

## Supporting information

# Significantly Improved Black Phase Stability of FAPbI<sub>3</sub> Nanowires via Spatially Confined Vapor Phase Growth in Nanoporous Templates

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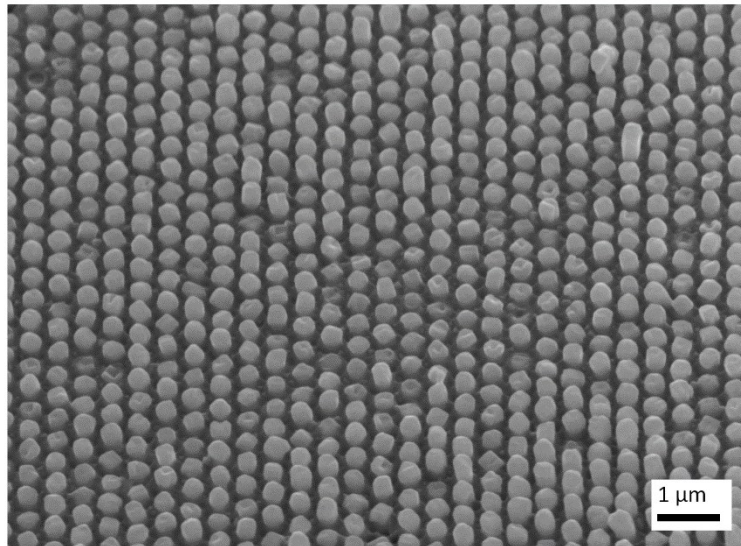
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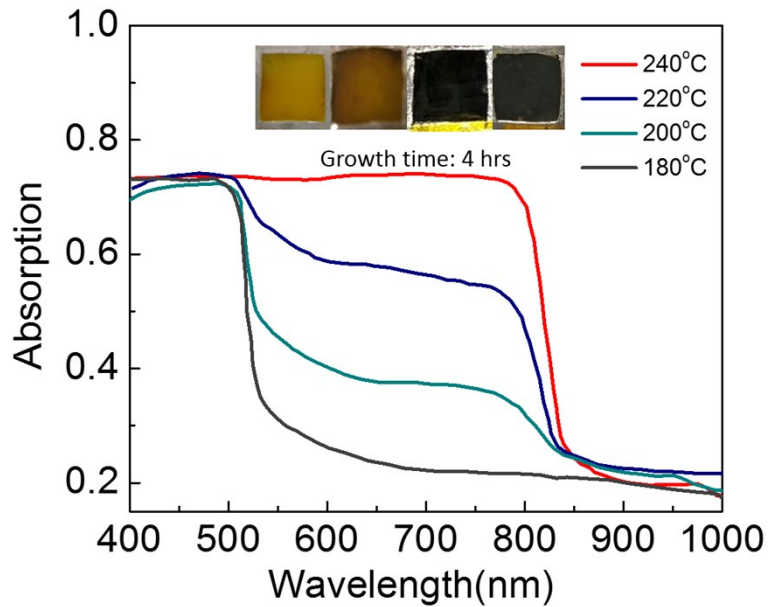
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**Top-view SEM image of FAPbI<sub>3</sub> NWs/PAM sample**



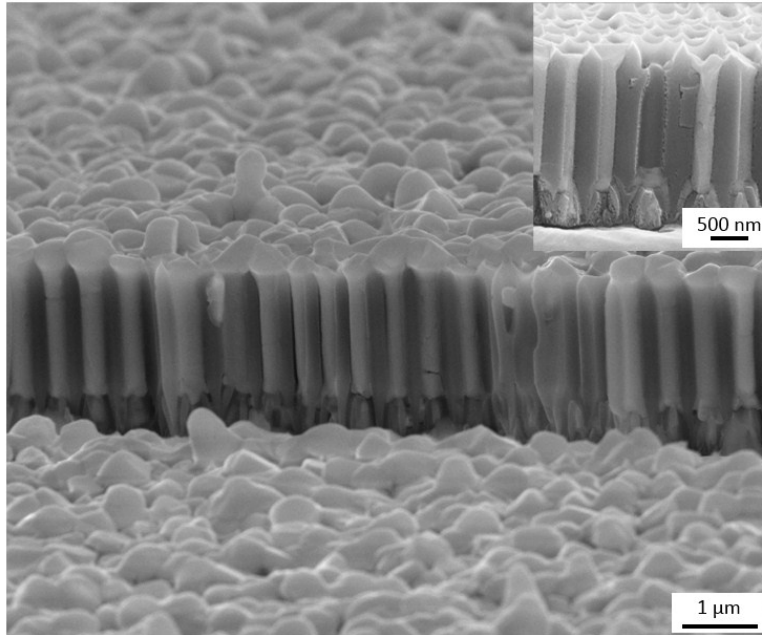
**Figure S1.** Top view of an ordered NW/PAM sample with minor overgrowth.

### Light absorption of NWs/PAM samples grown at different temperature



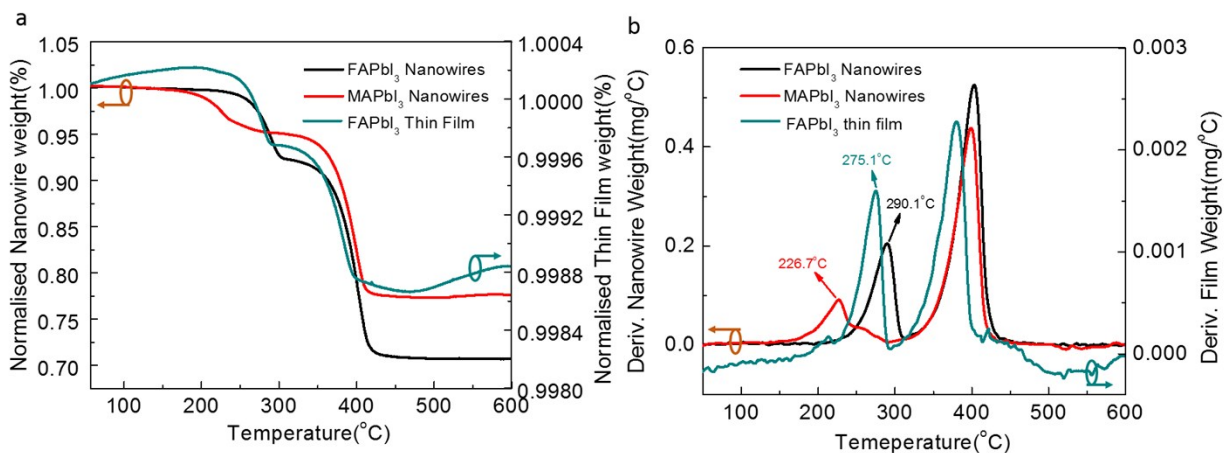
**Figure S2.** UV-Vis spectrum of NWs/PAM samples grown at different temperature (180 °C-240 °C) for 4 hrs.

**MAPbI<sub>3</sub> NWs grown with CVD for comparison**



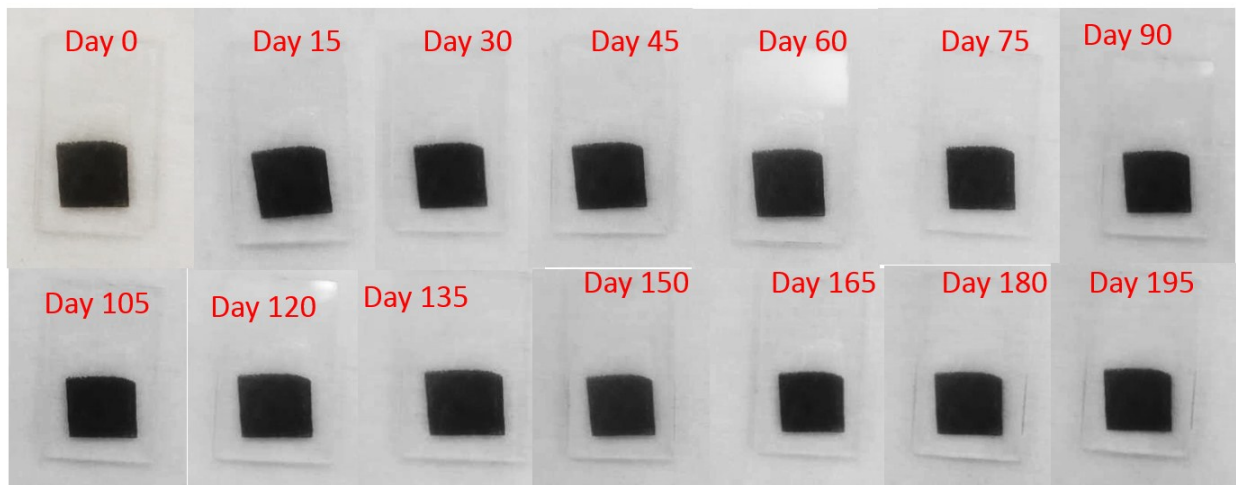
**Figure S3.** Cross-section view SEM images of MAPbI<sub>3</sub> NWs grown with CVD method at temperature of 180 °C.

### Thermal stability comparison of FAPbI<sub>3</sub> NWs/PAM sample



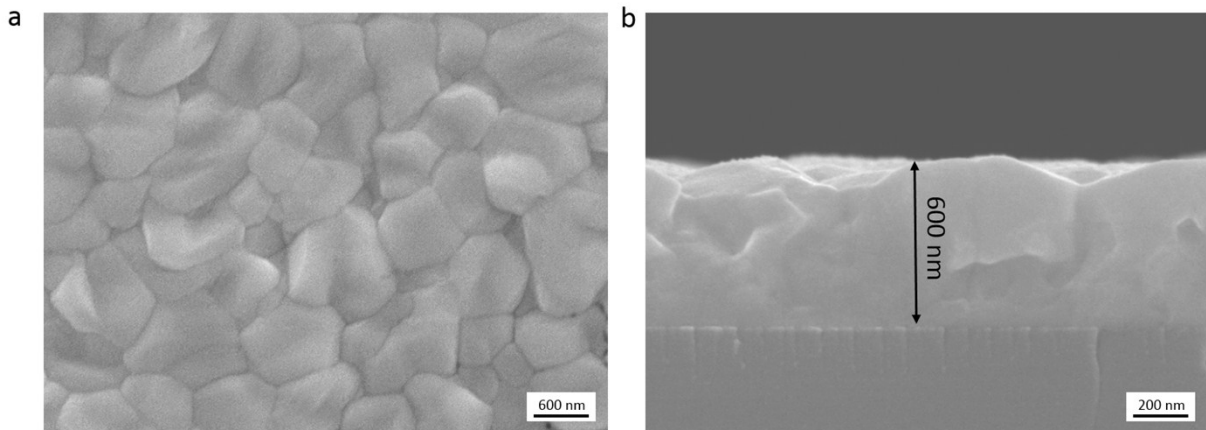
**Figure S4.** TGA analysis of FAPbI<sub>3</sub> NWs/PAM, MAPbI<sub>3</sub> NWs/PAM and FAPbI<sub>3</sub> film samples (a) and their corresponding 1st derivatives (b).

## Stability analysis of FAPbI<sub>3</sub> NWs/PAM sample



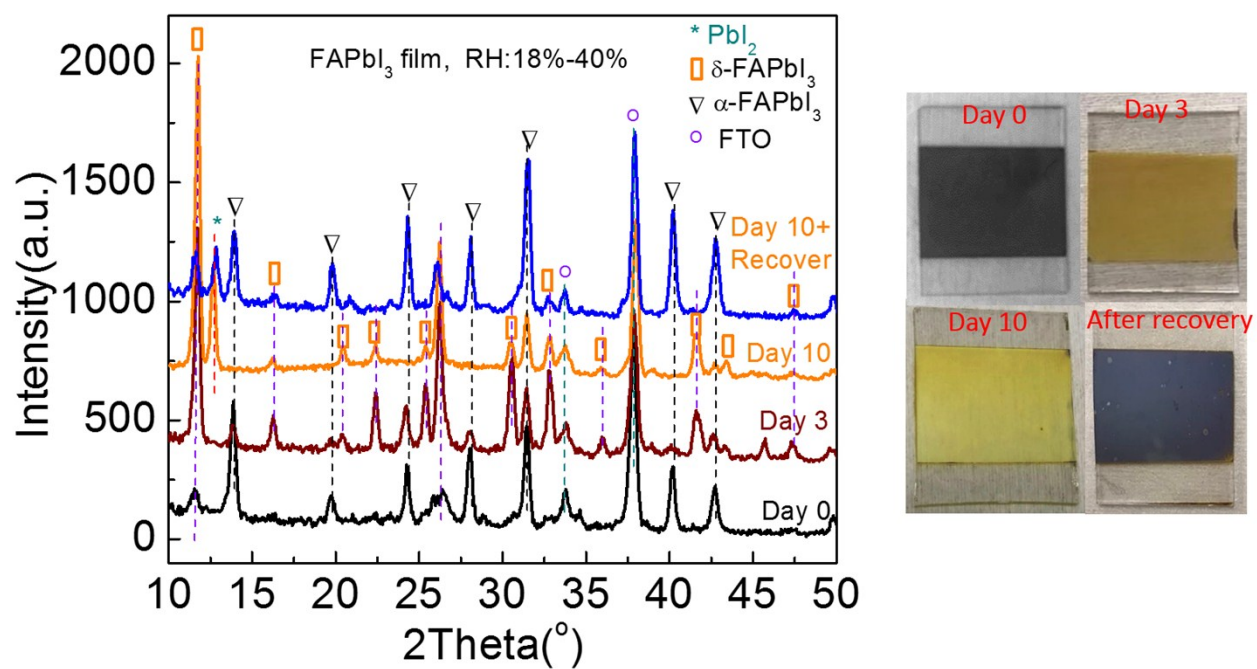
**Figure S5.** Optical photos of FAPbI<sub>3</sub> NWs/PAM sample stored in ambient condition with Relative humidity ranging from 18%-40% vs time.

## Morphology of FAPbI<sub>3</sub> film



**Figure S6.** SEM images of evaporated FAPbI<sub>3</sub> film on FTO substrate in top (a) and cross-section view (b).

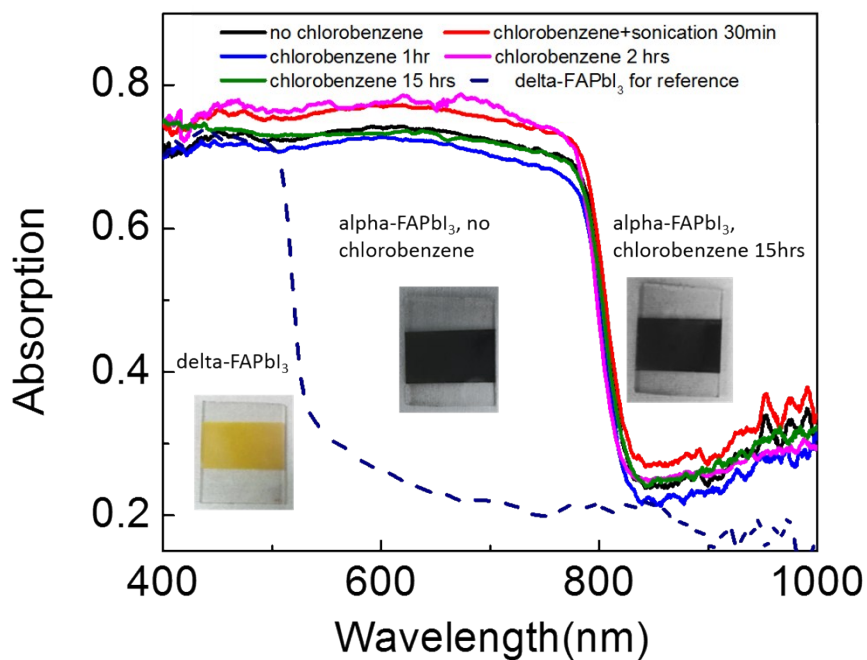
## Stability analysis of FAPbI<sub>3</sub> film



**Figure S7.** XRD evolution of FAPbI<sub>3</sub> film stored in ambient condition with Relative humidity range from 18%-40% vs time and the corresponding photos.



## Chlorobenzene test of $\alpha$ -FAPbI<sub>3</sub> film



**Figure S8.** UV-vis spectrums and photos of evaporated FAPbI<sub>3</sub> film in chlorobenzene at different condition: (a) 30 min chlorobenzene+sonication; (b) 1hr min chlorobenzene; (c) 2hrs chlorobenzene; (d) 15 hrs chlorobenzene.

**Stability analysis of FAPbI<sub>3</sub> NWs/PAM in ambient with RH 97%**

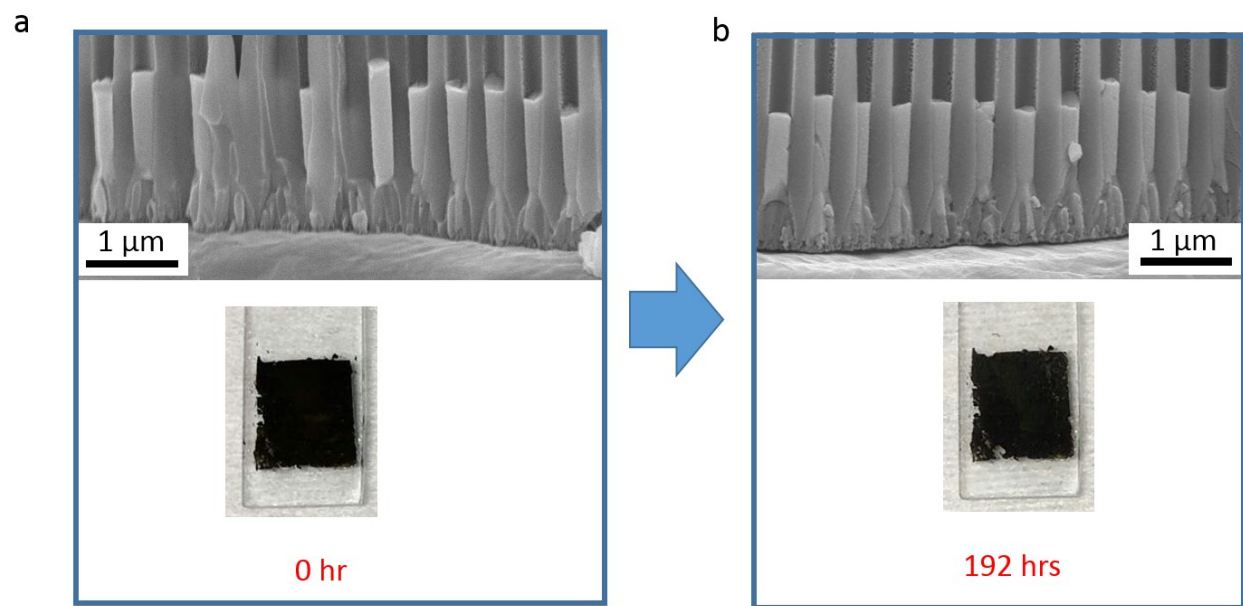


Figure S9. SEM image and Photo of FAPbI<sub>3</sub> NWs/PAM before (a) and after aging in RH 97% environment for 192 hrs (b).

## Comparison of phase stability of our FAPbI<sub>3</sub> NWs/PAM sample with others

	Morphology	Storage environment	$\alpha$ -phase stable time	Reference
FAPbI <sub>3</sub>	NWs in PAM	Air, RH: 18~40%	>210 days	Our sample
FAPbI <sub>3</sub>	Polycrystalline film	Air, RH: 97%	>192 hrs	Our control sample
FAPbI <sub>3</sub>	Polycrystalline film	Air, RH: 18~40%	3 days	Ref 20
FAPbI <sub>3</sub>	Polycrystalline film	Air, RH: 50%	5 min	Ref 38
FAPbI <sub>3</sub>	Polycrystalline film	Inert gas	10 min	Ref 23
FAPbI <sub>3</sub>	Polycrystalline film	Air, RH:90%	4 hrs	Ref 47
FAPbI <sub>3</sub>	Polycrystalline film	Air, RH:50%	< 5 days	Ref 38
FAPbI <sub>3</sub>	Single crystals	Inert gas	24 hrs	Ref 39
FAPbI <sub>3</sub>	Single crystals	Inert gas	10 days	Ref S1
FAPbI <sub>3</sub>	Single crystals	Air, RH: 40-50%	7 days	
FAPbI <sub>3</sub>	surface modified NWs	Air, RH: 15-20%	>23 days	
FAPbI <sub>3</sub>	surface modified NWs	ambient	>4 months	Ref 25
FA <sub>0.85</sub> CS <sub>0.15</sub> PbI <sub>3</sub>	Polycrystalline film	Air, RH:15%	30 days	Ref 23
FAPb <sub>0.95</sub> Bi <sub>0.05</sub> I <sub>3</sub>	Polycrystalline film	Air, RH: 50%	>15 days	Ref S2

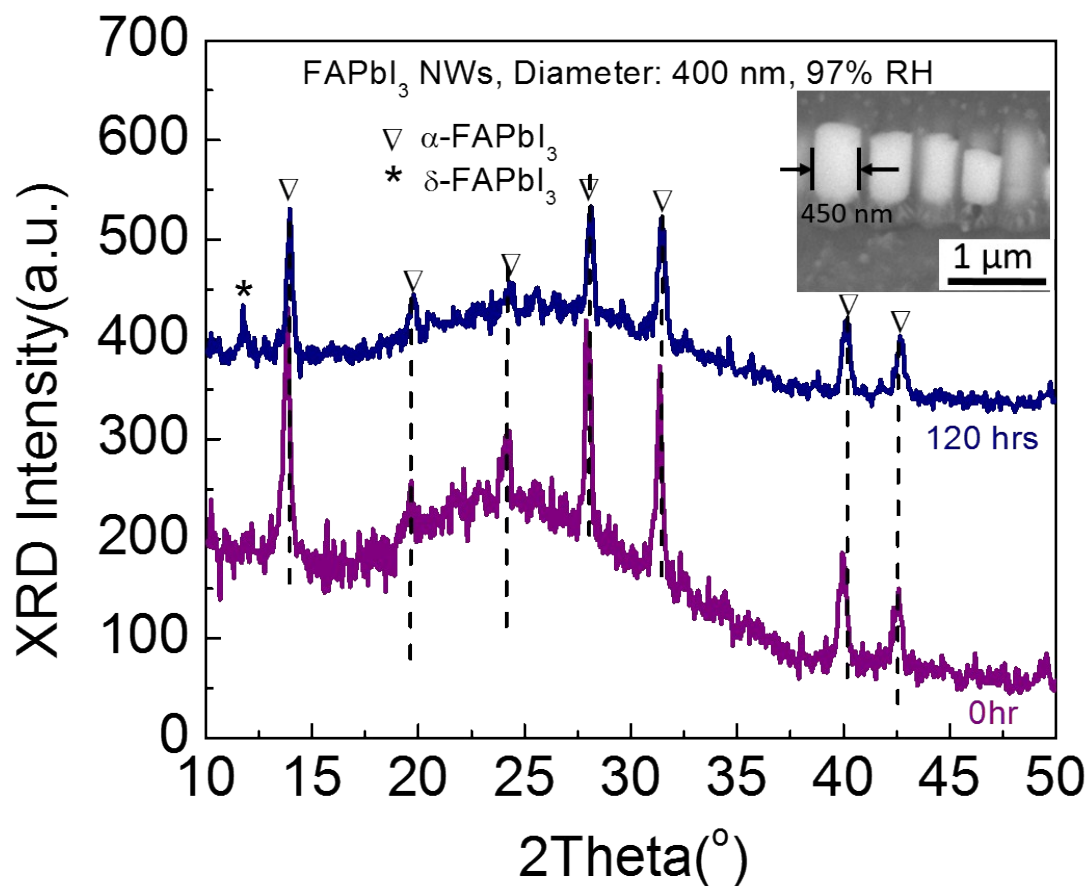
Table 1. Comparison of  $\alpha$  -phase stable time of our FAPbI<sub>3</sub> NWs/PAM sample with reported values.

### Reference

S1. Liu, Y.; Sun, J.; Yang, Z.; Yang, D.; Ren, X.; Xu, H.; Liu, S. F. *Adv. Opt. Mater.* **2016**, 4, (11), 1829-1837.

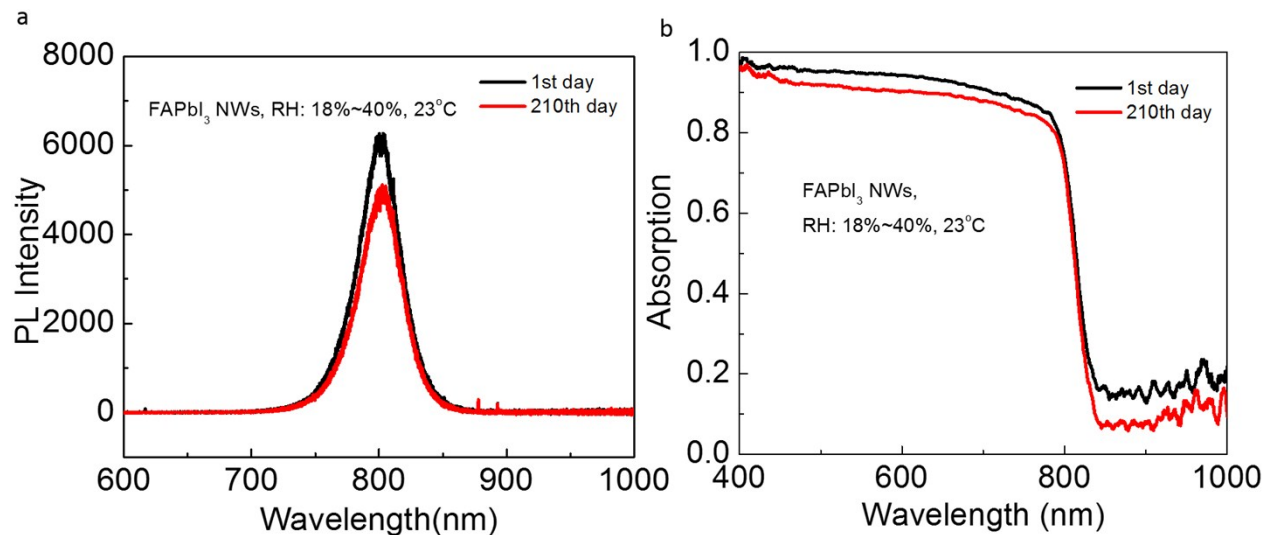
S2. Hu, Y.; Qiu, T.; Bai, F.; Miao, X.; Zhang, S. *J. Mater. Chem. A* **2017**, 5, (48), 25258-25265.

### Phase stability of large-diameter alpha-FAPbI<sub>3</sub> NWs in AAM



**Figure S10.** XRD of large-diameter FAPbI<sub>3</sub> NWs (~450 nm) in freestanding PAM stored at wet condition (temperature: 23 °C, Relative humidity: 97%) vs time.

### Optical properties stability of FAPbI<sub>3</sub> NWs/PAM sample



**Figure S11.** PL (a) and UV-vis (b) curves of FAPbI<sub>3</sub> NWs/PAM sample before and after storing in ambient condition with relative humidity range from 18%-40% for 210 days.