Supporting Information for

Highly efficient fluorescent and colorimetric sensing of organic amine vapors based on Organometal halide perovskite nanostructures

Pengcheng Wu[a,b,c], Qingguo He[a*], Defeng Zhu[a], Haibo Jiang[a,b,c], Zinuo Jiao[a,c], YuZhang [a], WeiXu[a], Yanyan Fu[a], Huimin Cao[a] and Jiangong Cheng [a*]

[a]State Key Lab of Transducer Technology, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Changning Road 865, Shanghai, 200050, China

[b]School of Physical Science and Technology, ShanghaiTech University, Haike Road 100, Shanghai, 201210, China.

[c]University of the Chinese Academy of Sciences, Yuquan Road 19, Beijing, 100039, P. R. China.

Excitation and Emission discussing

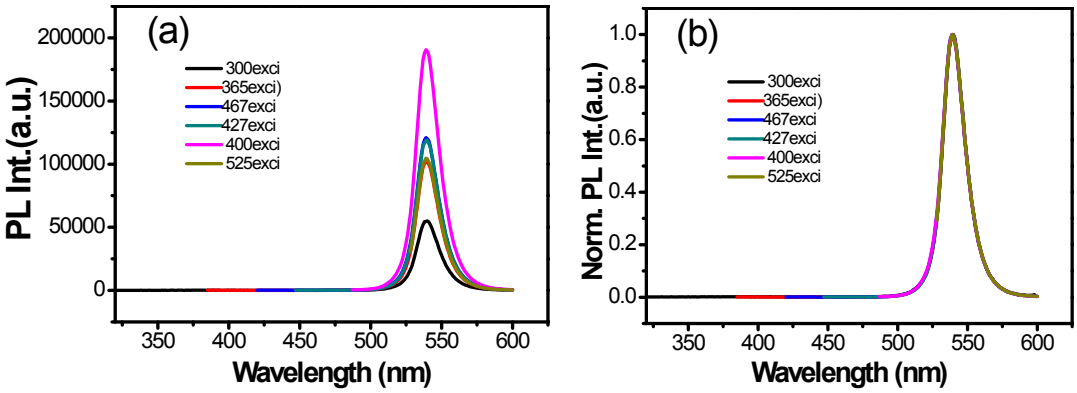


Figure S1. The emission of $MaPbBr_3$ at different excitation wavelengths (a), the normalized emission of $MaPbBr_3$ at different excitation wavelengths (b)

We obtain the fluorescence spectrum under the excitation of the typical absorption band, such as 300 nm, 400 nm, 427 nm, 467 nm, 525 nm, respectively. We also selected

365 nm for excitation because we often monitor the fluorescence image via naked eye under the excitation of one handheld UV lamp with a wavelength of 365 nm. As shown in Figure S1 (a), the emission spectrum only exhibited a highly symmetric band centered at 534 nm, and the normalized emission peak are completely overlapped [Figure S1 (b)]. It seems that 400 nm is the most appropriate excitation wavelength as the emission intensity is the strongest.

The changes of absorption spectrum discussing

We think the small absorption peaks at 427 nm and 525 nm are related to the crystal structure of $MAPbBr_3$. The reason is that upon interaction with BA and DEA, the crystal state is destroyed, but the crystal state is kept upon interaction with AN by XRD result in Figure 9. Correspondingly, the absorption band changed upon exposure to BA and DEA, but no change for AN. So we think the two absorption peaks are related to the crystal structure of $MAPbBr_3$.

In the Figure 8, we prepared four samples of $MAPbBr_3$ film, one for reference and the other three for exposure to BA, DEA and AN. But after exposure to AN, it seems that the absorption peak at 525 nm is increased, and the position is overlapped with the emission band at 534 nm. If it is true, the energy hopping should happen.

To prove it, we designed and conducted another experiment. Firstly, at the bottom of the cuvette a piece of cotton was placed, then one $MAPbBr_3$ film was put inside on top of the cotton. The film was fixed at an angle of 30^o relative to the incident light. After that, the absorption spectrum of $MAPbBr_3$ was measured as Figure S2(a) shows. Secondly, a drop of AN was injected into the bottom of cuvette to avoid a direct contact of the AN liquid with $MAPbBr_3$. One minute later, the absorption spectrum of AN vapor-treated $MAPbBr_3$ was obtained as Figure S2(b). This test could prevent the problem of the position and angle change of $MAPbBr_3$ film before and after the interaction with AN. As can be seen in Figure S2(a) and S2(b), the position and absorbance of the absorption band at 525 nm showed no any change (both were 0.057). So the fluorescence quenching should not come from the increased self-absorption, and

not from the energy hopping.

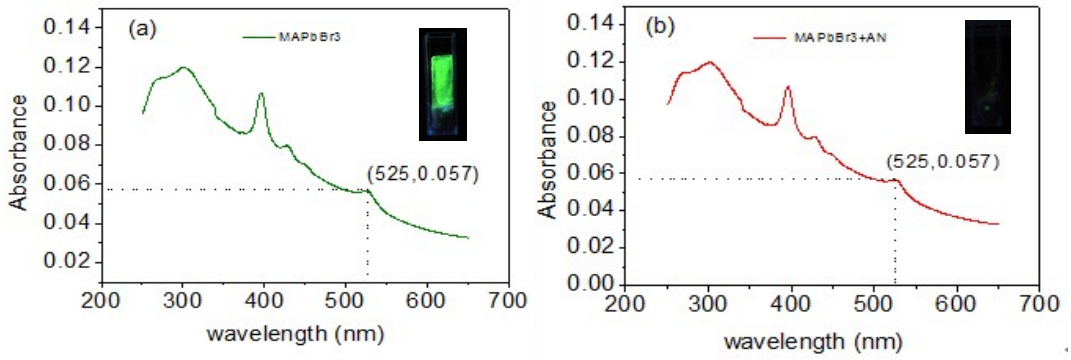


Figure S2. The absorption spectrum of $MAPbBr_3$ (a) and the absorption spectrum of $MAPbBr_3$ exposed to AN vapour (b). Inset: photographs of the emitter illuminated with UV light-lamp centered at 365 nm.

But another concern is, why the normalized absorption in Figure 8 showed the misleading result? We doubt it may be related to the position and angle of the film, which changed the ratio of the absorbance between the absorption band at 525 and 400 nm. So we did another experiment. A $MAPbBr_3$ film was put inside the cuvette, the absorption band was measured at angles of 30°, 45 ° and 60 ° relative to the incident light. As Figure S3 shows, although the sample is same, the relative ratio of absorbance at 400 and 525 nm will change when the angle of the sensing film relative to the incident light is changed.

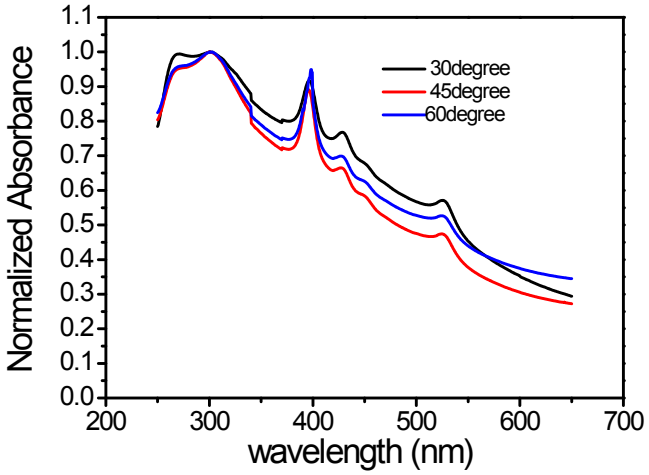


Figure S3. The absorption spectrums of $MAPbBr_3$ when the angle between the incident light and the sensing film was 30°, 45 ° and 60 °, respectively.

Fluorescence Lifetime fitting

Calculated using 3 exponentials

Prompt data : Prompt
Decay data : AN-treated $MAPbBr_3$+vacuum treatment Decay

The initial parameters are:

Shift Value = Fixed 0 ch; 0 sec

T1 Estimate = 0.0995 ch; $1.091907E^{-11}$ sec
T2 Estimate = 0.199 ch; $2.183814E^{-11}$ sec
T3 Estimate = 0.398 ch; $4.367627E^{-11}$ sec

A Free
B1 Free
B2 Free
B3 Free

Prompt and decay LO = 426 ch; $4.674897E^{-08}$ sec
Prompt and decay HI = 3992 ch; $4.380796E^{-07}$ sec

Background on prompt = 3.259259
Time calibration = $2.194787E^{-10}$ sec/ch

The fitted parameters are:

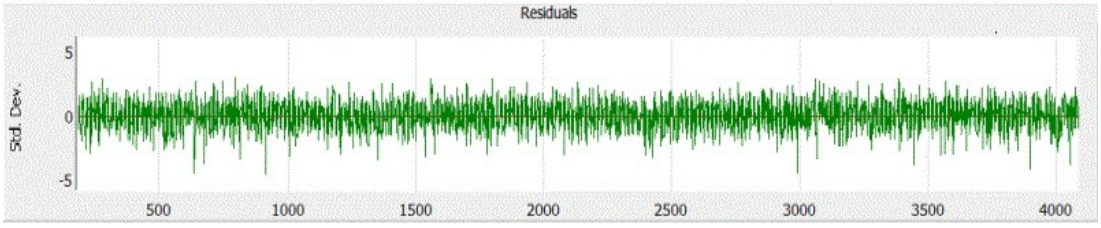
SHIFT = 0 ch

T1 = 0.1144809 ch; $1.256306E^{-11}$ sec S.Dev = $2.473097E^{-13}$ sec
T2 = 68.01256 ch; $7.463655E^{-09}$ sec S.Dev = $1.023386E^{-10}$ sec
T3 = 234.8233 ch; $2.576936E^{-08}$ sec S.Dev = $9.787781E^{-10}$ sec
A = 4.776157 S.Dev = $4.247609E^{-02}$
B1 = 81.45789 [0.01 Rel.Ampl][0.04 Alpha] S.Dev = 42.10135
B2 = 1749.974 [88.38 Rel.Ampl][0.92 Alpha] S.Dev = 6.279984
B3 = 66.71081 [11.63 Rel.Ampl][0.04 Alpha] S.Dev = 1.337844
Average Life Time = $7.787254E^{-09}$ sec
CHISQ = 1.077861 [3560 degrees of freedom]

Chi-squared Probability = $1.9288E^{-20}$ percent
Durbin-Watson Parameter = 1.783174
Negative residuals = 32.32408 percent
Residuals < 1 s.dev = 59.85422 percent

Residuals < 2 s.dev = 94.86964 percent
Residuals < 3 s.dev = 98.40202 percent
Residuals < 4 s.dev = 99.80376 percent

(a)



(b)

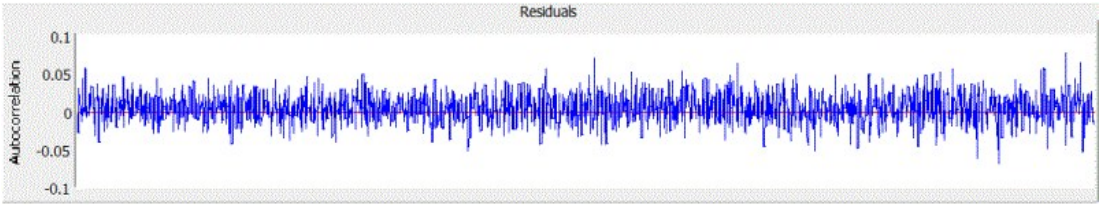


Figure S4. The residuals (a) and the autocorrelation of the residuals (b)

Calculated using 3 exponentials

Prompt data : Prompt
Decay data : $MAPbBr_3$ Decay

The initial parameters are:

Shift Value = Fixed 0 ch; 0 sec

T1 Estimate = 92.8822 ch; $1.019283E^{-08}$ sec
T2 Estimate = 185.7644 ch; $2.038567E^{-08}$ sec
T3 Estimate = 371.5288 ch; $4.077134E^{-08}$ sec

A Free
B1 Free
B2 Free
B3 Free

Prompt and decay LO = 421 ch; $4.620027E^{-08}$ sec
Prompt and decay HI = 3938 ch; $4.321536E^{-07}$ sec

Background on prompt = 3.178571
Time calibration =$2.194787E^{-10}$ sec/ch

The fitted parameters are:

SHIFT = 0 ch

T1	= 105.6316	ch;	1.159195E^{-08}	sec	S.Dev = 6.871596E^{-10}	sec
T2	= 437.433	ch;	4.800363E^{-08}	sec	S.Dev = 5.099626E^{-09}	sec
T3	= 58.16223	ch;	6.382687E^{-09}	sec	S.Dev = 1.218477E^{-10}	sec
A	= 5.480542				S.Dev = 5.213265E^{-02}	
B1	= 1225.763	[55.64 Rel.Ampl][0.42 Alpha] S.Dev = 11.48019				
B2	= 17.18046	[3.23 Rel.Ampl][0.01 Alpha] S.Dev = 0.7912744				
B3	= 1645.331	[41.13 Rel.Ampl][0.57 Alpha] S.Dev = 18.1317				

Average Life Time = 8.841036E^{-09} sec

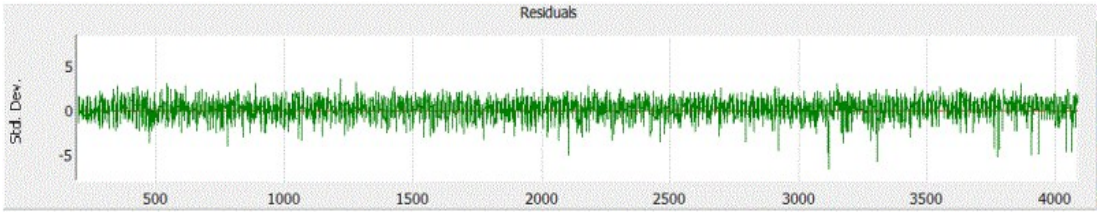
CHISQ = 1.084371 [3511 degrees of freedom]

Chi-squared Probability = 1.9288E^{-20} percent

Durbin-Watson Parameter = 1.819796

Negative residuals	=	35.53155 percent
Residuals < 1 s.dev	=	64.78113 percent
Residuals < 2 s.dev	=	94.34338 percent
Residuals < 3 s.dev	=	99.00512 percent
Residuals < 4 s.dev	=	99.31779 percent

(a)



(b)

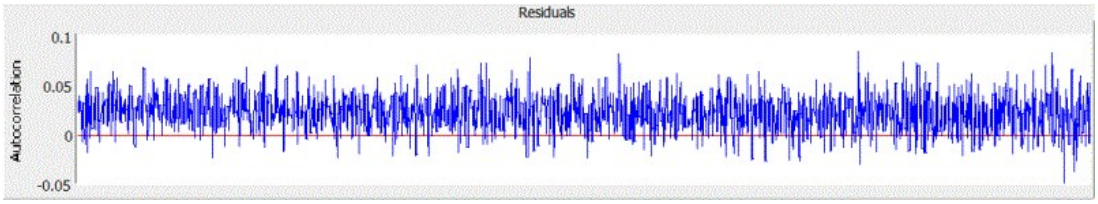


Figure S5. The residuals (a) and the autocorrelation of the residuals (b)