Supporting information

Dynamic monitoring of light soaking effect of organic-inorganic perovskite solar cells doped with alkali metal ions

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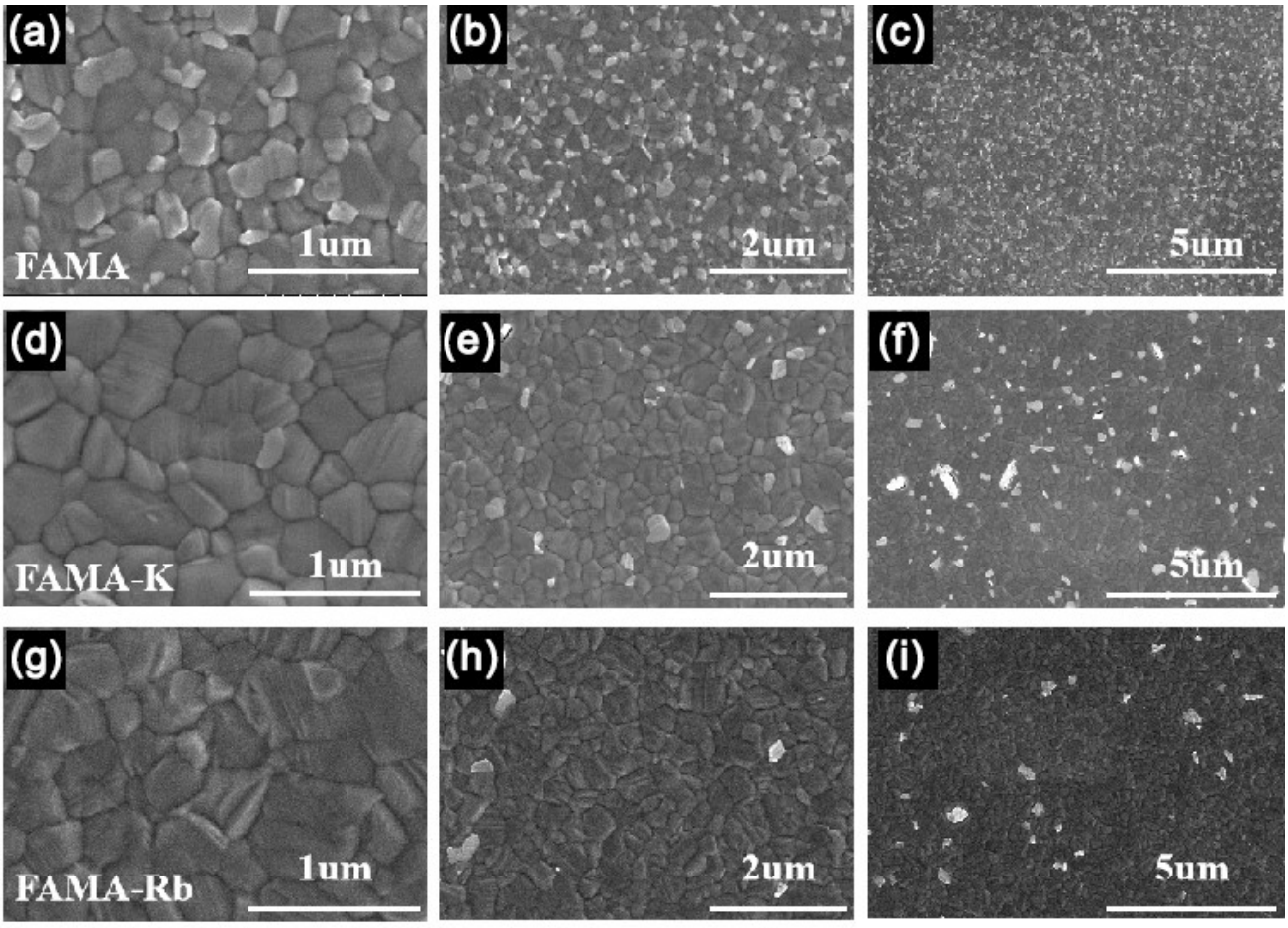

Figure S1 SEM images of perovskite thin films regulated by different alkali metal ions. (a)-(c) represent FAMA, (d)-(f) represent FAMA-K, and (g)-(i) represent FAMA-Rb.

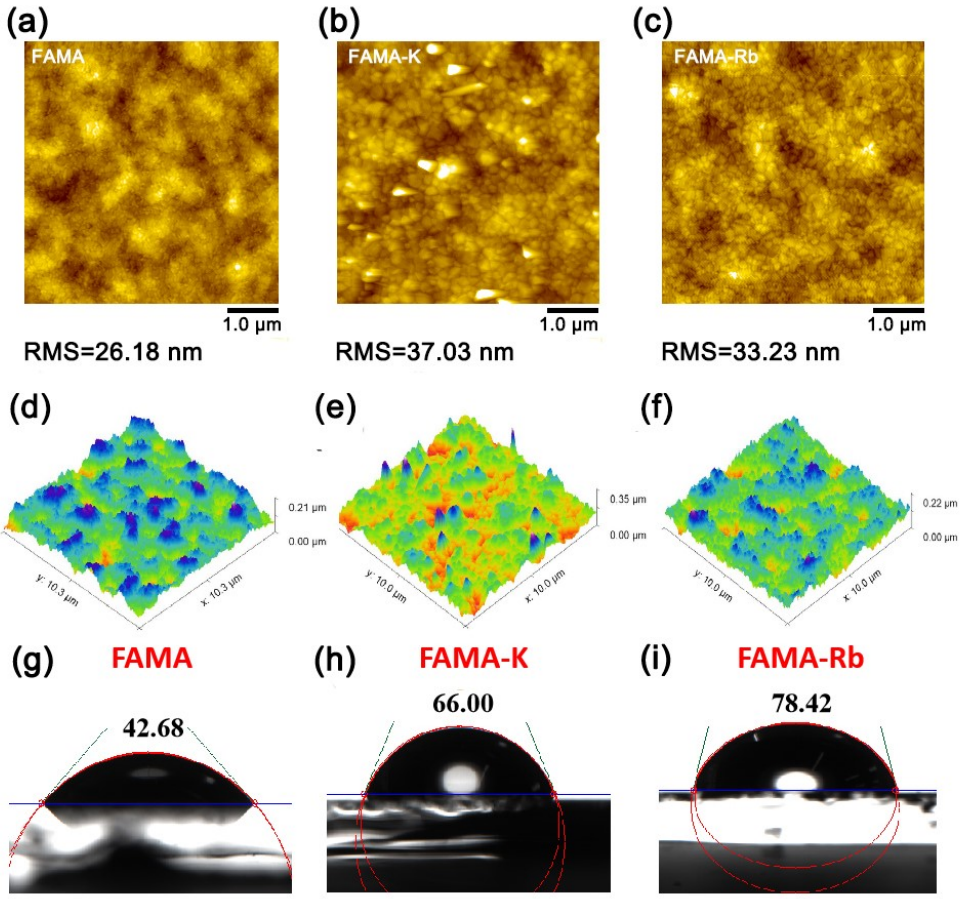

Figure S2 Atomic force microscope 2D images of (a) FAMA, (b) FAMA-K and (c) FAMA-Rb. Atomic force microscope 3D images of (d) FAMA, (e) FAMA-K and (f) FAMA-Rb. Contact angle test images of (g) FAMA, (h) FAMA-K and (i) FAMA-Rb.

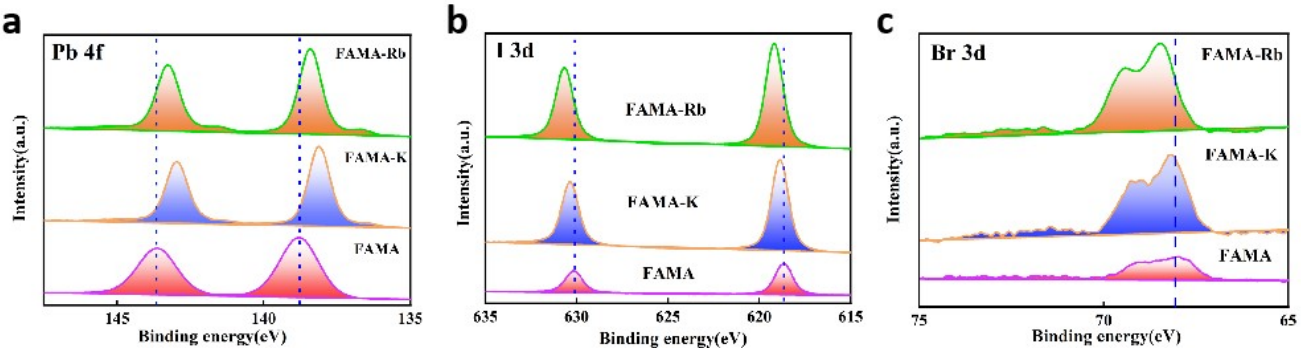

Figure S3 XPS pattern of FAMA, FAMA-K and FAMA-Rb.

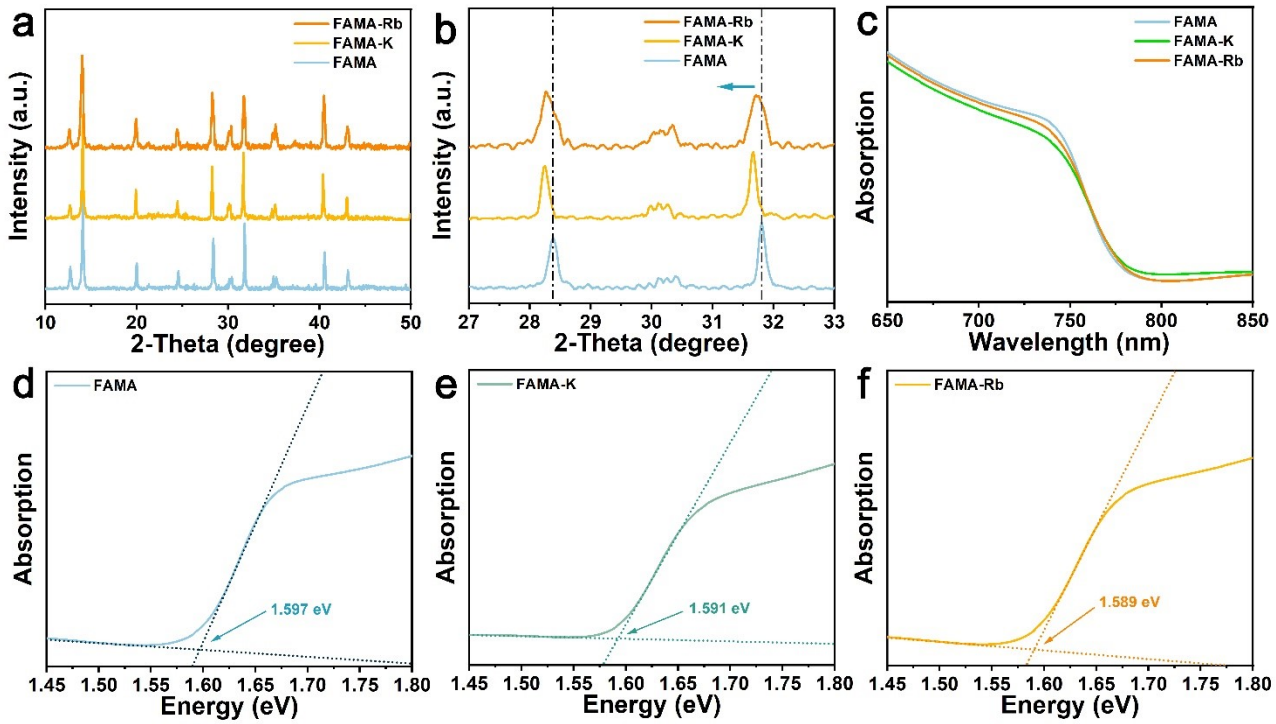

Figure S4 (a) XRD patterns and (b) shift in amplifying peaks for FAMA and alkali metal ions doped FAMA films. (c) UV-Vis spectra of FAMA film and alkali metal ions doped FAMA films. The tauc plots $((ahv)^2 \sim hv)$ of (d) FAMA, (e) FAMA-K and (f) FAMA-Rb perovskite film.

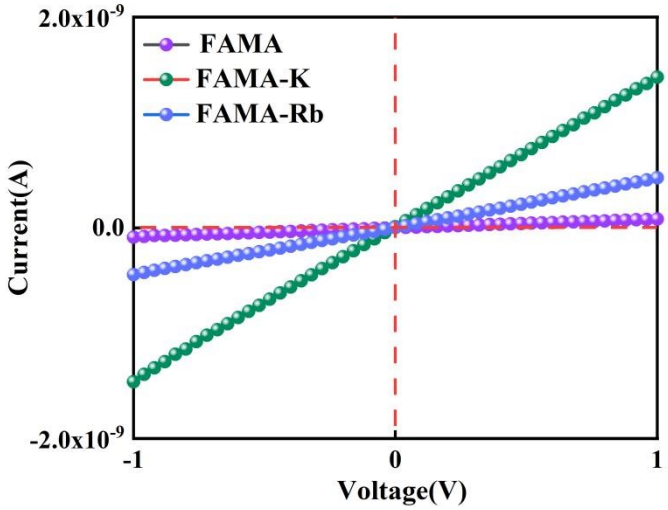

Figure S5 I-V curves of perovskite films doped by alkali metal ions.

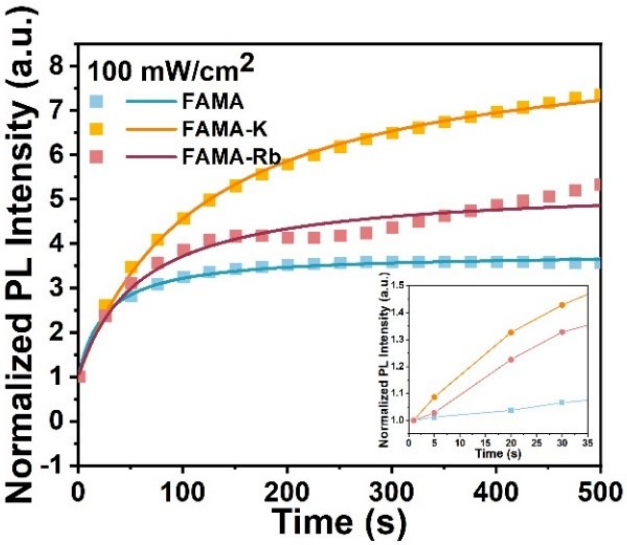

Figure S6 The normalized change curves of PL intensity and fitting curves of PL enhancement saturation time for FAMA, FAMA-K and FAMA-Rb perovskite films were obtained under continuous illumination with an intensity of 100 mW/cm^2. The inset shows an enlarged PL intensity spectrum over 30 s. These curves were extracted from the 3D contour mapping of PL intensity at a specific wavelength corresponding to the perovskite bandgap.

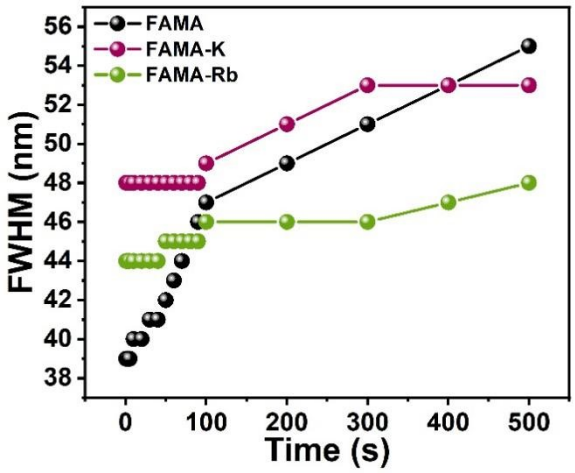

Figure S7 The time-dependent FWHM of PL peak of FAMA, FAMA-K and FAMA-Rb perovskite film.

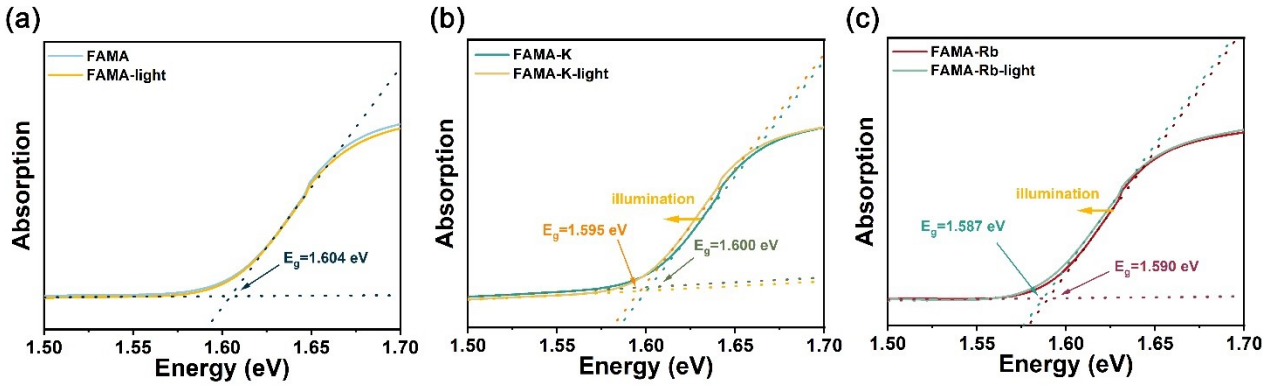

Figure S8 Tauc plots ((ahv)^2~hv) of (a) FAMA, (b) FAMA-K, and (c) FAMA-Rb perovskite films.

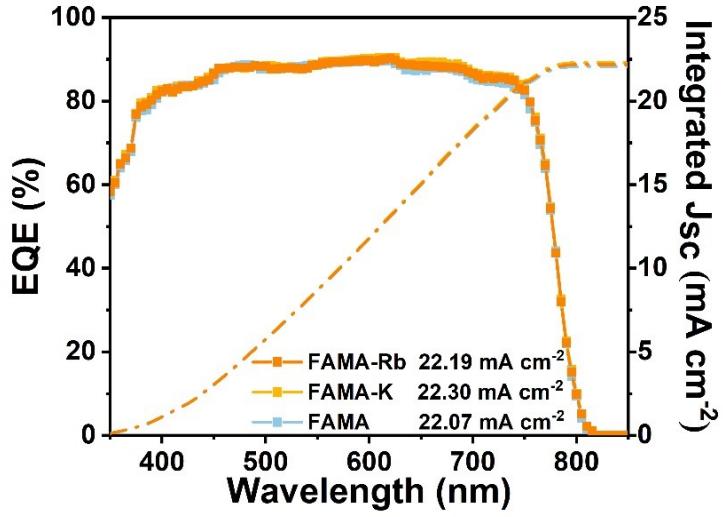

Figure S9 The EQE spectra of FAMA, FAMA-K and FAMA-Rb PSCs.

Table S1 Fitting parameters of for time resolved photoluminescence decay with an excitation of 10 W/cm^2. Bi-exponential decay models was used for FAMA perovskites. The values in parenthesis indicate proportion of each decay component.

	Time (s)	A_1	τ_1	A_2	τ_2	Effective lifetime (ns)
FAMA	100	5.18 (0.9435)	1.78	0.31 (0.0565)	262.74	16.51
	200	2.21	2.36	0.35	278.27	40.08

		(0.8633)		(0.1367)		
	300	0.75 (0.6696)	4.11	0.37 (0.3304)	300.42	101.99
	400	0.32 (0.4324)	8.71	0.42 (0.5676)	341.25	197.44
	500	0.38 (0.4691)	7.14	0.43 (0.5309)	328.87	177.93

Table S2 Fitting parameters of for time resolved photoluminescence decay with an excitation of 10 W/cm^2. Bi-exponential decay models was used for FAMA-K perovskites. The values in parenthesis indicate proportion of each decay component.

	Time (s)	A_1	τ_1	A_2	τ_2	Effective lifetime (ns)
FAMA-K	100	0.52 (0.6190)	5.38	0.32 (0.3810)	295.02	115.71
	200	0.35 (0.4861)	9.24	0.37 (0.5139)	334.4	175.85
	300	0.32 (0.4384)	10.07	0.41 (0.5616)	359	206.04
	400	0.3 (0.4348)	10.31	0.39 (0.5652)	366.19	211.45
	500	0.28 (0.4058)	11.8	0.41 (0.5942)	383.3	232.54

Table S3 Fitting parameters of for time resolved photoluminescence decay with an excitation of 10 W/cm^2. Bi-exponential decay models was used for FAMA-Rb perovskites. The values in parenthesis indicate proportion of each decay component.

	Time (s)	A_1	τ_1	A_2	τ_2	Effective lifetime (ns)
FAMA-Rb	100	0.3814 (0.4524)	13.82	0.46 (0.5476)	190.99	212.07
	200	0.3512	18.85	0.52	355.32	284.22

	(0.4023)		(0.5977)		
300	0.3502 (0.3846)	20.99	0.56 (0.6154)	440.58	333.27
400	0.3574 (0.3723)	22.36	0.59 (0.6277)	499.95	372.38
500	0.3577 (0.3608)	23.63	0.62 (0.6392)	558.37	426.01

Table S4 The performance parameters of PSCs based on FAMA under continuously light illumination.

	Time (h)	Sweep	J_{sc} (mA cm^{-2})	V_{oc} (V)	FF	PCE (%)
FAMA	0	FS	22.67	1.037	0.72	17.15
		RS	22.72	1.047	0.73	17.56
	24	FS	22.52	1.035	0.70	16.50
		RS	22.60	1.042	0.73	17.42
	48	FS	22.46	1.020	0.68	15.58
		RS	22.50	1.031	0.69	16.03

Table S5 The performance parameters of PSCs based on FAMA-K under continuously light illumination.

	Time (h)	Sweep	J_{sc} (mA cm^{-2})	V_{oc} (V)	FF	PCE (%)
FAMA-K	0	FS	22.74	1.067	0.75	18.10
		RS	22.84	1.075	0.76	18.66
	24	FS	22.79	1.081	0.76	18.88
		RS	22.89	1.090	0.78	19.50
	48	FS	22.80	1.085	0.76	18.96
		RS	22.87	1.092	0.77	19.27

Table S6 The performance parameters of PSCs based on FAMA-Rb under continuously light illumination

	Time (h)	Sweep	J_{sc}	V_{oc} (V)	FF	PCE (%)

			(mA cm^{-2})			
FAMA-Rb	0	FS	22.72	1.071	0.75	18.27
		RS	22.77	1.077	0.75	18.63
	24	FS	22.62	1.056	0.73	17.48
		RS	22.65	1.063	0.72	17.41
	48	FS	22.64	1.067	0.74	18.00
		RS	22.70	1.072	0.73	17.94