

Supporting Information

Decay-Length-Guided Electrode Spacing for Wide-Linear-Dynamic-Range CsPbBr₃ Nanowire Photodetectors

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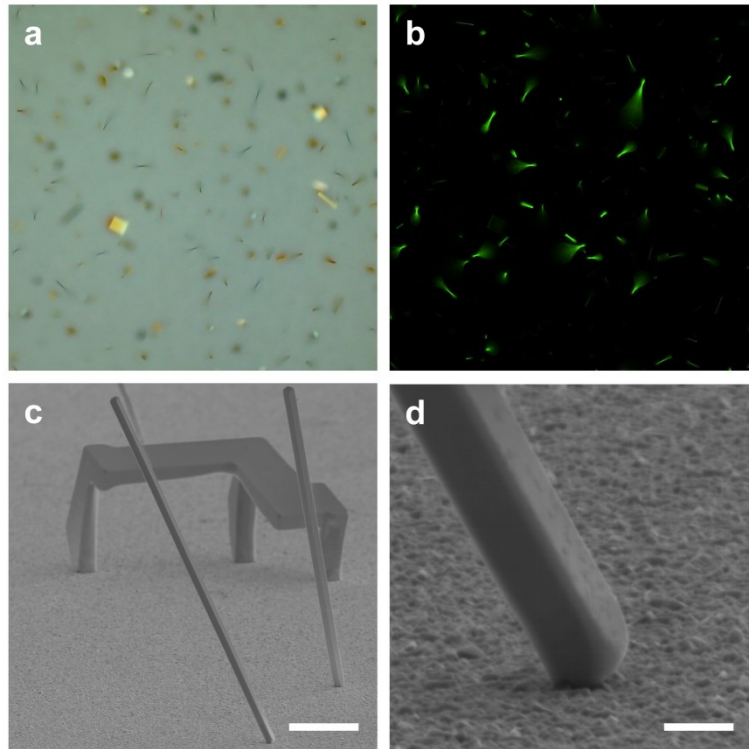


Figure S1. (a) Optical microscopy image of CsPbBr₃ NWs grown on an FTO substrate with a tilted configuration. (b) Corresponding fluorescence microscopy image of the NWs on FTO. (c) SEM image showing the tilted growth of the NWs on the FTO substrate. Scale bar: 10 μm . (d) Enlarged SEM image of the tilted NW, highlighting the intimate contact between one end of the NW and the FTO substrate. Scale bar: 1 μm .

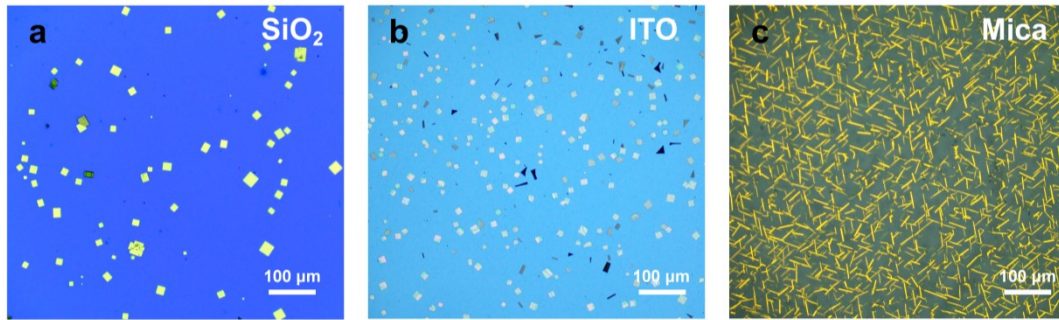


Figure S2. Growth of CsPbBr₃ single crystals on SiO₂/Si, ITO, and mica substrates by CVD.

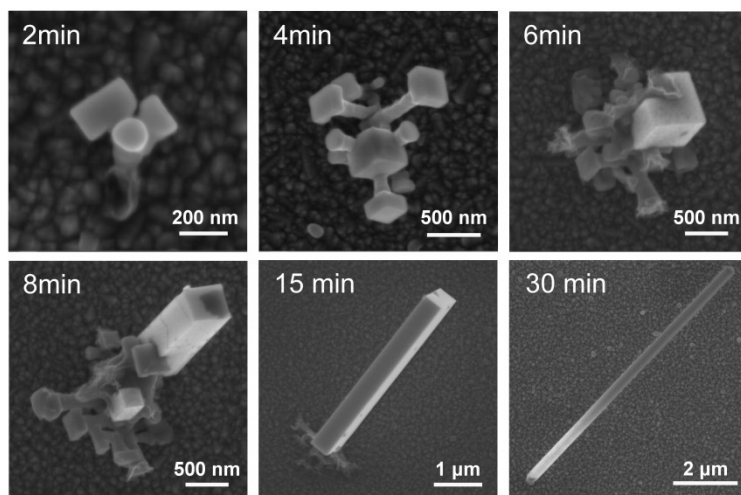


Figure S3. Time-dependent SEM images of CsPbBr₃ NWs grown by CVD, showing the evolution of morphology and size with increasing growth time.

Synthesis of CsPbBr₃ NWs by solution method:

CsPbBr₃ NWs were synthesized via an anti-solvent-assisted method. PbBr₂ and CsBr with a molar ratio of 1:1 were dissolved in DMF to obtain a 0.05 M precursor solution. The mixture was magnetically stirred at 25 °C for 4 h until a clear solution was obtained, and then filtered through a 0.22 μm nylon 66 membrane. Subsequently, 10 μL of the precursor solution was deposited onto a cleaned FTO glass substrate. The substrate was then transferred into a sealed beaker containing a small amount of isopropanol, which served as the anti-solvent. After standing for several hours, CsPbBr₃ NWs were formed on the FTO substrate.

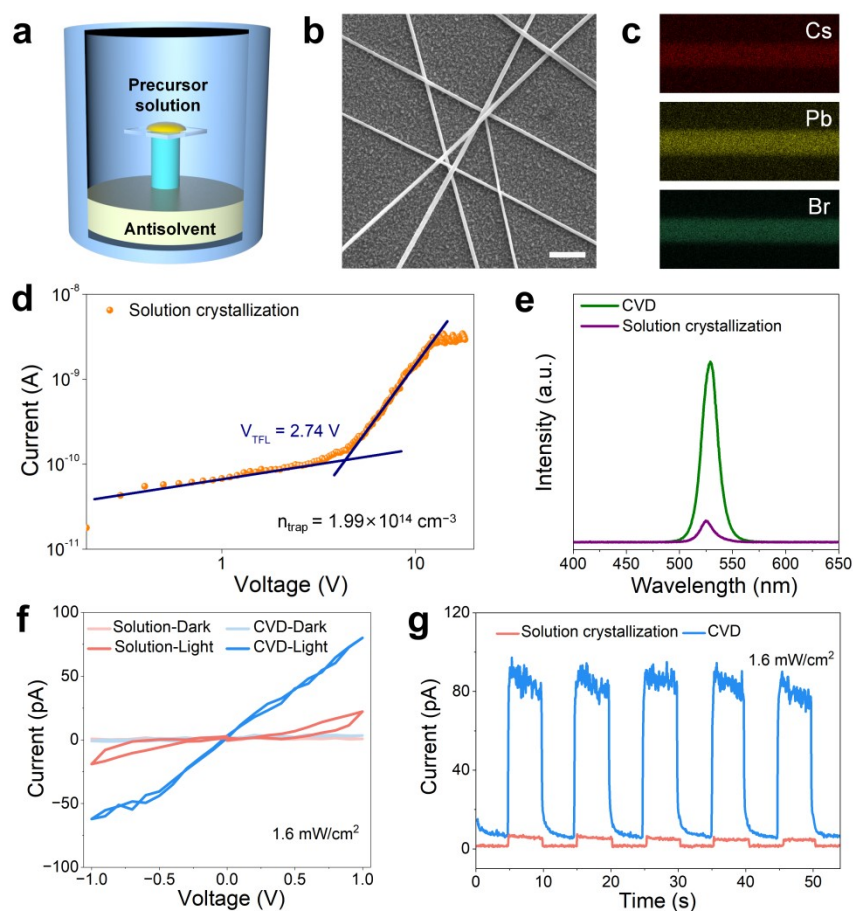


Figure S4. (a) Schematic drawing of the solution synthesis setup for NW growth. (b) SEM image of NWs on FTO substrate. Scale bar: 3 μm. (c) EDS of Cs, Pb, and Br along a NW. (d) Space charge limited current characteristics for a NW. (e-g) Comparison of PL and photoresponse properties of NWs synthesized by the solution method and the CVD method.

CsPbBr₃ NW field-effect transistor measurements:

Transfer-characteristic measurements were conducted using the highly doped Si substrate as the global back gate and 300 nm SiO₂ as the gate dielectric. The measurement was carried out at 80 K to suppress ion migration in the perovskite nanowire and thus obtain a more reliable gate-modulated electronic transport response. The transfer curve confirms p-type behavior of the CsPbBr₃ nanowire, indicating that holes are the majority carriers and photogenerated electrons are the minority carriers. The hole concentration of the CsPbBr₃ nanowire and the depletion width of the Schottky-contact can then be estimated. The NW is approximated using a cylinder-on-plane model with an effective radius, the gate capacitance per unit length is¹:

$$\hat{C}_g = \frac{2\pi\epsilon_0\epsilon_{ox}}{\cosh^{-1}\left(\frac{t_{ox} + r}{r}\right)}$$

where ϵ_0 is the vacuum permittivity, ϵ_{ox} is the relative dielectric constant of SiO₂, the t_{ox} is the thickness of the SiO₂ layer, the r is the effective radius. The capacitances per unit length obtained from the cylinder-on-plane model is 0.155 nF/m. The effective hole concentration can then be estimated from the gate-induced charge needed to deplete the NW:

$$p_{eff} = \frac{\hat{C}_g |V_{th}|}{qA}$$

where q is the elementary charge, V_{th} is the effective threshold depletion voltage, From the transfer curve, the effective threshold/depletion voltage is estimated to be approximately -22 V. and A is the cross-sectional area of the NW. The p_{eff} is $\sim 7.8 \times 10^{16} \text{ cm}^{-3}$. The depletion width near the Au/CsPbBr₃ Schottky contact was estimated using the depletion approximation²:

$$W = \sqrt{\frac{2\epsilon\epsilon_0(V_{dep})}{qp_{eff}}}$$

where ϵ is the relative dielectric constant, V_{dep} is the effective potential drop across the Schottky depletion region. For V_{dep} from 0.1 to 0.5 V, W is estimated to increase from approximately 48 nm to 108 nm.

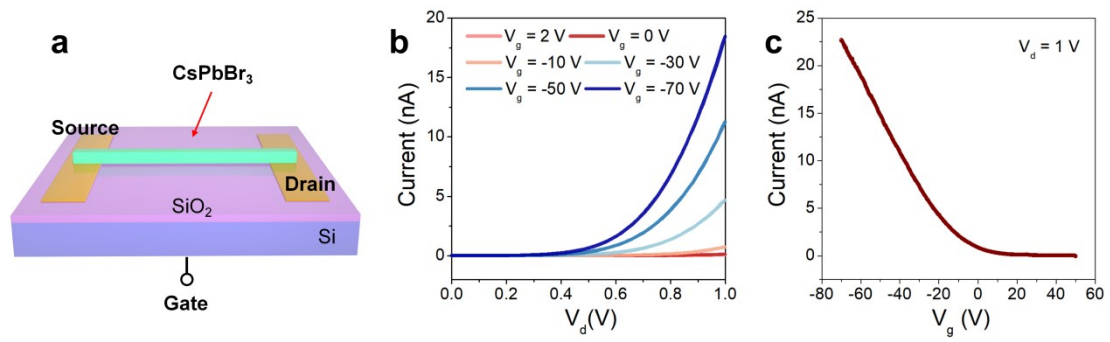


Figure S5. (a) Schematic illustration of a CsPbBr₃ NW FET. **(b)** Output characteristic curves. **(c)** Transfer characteristic curve.

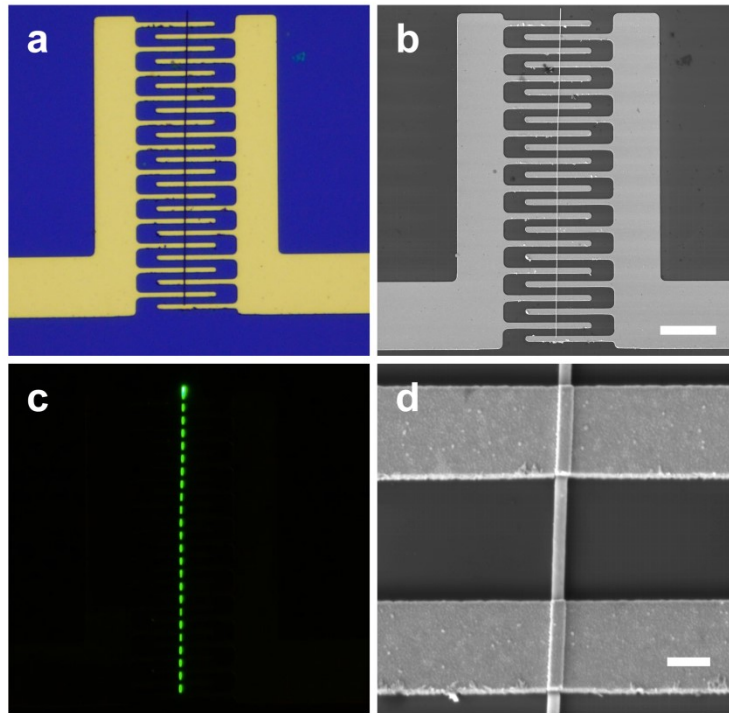


Figure S6. (a) Optical microscopy image of the CsPbBr₃ PD with interdigitated electrodes. (b) SEM image of the CsPbBr₃ PD. Scale bar: 20 μm. (c) Fluorescence microscopy image of the CsPbBr₃ PD. (d) Enlarged SEM image of the region in (b). Scale bar: 1 μm.

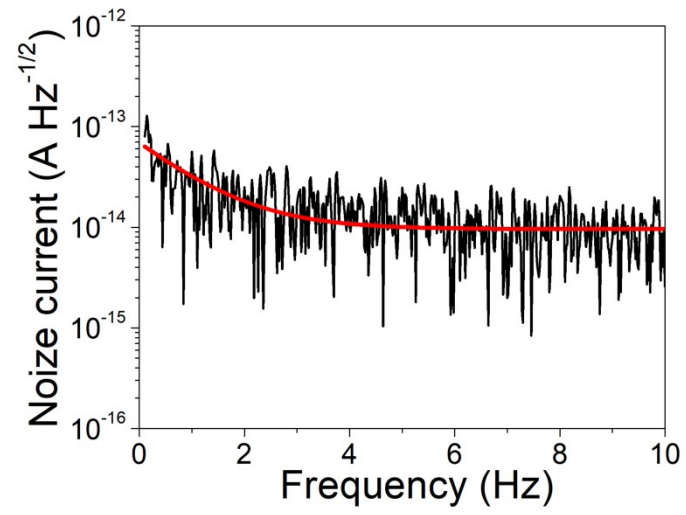


Figure S7. The measured total noise current from 0.1 to 10 Hz.

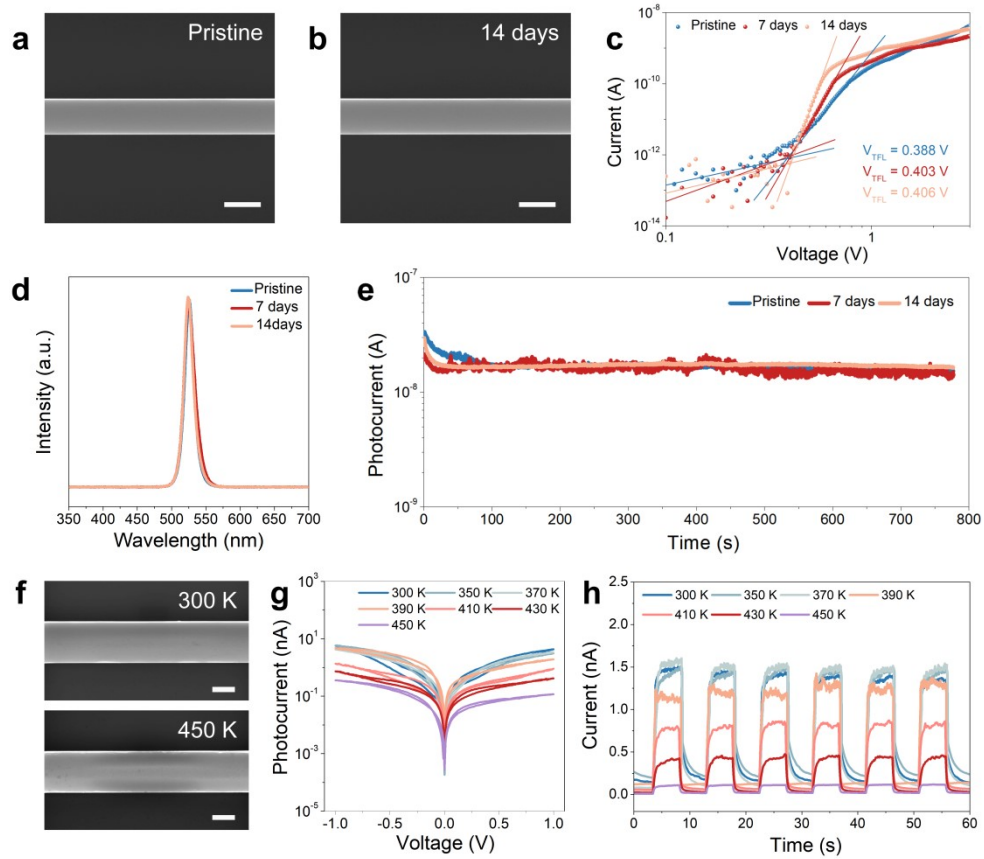


Figure S8. (a,b) SEM images of the CsPbBr₃ NW measured at the initial state and after 14 days of storage, respectively. Scale bar: 500 nm. (c) Space-charge-limited current characteristics of the NW measured initially, after 7 days, and after 14 days. (d) PL spectra of NW measured initially, after 7 days, and after 14 days. (e) Photocurrent stability of the NW measured initially, after 7 days, and after 14 days. (f) SEM images of the CsPbBr₃ NW measured at 300 K and 450 K. Scale bar: 500 nm. (g,h) Temperature-dependent I-V and I-T characteristics of the CsPbBr₃ NW measured from 300 K to 450 K.

Calculation of injected carrier density:

The average photogenerated carrier density under high irradiance was estimated using³⁻⁵:

$$\Delta n_{ph} = \frac{\eta_{abs} P \tau_{eff}}{h \nu t}$$

where P is the incident irradiance, η_{abs} is the absorption efficiency, τ_{eff} is the effective carrier lifetime, $h \nu$ is the photon energy, and t is the effective absorption thickness. The P is 56.8 W cm^{-2} , τ_{eff} is 57 ns , t is 300 nm , the photogenerated carrier density is estimated to be $2.22 \cdot \eta_{abs} \times 10^{17} \text{ cm}^{-3}$. For moderate-to-strong absorption, this value is comparable to the effective hole concentration extracted from the transfer characteristic.

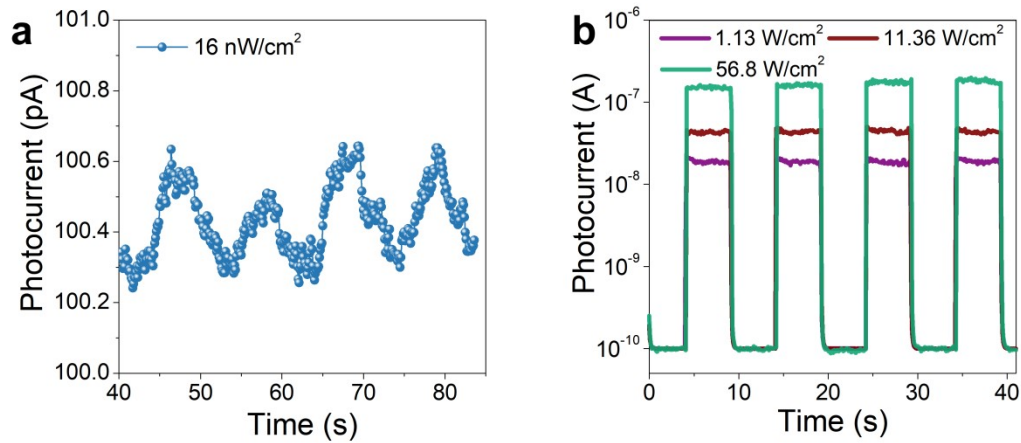


Figure S9. (a) I-T response of the CsPbBr₃ PD under 16 nW cm^{-2} light illumination. (b) I-T response of the device under strong light illumination. The device maintains a clear photoresponse under illumination intensity up to 56.8 W cm^{-2} .

Reference

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