Phi: Psi:	45.0	Phi:45.0 Psi:38.9	Phi:45.0 Psi:44.4	Phi:45.0 Psi:50.0	Phi:90.0 Psi:0.0	Phi:90.0	Phi:90.0 Psi:11.1	Phi:90.0 Psi:16.7	Phi:90.0 Psi:22.2	Phi:90.0	Phi:90.0	Phi:90.0
Omega:7.00	Omega:7.00	Ome	ega:7.00	Omega:7.00	Omega:7.0	0 Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00
			5.0	14.15	1 1 1				1	15	1.0	100	Sec. 1	42.5
	6.2.5	200		1000			100			57	22	S. Con	1.4	
The Cost		1.6		100	Q.		15. 24	Traine)		1999	1.1	20.2	1.1.1	100
1845		10		22			12.42	1.1	258	SAC)	1. 27			
1. M.	1222	110	100	100	100	10000	10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1. P. C.	STAR ST	1000	Sec. 25.2	10.000	1. 1. 1. 1. A.	19 C 19 19

Figure S3: Stress analysis of Glass/FTO/SnO $_2$ /FAPbI $_3$  based film using XRD

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								:	Sample				
Materia	al H K	L Wavele	ength 2	Theta	Poisson	Young	S1	1/2 S2	Arx				
FAPbl	3 001	Cu_Ka	1 1	4.100	0.300	111000	-2.703E-6	1.171E-5	1.000				
Measured	ı.		Pe	ak Evalu:	ation Methor	1.		Stress M	odel		Pseudo-Hy	/dro:	
25-Nov	-2022			Gravity (	30)			Norma	1		-/- <u>+</u> -/-		
								Normal:					
								29.6 <u>+</u>	50.2				
Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	Phi:0.0	2 Phi:0.0	Phi:0.0	Phi:0.0	Phi:45.0	Phi:45.0 Psi:5.6	Phi:45.0	Phi:45.0
Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega	7.00 Omega	7.00 Omega	.7.00 Omega:7.0	0 Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00
	20.94								1000		22.21		
			326							- 13 H		100	
											5		1.200
									1.20				2.7.3
	1963	92 C	233 - A						13273	2.157	1		199
Phi:45.0 ¥	Phi:45.0	Phi: 45.0	Phi: 45.0 Psi: 38.9	Phi: 45.0	) Phi:45.0 Psi:50.0	Phi:90.	0 Phi:90.0	Phi:90.0	Phi:90.0 Psi:16.7	Phi:90.0	Phi:90.0	Phi:90.0 Psi:33.3	Phi:90.0
Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	) Omega:	7.00 Omega	7.00 Omega	:7.00 Omega:7.0	0 Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00	Omega:7.00
3 6. 3		1000	1944	10000					4.7.4			12-1	
			S. 3							1.15	14	81- V	
	-	5 5 5 5 S	100	AN CO			Se Sain			6.24		100	1.1
4.00%		12.25				10		\$			12		
	2000	2.54%	1.75		112 2 12	12 24	<u> 19</u> 2,63	1000	See.	200 8	24. C	10 10	1.100

**Figure S4:** Stress analysis of Glass/FAPbI<sub>3</sub> based film using XRD.

Table S4: Mechanical properties and XRD peak at (001) of FAPbI<sub>3</sub> film.<sup>6-8</sup>

Plane	(001)				
20	14.1				
Poisson's ratio	0.3				
Young Modulus	11.1 GPa				



**Figure S5:** Shows the atomic structure model of the FAPbI<sub>3</sub>/SnO<sub>2</sub> interfacial mismatch (dotted lines) at the different axis, (a) 2D structure in the b-c direction, (b) 3D structure, and (c) 2D structure in the a-b direction.



Figure S6: XPS spectra of FAPbI<sub>3</sub> film; (a) Pb 4f, (b) I 3d, (c) N1s, and (d) C1s.



Figure S7: EDS Spectral analysis; (a) EDS sum spectrum of FAPbI<sub>3</sub>, and (b) Elemental mapping of C, N, Pb and I in the perovskite structure



**Figure S8:** Stability of  $\alpha$ -FAPbI<sub>3</sub> film at different substrates; (a) At 0-hour (fresh film), (b) film after 6 hours, and (c) film after 20 hours.



Figure S9: XPS spectra of Pb 4f, I 3d (S1) fresh film, and (S1.3) three months aged sample.



Figure S10: XPS survey of; (S1) fresh film, and (S1.3) three months aged sample.



Figure S11: XRD pattern and SEM images (top-view) of  $\alpha$ -FAPbI<sub>3</sub> film on Glass/FTO/SnO<sub>2</sub> coated substrates; (S1) fresh film, and (S1.3) three months aged sample.

**Table S5:** Average experimental data for the photovoltaic performance of 25 devices in reverse direction.

Device data of	J <sub>SC</sub> (mA/cm <sup>2</sup> )	V <sub>OC</sub> (V)	FF (%)	Efficiency (%)
25 cells	$25.7 \pm 0.5$	$1.031 \pm 0.024$	$68.2 \pm 5.4$	$18.26 \pm 2.2$

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