2D Lead Halide Perovskite Scintillation Crystals for Fast-timing Detection and Imaging

Yunyun Li, Wen Li, Yuntao Wu

State Key Laboratory of Functional Crystals and Devices, Shanghai Institute of Ceramics, Chinese Academy of Science, No. 588 Heshuo Road, Jiading, Shanghai, China
Corresponding Author Email: liyunyun@mail.sic.ac.cn

The rising demand for high-frame rate imaging has driven extensive research on fast scintillators, particularly in emerging two-dimensional (2D) lead halide perovskites [1]. They have drawn tremendous attention owing to their unique virtues of solution processability, robust environmental stability, tunable emission, and in particular intense radioluminescence (RL) with fast decay [2,3]. However, understanding of the core scientific issues, such as the intrinsic physical mechanisms behind their ultrafast scintillation, the principles governing the controllable growth of high-quality crystals, and the precise control of defect states, remains significantly limited [4-6].

We developed a series of 2D lead halide perovskite scintillation crystals via low-temperature solution method such as $(HAD)PbCl_4$, $(TMFI)_2PbBr_4$, $(PEA)_2PbBr_4$. Among them, $(HAD)PbCl_4$ is the most studied one not only for its fast and bright scintillation properties, but also for its interesting and inspiring photophysical mechanism. $(HAD)PbCl_4$ scintillator demonstrates a high light yield of 16,200 photons MeV^{-1}, a fast decay time of 12.4 ns, enabling a dynamic X-ray imaging with a high frame rate of 1000 fps. This work provides fundamental insights into excitonic processes in 2D perovskites via defect engineering, advancing these materials toward fast radiation detection and imaging.

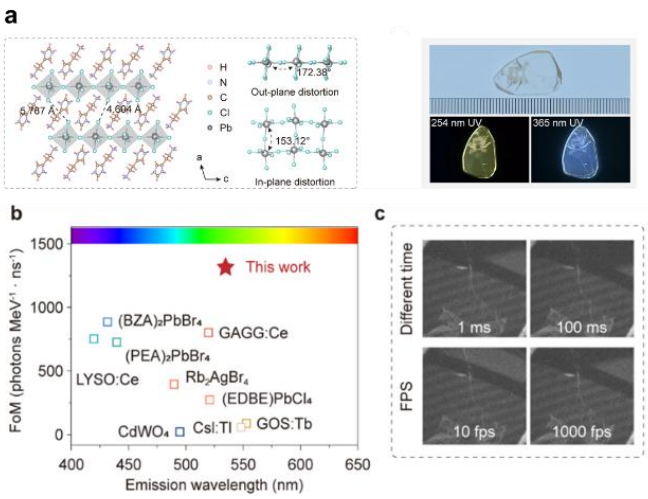

Figure 1. Single crystal structure (a), high FoM value (b), and high-frame rate dynamic X-ray imaging (c) of 2D $(HAD)PbCl_4$ perovskite.

References

[1] K. Goda, K. K. Tsia, B. Jalali, Serial time-encoded amplified imaging for real-time observation of fast dynamic phenomena. *Nature* **458**, 1145-1149 (2009).
[2] W. Li, *et al*. Arising 2D perovskites for ionizing radiation detection. *Adv. Mater.* **36**, 1-36 (2024).
[3] M. D. Birowosuto, *et al.* X-ray scintillation in lead halide perovskite crystals. *Sci. Rep.* **6**, 37254 (2016).
[4] X. Gong, *et al*. Electron-phonon interaction in efficient perovskite blue emitters. *Nat. Mater.* **17**, 550-556 (2018).
[5] H. Hu, *et al.* Observation of defect luminescence in 2D Dion-Jacobson perovskites. *Adv. Opt. Mater.* **9**, 1-8 (2021).
[6] W. Shao, *et al.* Synergy of organic and inorganic sites in 2D perovskite for fast neutron and X-ray imaging. *Adv. Funct. Mater.* **33**, 1-9 (2023).

Acknowledgments: This work was supported by the National Natural Science Foundation of China (12575331, 12575203), the National Key R&D Program of China (2022YFB3503600, 2022YFB3503900).