Supplementary Information

Ion Migration and Dark Current Suppression in Quasi-2D Perovskite-Based X-Ray Detectors

Zhenting Yang[1], Aimiao Qin[2], Haiqing Qin[3], Zhenlin Li[4], Yong Xiang[1,5], Hao Liu[6], Jinyu Qiu[7], and Xinyu Wang[1]*

[1] School of Materials and Energy, University of Electronic Science and Technology of China, Chengdu, China

[2] Key Laboratory of New Processing Technology for Nonferrous Metal & Materials, Ministry of Education/Guangxi Key Laboratory of Optical and Electronic Materials and Devices, Guilin University of Technology, Guilin, China

[3] Guangxi Key Laboratory of Superhard Material, National Engineering Research Center for Special Mineral Material, Guangxi Technology Innovation Center for Special Mineral Material，China Nonferrous Metal (Guilin) Geology And Mining Co., Ltd., Guilin, China.

[4] Department of Radiology, West China Hospital, Sichuan University, Chengdu, China

[5] Tianfu Jiangxi Laboratory, Chengdu, China

[6] BOE Technology Group Co., Ltd, Beijing, China

[7] Chengdu Experimental Foreign Languages School International Department, Chengdu, Sichuan, China

*Corresponding author: xinyuwang@uestc.edu.cn

The digital image of perovskite with low n-values

Regarding low n-value perovskites (e.g., n=1 and n=2), these materials theoretically exhibit significant two-dimensional properties but face challenges in the fabrication process. When utilizing a spraying method to produce these low n-value perovskites, we encountered difficulties in achieving uniform and continuous thick films. Additionally, these materials demonstrated high dark current densities (see Figure S4 (a) and (b)). This issue likely arises from the significant increase in organic components, which hinders solvent evaporation and leads to excessive interfaces and defects during the formation process of films (see Figure S1).

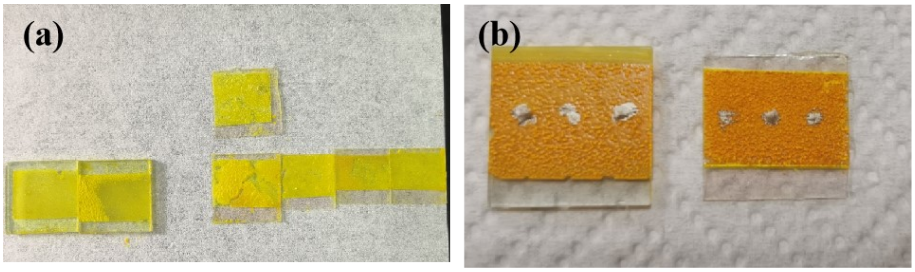

Figure S1 (a) and (b) the digital image of n=1 and n=2 perovskite thick films, respectively

The survey the contact angles (CA) of precursor solutions on the substrate

The wettability of the precursor solution on the substrate were characterized by survey CA. As shown in Figure S2 (a-c), the CA of precursor solutions with three different n value on the substrate were measured. The CA for the n=∞ precursor solution was 33.5°, for the n=10 precursor solution was 30.2°, and for the n=6 precursor solution was 27.3°. The experimental results show that the introduction of n-BABr can achieve rapid spontaneous diffusion of perovskite solution on the substrate, which is beneficial for the precursor solution to form a uniform liquid film on the substrate.

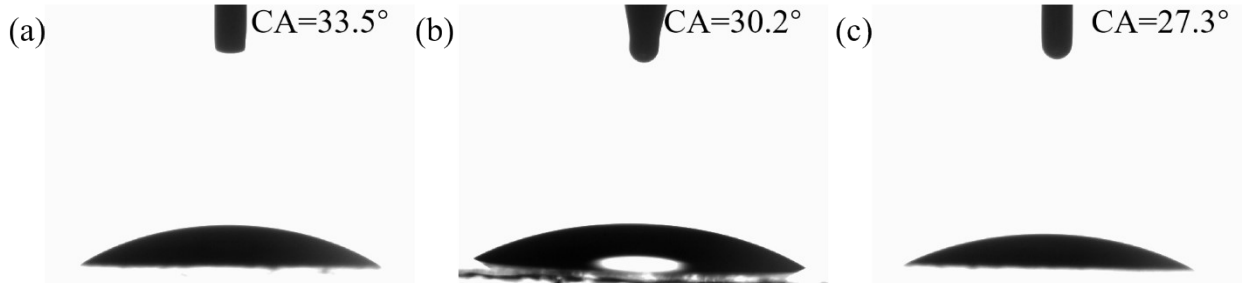

Figure S2 (a), (b), and (c) the contact angles of n=∞, n=10, and n=6 perovskite precursor solutions on the substrate surface, respectively

The complete Cross-sectional SEM images of perovskite with different values

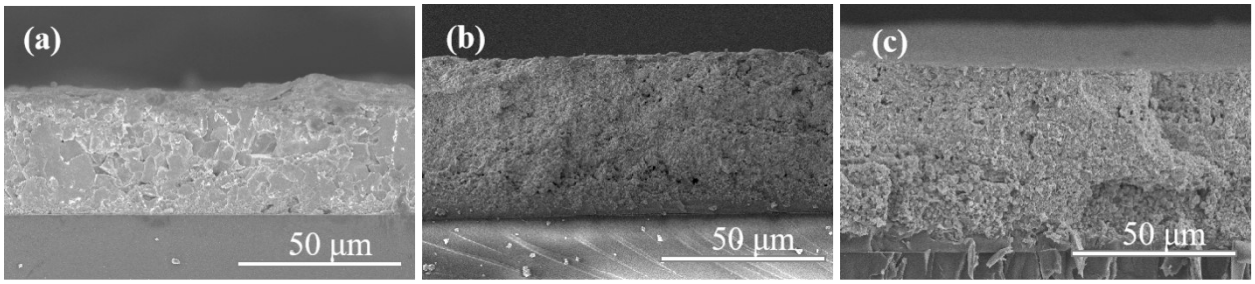

Figure S3 (a), (b), and (c) the complete Cross-sectional SEM images of perovskite about n=∞, n=10, and n=6, respectively

The current density-voltage curve of perovskite with different values

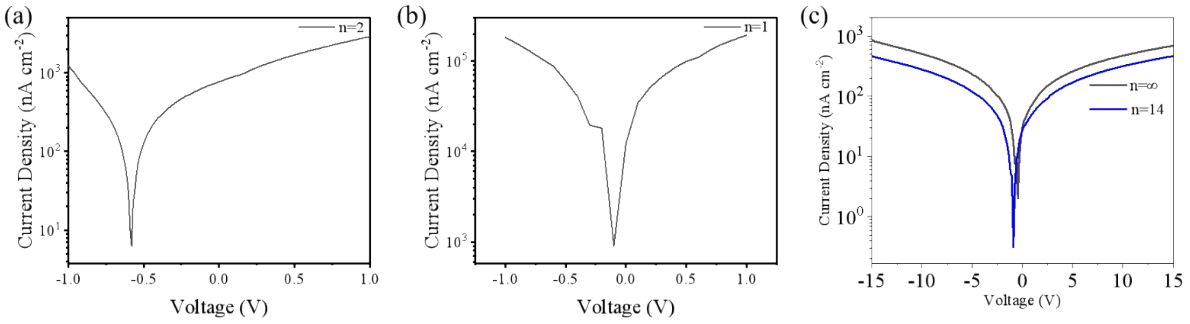

Figure S4 (a), (b) and (c) the J-V curve of n=2, n=1,and n=14 perovskite thick films, respectively

Table S1 Summary of the performance of the reported X-Ray detectors based on perovskites

Materials	Baseline drifting [pA cm^{-1} s^{-1} V^{-1}]	electric field [V mm^{-1}]	LoD [n Gy_{air} s^{-1}]	Ref.
α-Se	N/A	10000	5500	[S1]
$Cs_2AgBiBr_6$ SC	N/A	2.5	59.7	[S2]
$Cs_2AgBiBr_6$	0.074	50	95.3	[S3]
$PEA_2MA_8Pb_9I_{28}$	0.018	N/A	69	[S4]
$MA_3Bi_2I_9$	N/A	30	207	[S5]
$(BA)_2Cs_9Ag_5Bi_5Br_{31}$	0.016	320	139	our work

SC= single crystal; N/A = Not available; LoD= Limit of Detection.

Note 1 - Discussion of the choice of solution methods for perovskite fabrication

When developing perovskite materials for X-Ray detection, it is necessary to consider the thickness and size of the materials, which is crucial for achieving efficient X-Ray absorption and detection. The appropriate material thickness is usually within the range of tens to hundreds of micrometers (μm), which can ensure that X-Rays are fully absorbed when passing through the material. In addition, it should also have a large area size and be compatible with the transistor backplane at the imaging application.

The blade coating method can achieve large-area thick film growth, but during the process of solvent evaporation, the evaporation of solvent within the thick film can lead to cracking of the upper film layer.

The spin-coating method is mainly used to prepare small-sized perovskite films and is not feasible for large-area perovskite films. Moreover, the spin-coating method has a low utilization rate, resulting in a large amount of waste of precursor solution, which is not conducive to low-cost manufacturing.

Vacuum vapor deposition is a viable option for large-scale preparation of perovskite thin films. However, the high vacuum deposition environment consumes a large amount of electrical energy and has a slow deposition rate (1-2 Å/s), resulting in very low efficiency in preparing thick films.

Compared with the conventional methods for preparing perovskite mentioned above, the ultrasonic spraying method, can achieve thick films larger than 10 × 10 cm^2. The preparation speed of this method is high; it typically takes just 2 hours to achieve films with thicknesses of tens of micrometers. This method also has lower environmental requirements for preparation. Compared with blade coating, spray coating facilitates simultaneous solvent evaporation and crystal growth during the thick film preparation, preventing the cracking of the film surface caused by solvent evaporation. Therefore, ultrasonic spraying emerges as the preferred method for fabricating perovskite films that meet the fundamental thickness and size standards for X-ray detection.

Reference

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