Supporting Information

Liquid-Phase Growth and Optoelectronic Properties of Two-dimensional Hybrid Perovskites CH$_3$NH$_3$PbX$_3$ (X=Cl, Br, I)

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Figure S1. The MAPbBr$_3$ perovskites grown on the mica substrate without oleic acid.

(A, B) Optical images. (C) AFM image of the perovskite denoted by the dotted box in (B).

(D) High profile denoted by the black, green and yellow dash lines in (C). We note that the MAPbBr$_3$ perovskite sheets grown without oleic acid are as large as several hundreds, but it is hard to obtain the sheets thinner than 100 nm thick.
Figure S2. The optical and fluorescent images of 2D MAPbBr$_3$ perovskites grown on the mica substrate with oleic acid.
Figure S3. The liquid-phase growth of 2D MAPbI₃ perovskites on the mica. (A, B and C) Optical images. (D) AFM image of the MAPbI₃ perovskites denoted by the yellow dashed box in (A). (E) 3D image and high profile of the grown 2D MAPbI₃ perovskites. The grown 2D sheet with the thickness of 6 nm, and have the very sharp edge and smoothing surface. (G) PL of the 2D MAPbI₃ perovskites, which has a blue shift to the bulk MAPbI₃ perovskites. (H) Absorption of the 2D MAPbI₃ perovskites. According the Eillot model, the bandgap $E_g$ and the exciton binding energy $E_b$ can be estimated to be 1.62 eV and 10 meV, respectively. (I) The lifetime of the 757 nm peak, which is estimated to be 4 ns and 32 ns.
Figure S4. The liquid-phase growth of 2D MAPbCl$_3$ perovskites on the mica. (A, B and C) Optical images. (D) 3D AFM image and the high profile of the 2D MAPbCl$_3$ perovskite denoted by the yellow dashed box in (C).
Figure S5. The liquid-phase growth of 2D CsPbBr$_3$ perovskites on the mica. (A, B)

Optical and fluorescent images. (C) 3D AFM image and the high profile of the 2D CsPbBr$_3$ perovskite denoted by the yellow dashed box in (A, B).
Figure S6. Rocking-curve spectrum for the (002) face of the 2D MAPbBr$_3$ perovskite on mica.
Figure S7. XPS spectrum of the 2D MAPbBr$_3$ perovskite on mica.
Figure S8. Perovskites grown on the ITO, SiO$_2$/Si and quartz substrate. (A) The MAPbBr$_3$ perovskites grown on the ITO glass. (B) The MAPbBr$_3$ perovskites grown on the SiO$_2$/Si. (C) The MAPbBr$_3$ perovskites grown on the quartz. We note that the MAPbBr$_3$ perovskites prefer to crystallize in the solution with the substrates of ITO, SiO$_2$/Si and quartz, which is different from the liquid-phase growth on the mica surface. The MAPbBr$_3$ perovskites with different morphologies, such as thin MAPbBr$_3$ perovskite sheets (denoted by the yellow arrows), the MAPbBr$_3$ perovskite nanowires (denoted by the black arrows), the bulk MAPbBr$_3$ crystal (denoted by the red arrows), can be found.
Figure S9. The $I-V$ curve of a photodetector fabricated using 2D MAPbBr3 crystal grown by liquid-phase growth on mica without the OA addition.
<table>
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<tr>
<th>Perovskite interface absorbed with one K ion</th>
<th>MAPbBr₃-cubic-single layer</th>
<th>MAPbBr₃-orth-single Layer</th>
<th>MAPbBr₃-orth-single Layer</th>
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<tr>
<td>Interface without K ion</td>
<td>-121.77247161 eV</td>
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<td></td>
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<tr>
<td>Interface absorbed with one K ions</td>
<td>-121.28567324 eV</td>
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<td>Energy of single K ion</td>
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<td>Formation energy of interface</td>
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<td>Perovskite interface absorbed with two K ions</td>
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<td>Interface absorbed with two K ions</td>
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<td>1.1606341 eV</td>
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<td>Formation energy of interface</td>
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Table S1. The formation energy of the K/perovskite interface calculated by DFT
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<th>Device type</th>
<th>Material</th>
<th>Synthesis method</th>
<th>Responsivity (AW²)</th>
<th>Rise/Decay time (μs)</th>
<th>Voltage (V)</th>
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<td>This work</td>
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<td>Liquid epitaxy</td>
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<td>&lt;2×10⁻³/&lt;4×10⁻³</td>
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<td>Layered perovskite</td>
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<td>(CH₃(CH₂)₃NH₃)₂PbBr₃</td>
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Table S2. Device performance comparisons of 2D MAPbBr₃ perovskite photodetector in this work with the reported perovskite-based photodetectors.

References


