Supporting Materials

Crystal growth, transport behavior and X-ray detection of non-perovskite phase $NH_4Pb_2Br_5$

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1. The growth conditions, pictures and EDS spectrum of $NH_4Pb_2Br_5$ crystals.

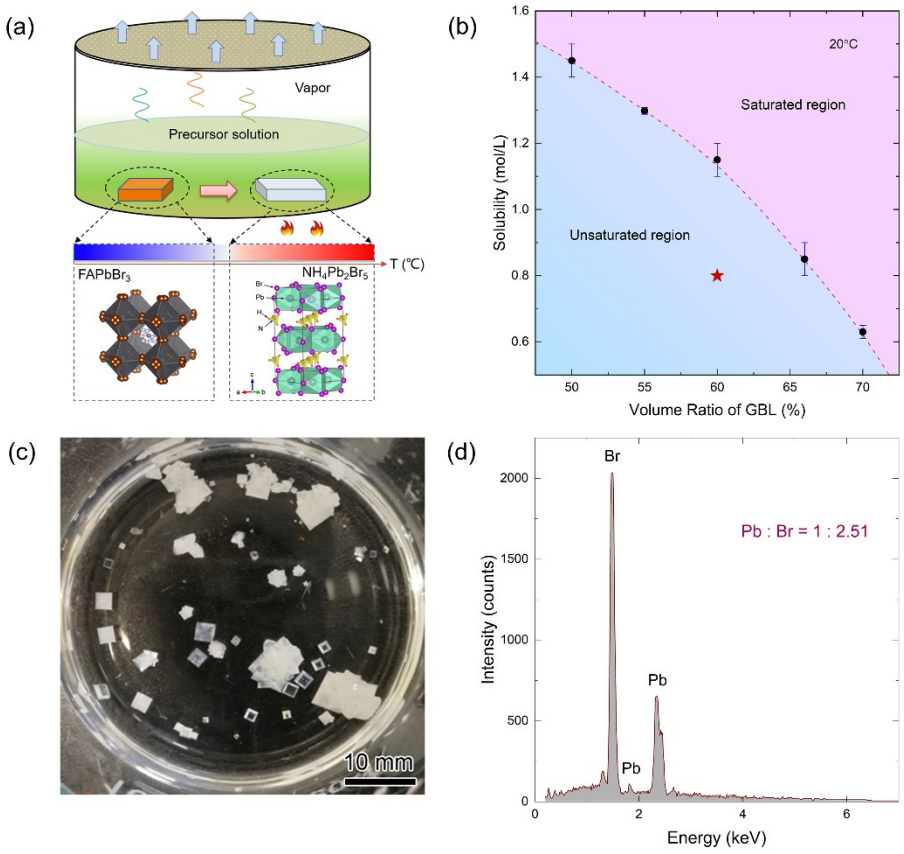

Fig. S1 (a) The $NH_4Pb_2Br_5$ crystals formed from as-grown $FAPbBr_3$, it is attributed to the decompose of FA organic group under the heating condition. (b) The solubility curves of the starting materials based on the ratio of the solvents DMF and GBL at room temperature. With the increasing of GBL content, the solubility is gradually decreasing. And saturated region and unsaturated region are obtained by distinguished by the solubility curve. Our optimum growth condition is located at the position of five-pointed star, which is in the unsaturated region. (c) Many millimeter-sized quadrate $NH_4Pb_2Br_5$ single crystals with white colors in the solution. (d) The EDS spectrum of $NH_4Pb_2Br_5$, which shows the molar ratio of Pb and Br is equal to 1:2.51.

2. The calibration of X-ray dose rate.

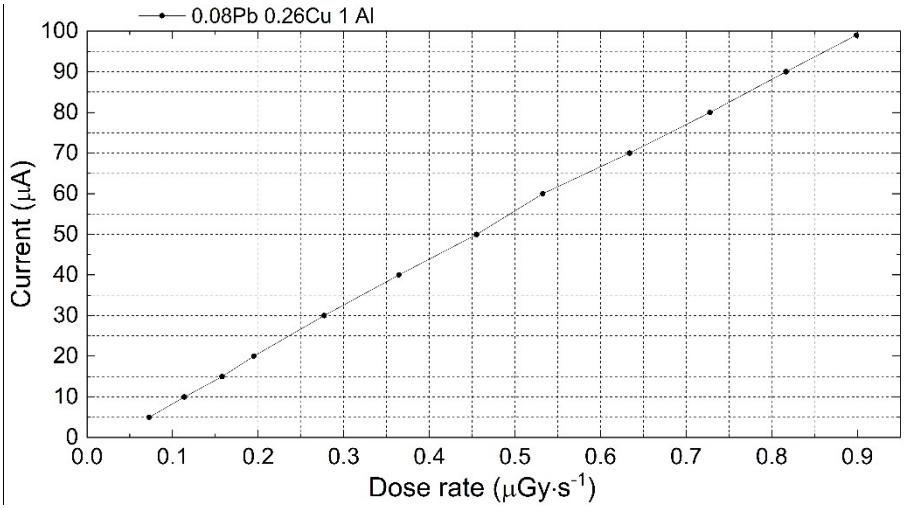

Fig. S2 The relationship between the dose rate and current of the X-ray tube.

3. The average attenuation efficiency ($\bar{\varepsilon}$) of $NH_4Pb_2Br_5$ crystal.

Using the XCOM application by NIST. (*Berger, M. J. XCOM photon cross section database; NIST physics laboratory: Gaithersburg, MA, 1998*) and the calculated desinty of 5.476 g/cm^3 using our refined cell parameters of $NH_4Pb_2Br_5$, the absorption coefficient of $NH_4Pb_2Br_5$ in the 1-1000 keV energy range can be calculated shown in Fig. S3(a). When the X-ray source was operated with a tube voltage of 40 kV, the attenuation efficiency (ε) could be calculated as $\varepsilon = 1 - \frac{I(x)}{I(0)} = 1 - e^{-\mu x}$, where x is the thickness and the absorption coefficient μ = 56.129 cm^{-1} at 40 keV. Fig. S3(b) demonstrates that the attenuation efficiencies (ε) of 40 keV X-ray photons could reach up to 100% with the $NH_4Pb_2Br_5$ crystal thickness of ~0.9 mm.

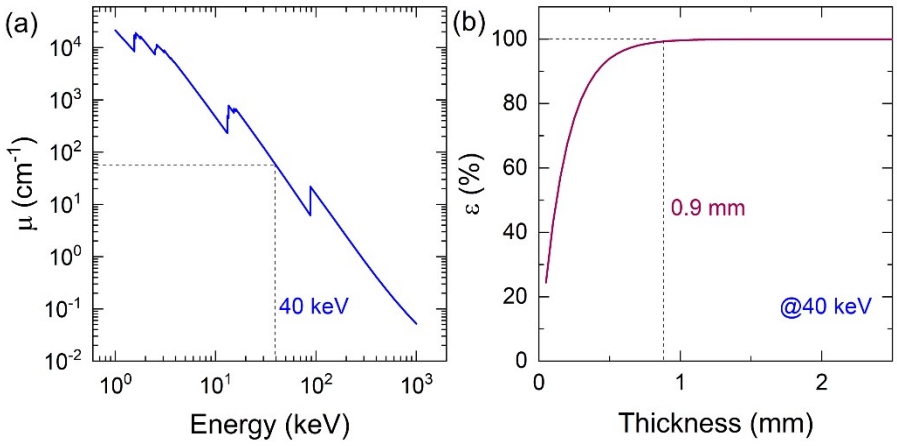

Fig. S3. (a) Absorption coefficients of $NH_4Pb_2Br_5$ in the 1-1000 keV energy range using the XCOM application by NIST. (b) Calculated attenuation efficiency (ε) of $NH_4Pb_2Br_5$ to 40 keV X-ray photons versus thickness.

4. The details of calculations about the mobility and mobility-lifetime product of $NH_4Pb_2Br_5$ crystals along *ab* plane and *c* direction

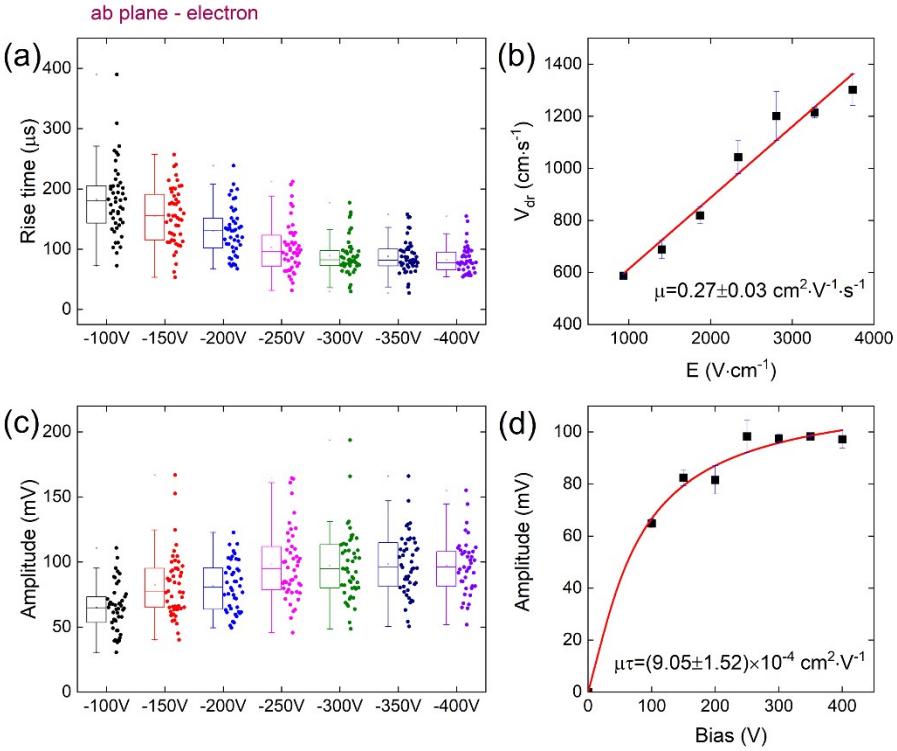

Fig. S4. The *electron* signals of Au/$NH_4Pb_2Br_5$/Au device along *ab* plane obtained from the preamplifier. (a) The statistics of the rise-times *vs* applied voltages, and (b)

the correspoding electric field dependent drifting velocities. (c) The statistics of bias dependent the amplitudes. (d) The fitting process of the moblity-lifetime products based on the single carrier Hecht equation.

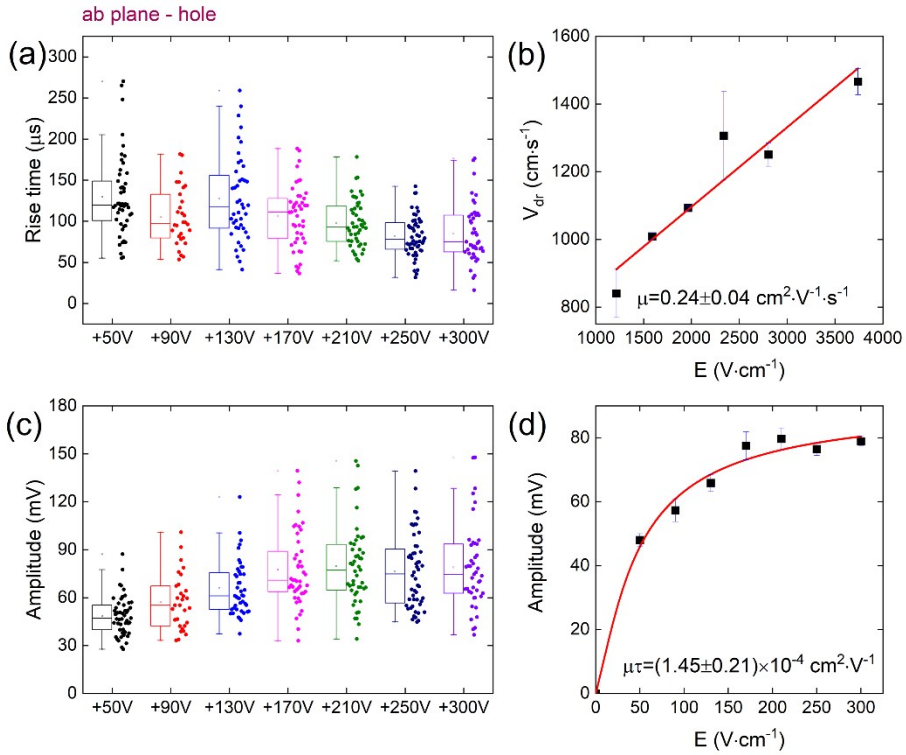

Fig. S5. The *hole* signals of Au/$NH_4Pb_2Br_5$/Au device along *ab* plane obtained from the preamplifier. (a) The statistics of the rise-times *vs* applied voltages, and (b) the correspoding electric field dependent drifting velocities. (c) The statistics of bias dependent the amplitudes. (d) The fitting process of the moblity-lifetime products based on the single carrier Hecht equation.

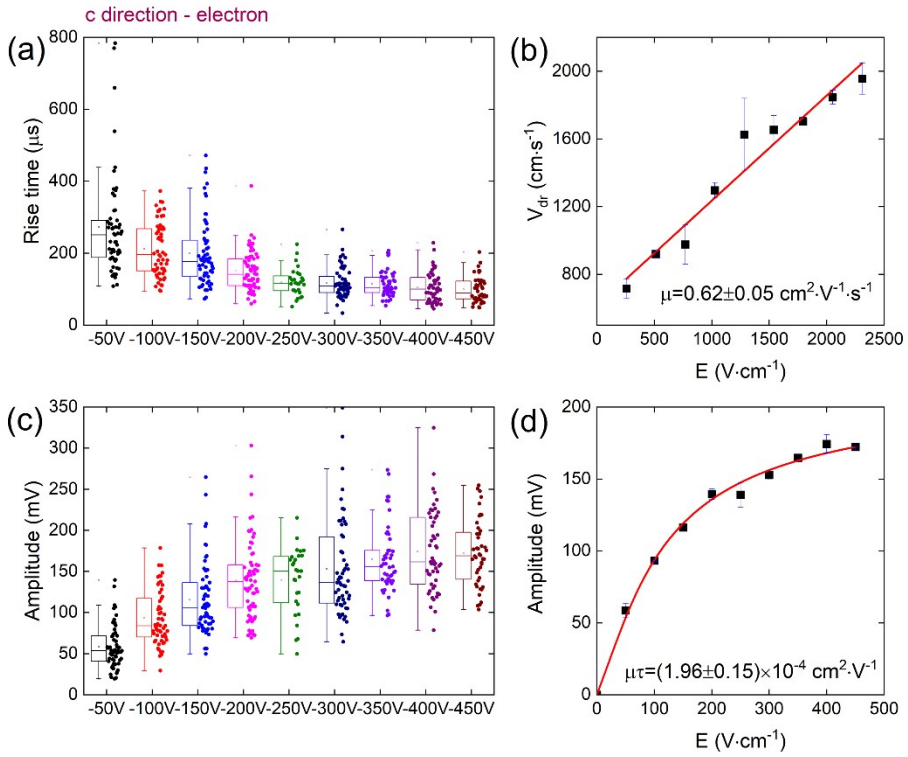

Fig. S6. The *electron* signals of Au/$NH_4Pb_2Br_5$/Au device along *c* direction obtained from the preamplifier. (a) The statistics of the rise-times *vs* applied voltages, and (b) the correspoding electric field dependent drifting velocities. (c) The statistics of bias dependent the amplitudes. (d) The fitting process of the moblity-lifetime products based on the single carrier Hecht equation.

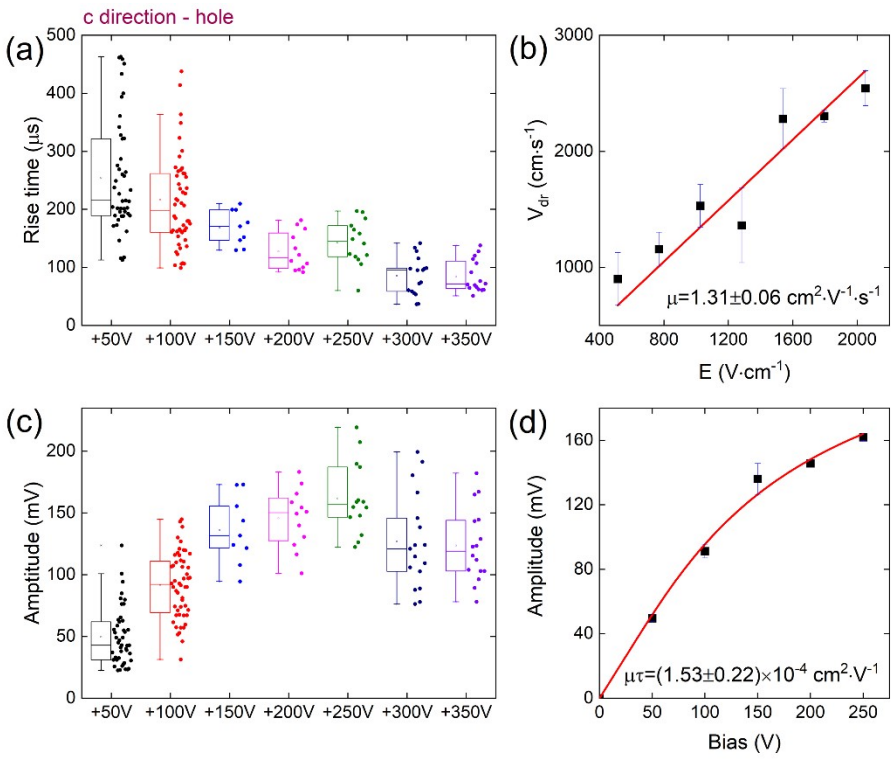

Fig. S7. The *hole* signals of Au/$NH_4Pb_2Br_5$/Au device along *c* direction obtained from the preamplifier. (a) The statistics of the rise-times *vs* applied voltages, and (b) the correspoding electric field dependent drifting velocities. (c) The statistics of bias dependent the amplitudes. (d) The fitting process of the moblity-lifetime products based on the single carrier Hecht equation.