Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

for

Giant reduction of random lasing threshold in $CH_3NH_3PbBr_3$ perovskite thin films by using patterned sapphire substrate

Guoen Weng,[1] Jiao Tian,[1] Shiming Chen,[1] Juanjuan Xue,[1] Jiyu Yan,[1] Xiaobo Hu,[1]
Shaoqiang Chen,*,[1,2] Ziqiang Zhu,[1] and Junhao Chu[1,2]

*Corresponding author: sqchen@ee.ecnu.edu.cn

[1]*Key Laboratory of Polar Materials and Devices, Ministry of Education, Department of Electronic Engineering, East China Normal University, 500 Dongchuan Road, Shanghai 200241, China*

[2]*Shanghai Institute of Intelligent Electronics & Systems, Fudan University, 220 Handan Road, Shanghai 200433, China*

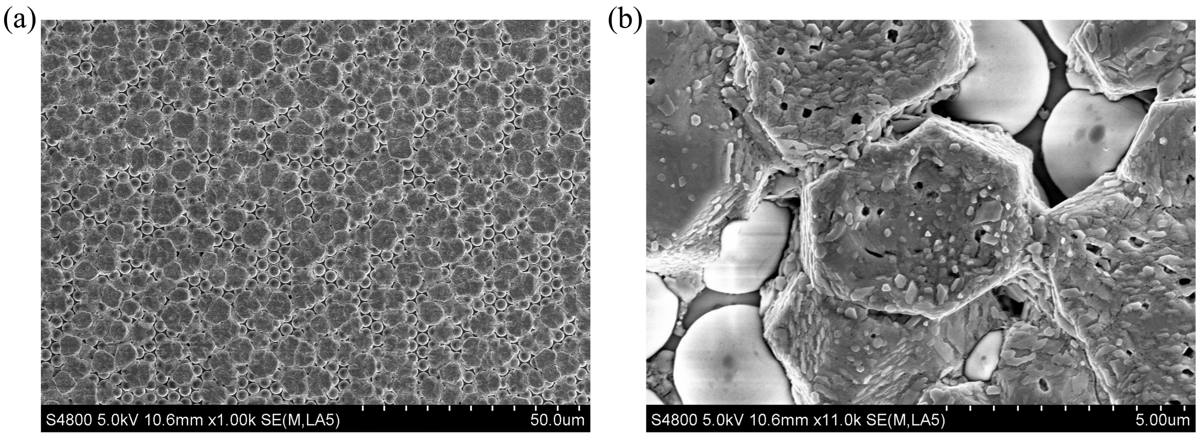

Fig. S1 Large scale top-view SEM images of the $CH_3NH_3PbBr_3$ perovskite thin films (a) and the corresponding expansion one (b) for the PSS samples. We can clearly see the perovskite particles or grains on the PSS. The perovskite/PSS interfaces could effectively redirect photons and thus enhance the random scattering of light in comparison to the FTO counterparts.

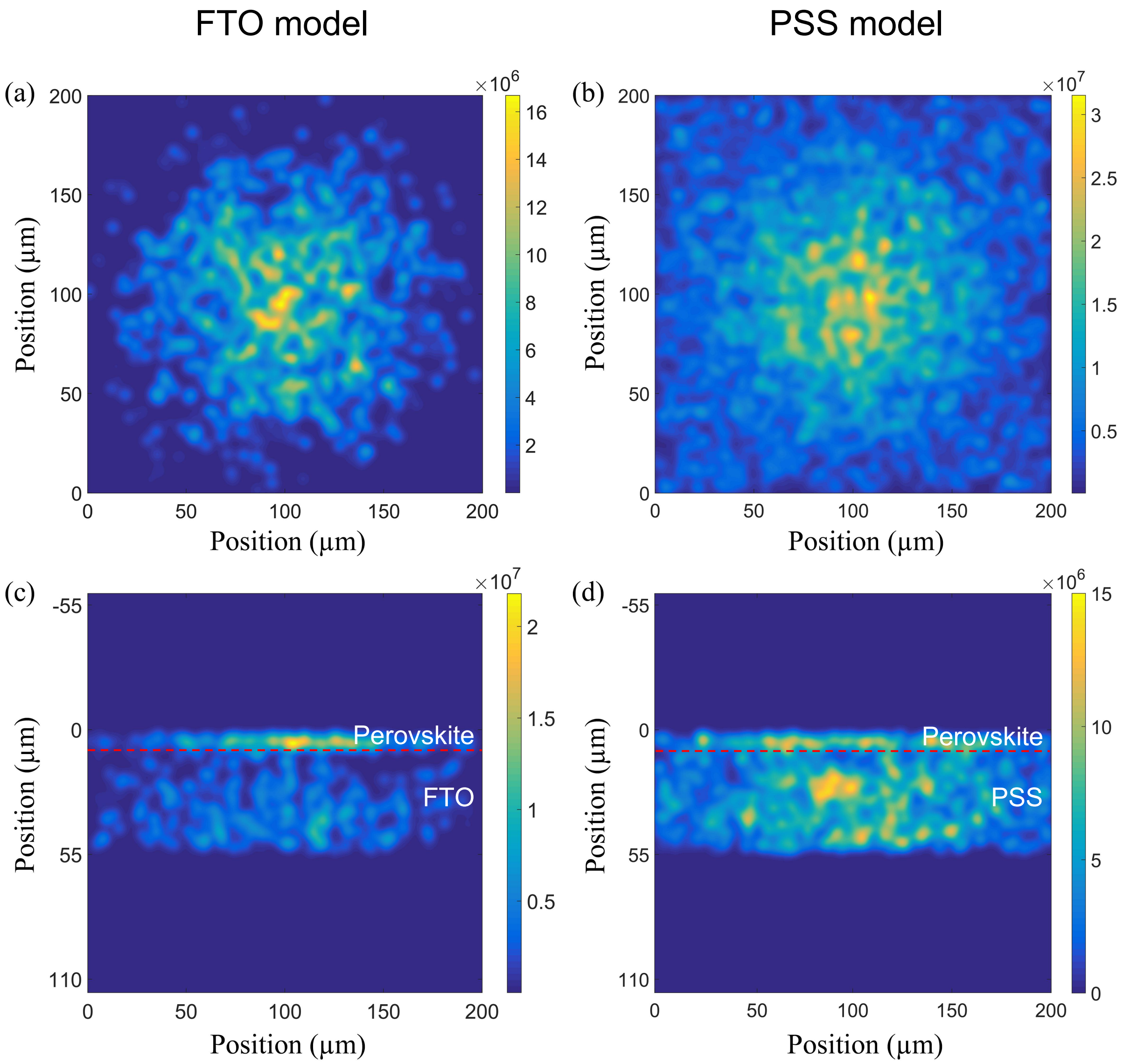

Fig. S2 Non-normalized two-dimensional (2D) intensity distributions of the luminous flue from the bottom and side facets of the perovskite/FTO (a, c) and perovskite/PSS (b, d) structures, respectively. In both simulations, the power of the disc-shaped Lamberian source was set to be 1 W. The absolute intensities and their intensity distributions of the top, bottom and side facets were obtained. The corresponding absolute intensities are listed in Table 1 for comparison.

Substrate	Absolute luminous flue (W)			
	Top	Sides (×4)	Bottom	Total
FTO	0.110	0.138	0.082	0.330
PSS	0.281	0.235	0.270	0.786

Table 1 Calculated absolute emission intensities from the top, sides, and bottom facets of the perovskite/FTO and perovskite/PSS structures, respectively. It is clearly seen that the perovskite film on the PSS always presents a higher emission efficiency for all six facets due to the enhanced random scattering induced by the patterned interface.

Substrate	LEE			
	Top	Sides (×4)	Bottom	Total
FTO	11.0%	13.8%	8.2%	33.0%
PSS	28.1%	23.5%	27.0%	78.6%

Table 2. Calculated corresponding LEEs from the top, sides, and bottom facets of the perovskite/FTO and perovskite/PSS structures, respectively.

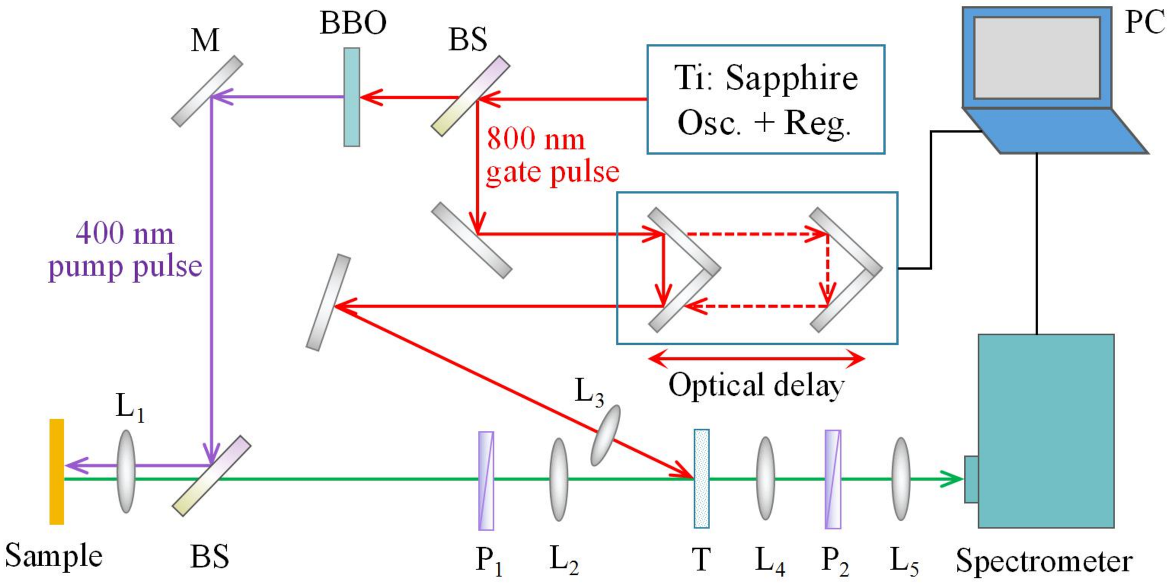

Fig. S3 Schematic diagram of the experimental apparatus. Osc.: Ti:sapphire oscillator; Reg.: regenerative amplifier; BS: beam splitter; BBO: β-BaB_2O_4 crystal; M: mirror; L: lens; P: polarizer; T: toluene solvent; PC: personal computer.

The fundamental beams (800 nm) from the regenerative amplifier were divided into two beams at a beam splitter: one is used as the excitation pulse of sample after the second harmonic generation (400 nm) at a phase-matching BBO crystal and the other as the gating laser pulse to rotate the polarization of luminescence at a Kerr medium (toluene).

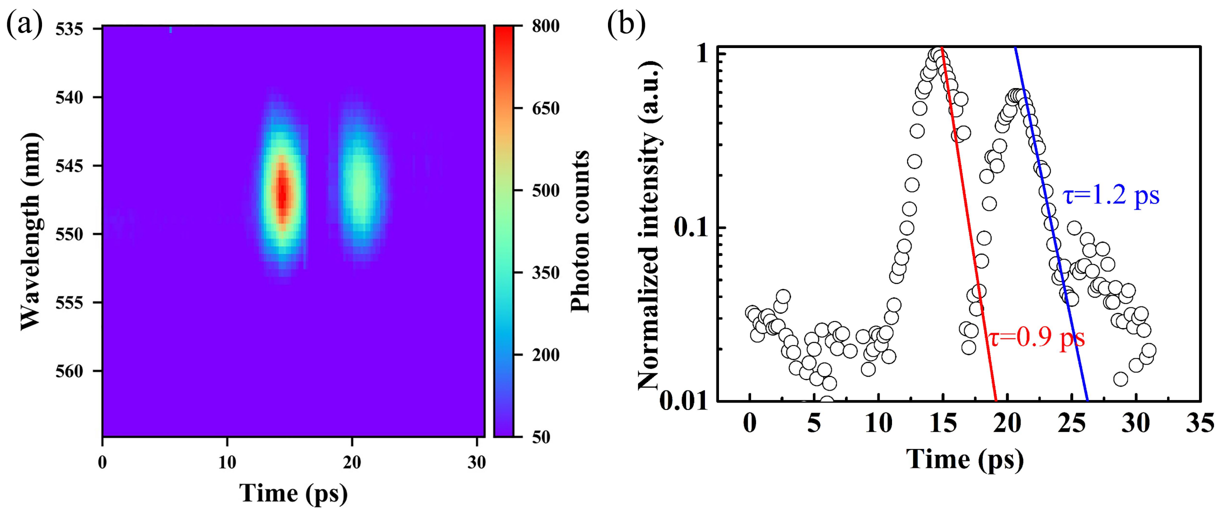

Fig. S4 TRPL image of the RL emission from the $CH_3NH_3PbBr_3$ perovskite films at excitation intensity of $2E_{th}$ for another sample (a). The corresponding spectrally-integrated waveforms of the emission pulses from the $CH_3NH_3PbBr_3$ films (b). The multiemission phenomenon was observed in all the PSS samples, while not for all the FTO counterparts.