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Supporting Information

Electrospray Prepared Flexible $CsPbBr_3$ Perovskite Film for efficient X-ray Detection

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Keywords:

$CsPbBr_3$ perovskite film, X-ray detection, flexible, electrospray.

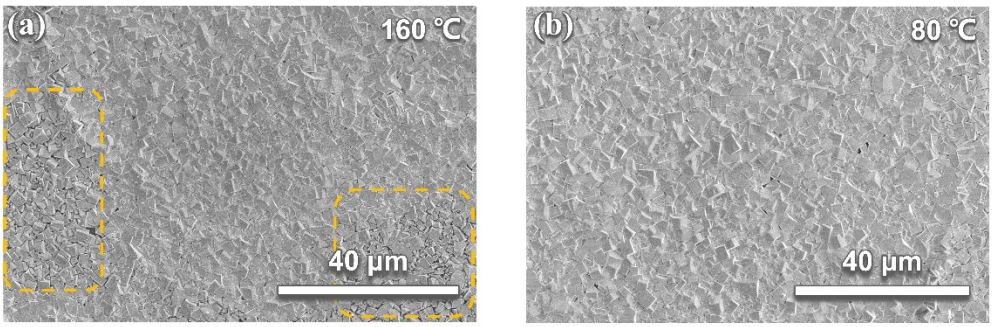

Fig. S1 (a-b) SEM images of the low-magnification morphology of the film at 160 ℃ and 80 ℃.

Calculation of resistivity for interdigital detectors

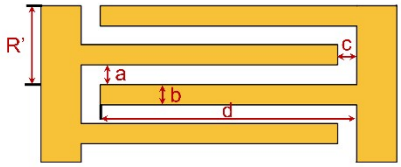

Fig. S2 Schematic diagram of partial cycle interdigital electrode

$$\frac{1}{R'}=\frac{4}{\frac{b}{c}(\frac{2c}{d-c}+1)R_f}+\frac{4}{\frac{c}{b}(\frac{2b}{a}+1)R_f}$$

$$\frac{1}{R}=\frac{n}{R'}$$

$$R_f=\frac{\rho}{\delta}$$

R' is single periodic parallel resistance and R_f is square resistance. R is total resistance of the $CsPbBr_3$ film from the experiment and n is the prepetition period of the parallel resistance. δ is the thickness of the film and ρ is resistivity of the film. Specifically, the values of a, b, c for the interdigital electrode are 0.5 mm. The value of d is 6.5 mm, the repetition period of electrode structure (n) is 4.5 and the thickness of the film is 3 μm.

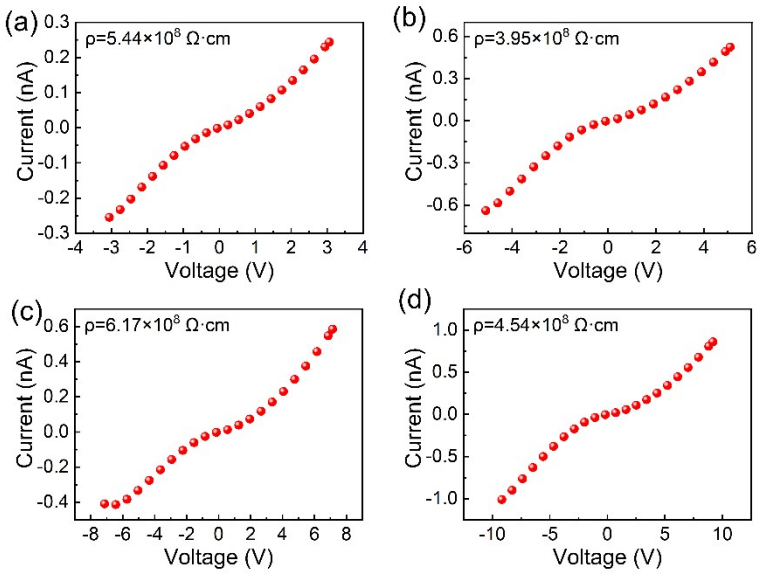

Fig. S3 (a-d) I-V curves of $CsPbBr_3$ film under different background voltage.

Calculation of the average attenuation efficiency ($\bar{\varepsilon}$) of CsPbBr3 film

X-ray tube voltage determines the energy of the X-ray photons. The source of X-ray tube voltages used in this work is 20 kV_p and 50 kV_p and the energy distributions of 20 kV_p and 50 kV_p were evaluated utilizing the software (SPEKTR 3.0) downloaded from http://istar.jhu.edu/downloads/, as shown in Fig. S4a. The average X-ray photon energy of 20 kV_p and 50 kV_p are 17.9 keV and 29.0 keV separately. Considering that $CsPbBr_3$ film cannot have sufficient thickness (3 μm) to absorb X-ray photons, the average attenuation efficiency ($\bar{\varepsilon}$) is needed to carefully calculate below.

Initially, the single energy X-ray attenuation efficiency (ε) can be calculated by $\varepsilon = 1 - e^{-\mu x}$, where x is the thickness of $CsPbBr_3$ film and μ is the absorption coefficient of $CsPbBr_3$ film. Fig. S4b reveals the absorption coefficient (μ) of $CsPbBr_3$ originated from X-COM database by NIST. When the thickness of $CsPbBr_3$ film is 3 μm, the diagram of the attenuation efficiency versus incident photon energy is illustrated in Fig. S4c. Therefore, to evaluate the average attenuation efficiency of $CsPbBr_3$, the relationship between the attenuation efficiency versus thickness with the tube voltage of 20 kV_p and 50 kV_p, is exhibited in Fig. S4d. The average attenuation efficiency ($\bar{\varepsilon}$) of $CsPbBr_3$ film (3 μm) results for 20 kV_p and 50 kV_p are 10.51 % and 2.71 %.

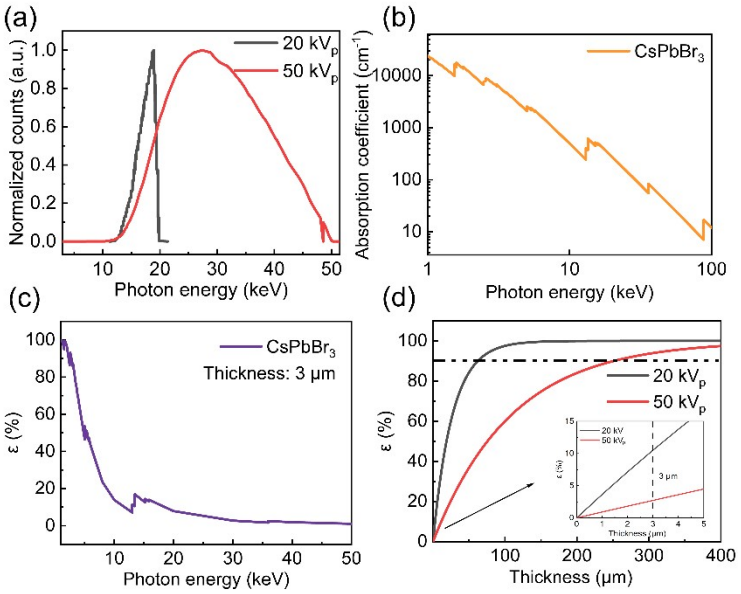

Fig. S4 (a) X-ray photon energy distribution at the tube voltage of 20 kV_p and 50 kV_p. (b) Absorption coefficient (μ) of $CsPbBr_3$ ranged from 1-100 keV utilizing X-COM by NIST. (c) Calculated attenuation efficiency (ε) of $CsPbBr_3$ with a thickness of 3 μm versus X-ray photon energy. (d) Calculated attenuation efficiency (ε) of $CsPbBr_3$ versus thickness with the tube voltage of 20 kV_p and 50 kV_p.

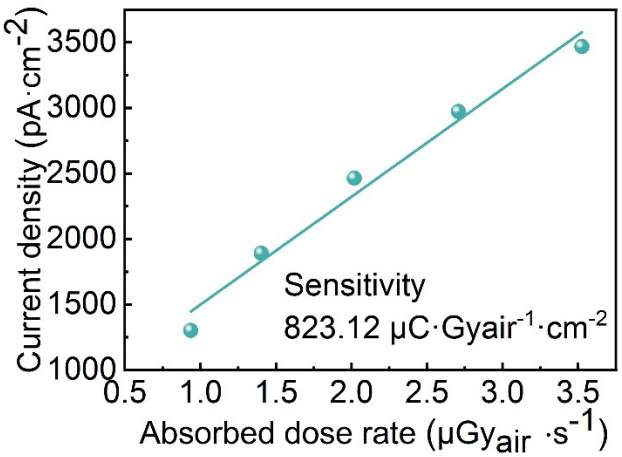

Fig. S5 The current density as a function of absorbed dose rate with 9V bias illuminated by the X-ray tube voltage of 20kV_p.

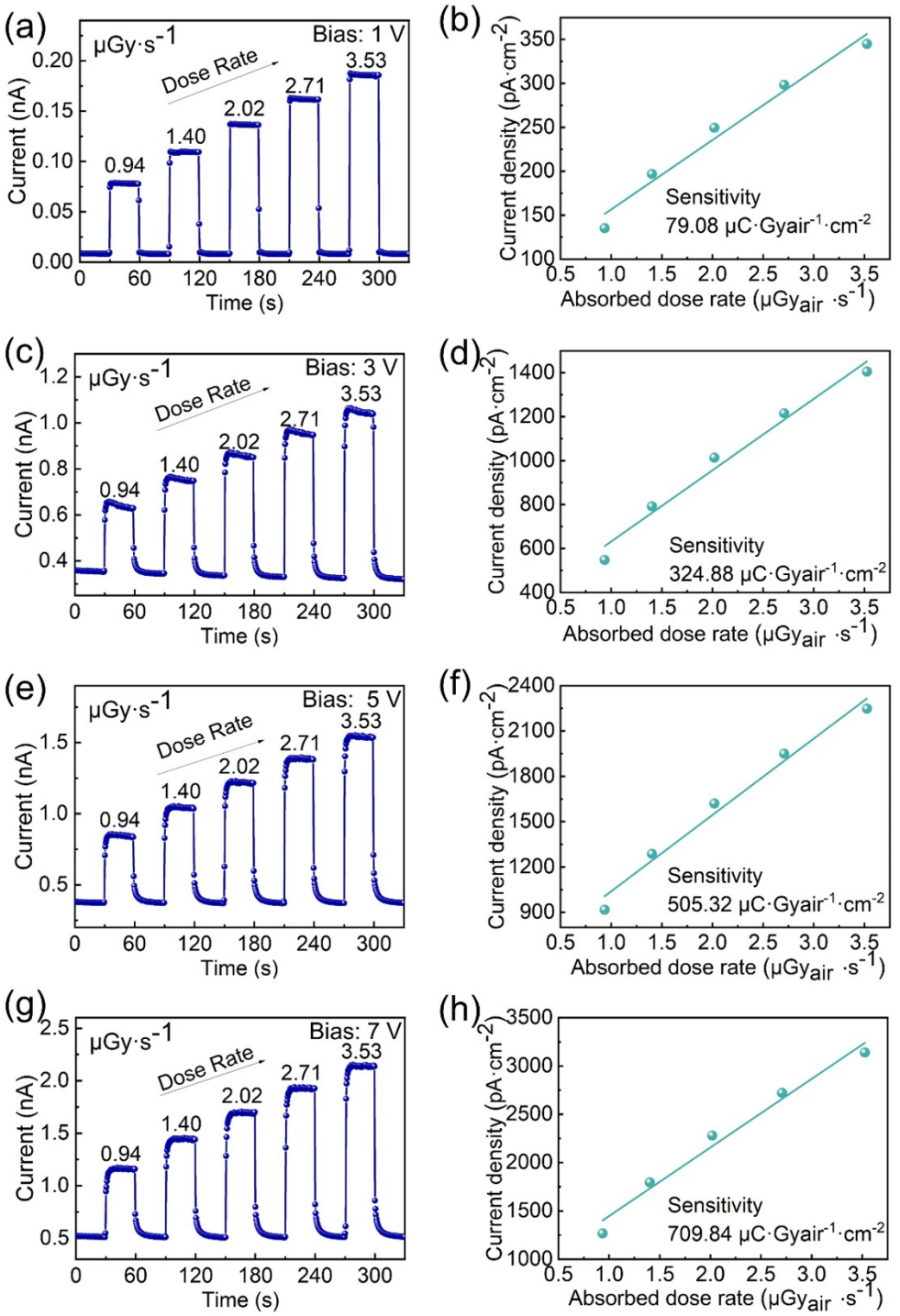

Fig. S6 (a)(c)(e)(g) I-t curves of $CsPbBr_3$ detector under 1, 3, 5 and 7V bias illuminated under the X-ray tube voltage of 20 kV_p. (b)(d)(f)(h) X-ray current density as a function of absorbed dose rate with 1, 3, 5 and 7V bias under the X-ray tube voltage of 20kV_p.

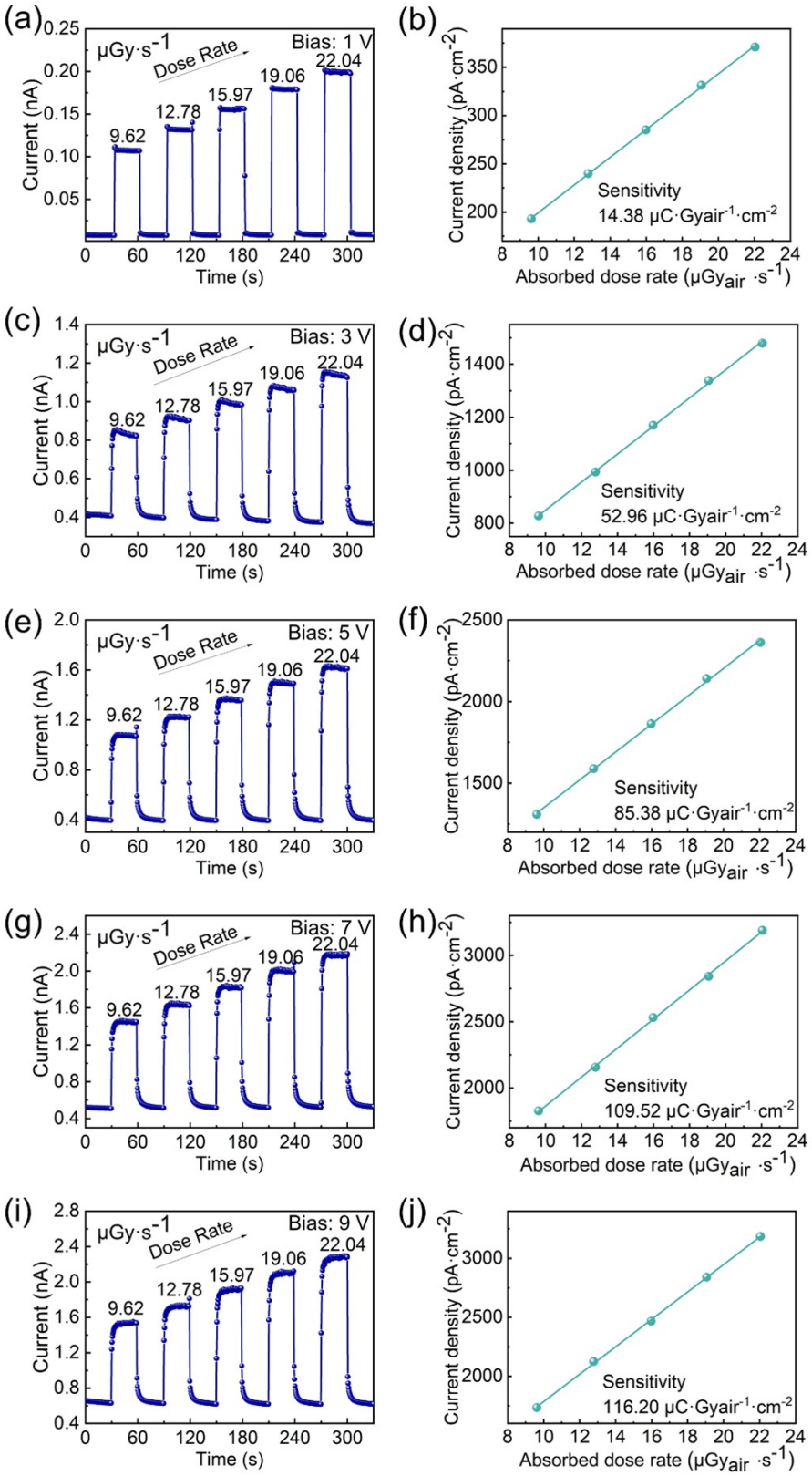

Fig. S7 (a)(c)(e)(g)(i) I-t curves of $CsPbBr_3$ detector under 1, 3, 5, 7 and 9V bias illuminated under the X-ray tube voltage of 50 kV_p. (b)(d)(f)(h)(j) X-ray current density as a function of absorbed dose rate with 1, 3, 5, 7 and 9V bias under the X-ray tube voltage of 50kV_p respectively.

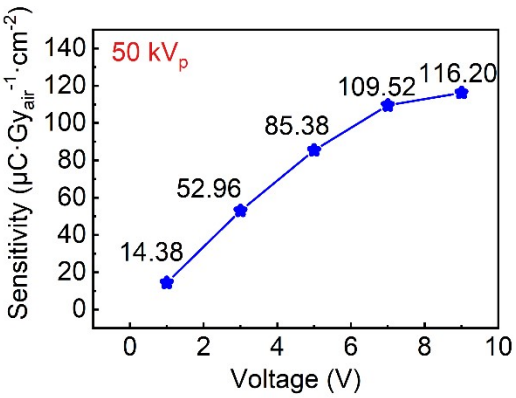

Fig. S8 A line diagram of sensitivity as a function of bias voltage under the X-ray source of 50 kV_p.

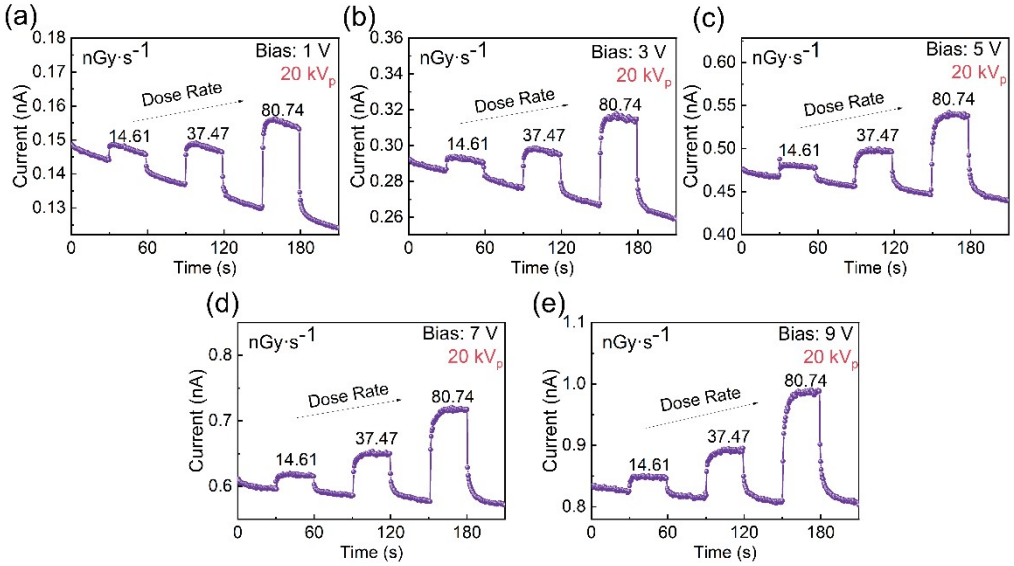

Fig. S9 I-t curves of the $CsPbBr_3$ detector at 1, 3, 5, 7, 9 V bias under the 20 kV_p Xray with the dose rate of 14.61, 37.47, 80.74 $\mu Gy_{air} \cdot s^{-1}$.