Support Information

Tailoring synaptic plasticity in perovskite QD-based asymmetric memristor

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Experimental Section

Materials:

All chemicals were purchased from Sigma Aldrich. Barium carbonate (Cs2CO3, 99.9%), lead bromide (PbBr2, 99.99%), oleic acid (OA, technical grade, 90%), 1-octadecene (ODE, technical grade, 90%), oleylamine (OAm, technical grade, 70%), hexane (anhydrous, 98%), toluene (anhydrous, 98%), methyl acetate (MeOAc, anhydrous, 99.5%). All chemicals are purchased without further purification.

Preparation of Cs-oleate:

The CsPbBr3 quantum dots were synthesized according to the procedure reported by Protesescu, et al. [1].The ruthenium oleate precursor was synthesized by loading 0.81 g of Cs_2CO_3, 40 mL of ODE and 2.5 mL of OA to 100 mL of 3-neck flask, and then heating to 120 ° C for 1h under a nitrogen atmosphere to ensure complete reaction of Cs_2CO_3 with OA. The prepared solution was maintained at 160 ° C to avoid further precipitation. Finally, get a transparent solution and preheat it 100° C.

Synthesis of $CsPbBr_3$ QDs:

Then, 5 mL of ODE mixed with 0.188mmol of $PbBr_2$ was placed in another 3-necked flask, and the temperature was maintained at 120 ° C for 60 min under vacuum, and 0.5 ml of OLAM and 0.5 ml of OA were injected, and the temperature was increased to 140 ° C under a flow rate of N_2 .Immediately, 0.4 ml of the yttrium oleate precursor was injected into the flask. The solution turned to fluorescent green, and the flask was immersed in an ice/water bath for quenching 5 seconds after HI.

Purification of CsPbBr3 QDs:

Purification of CsPbBr3 QDs was performed as previously reported by Swarnkar, et al.[2] Quantum dots of as-synthesized CsPbBr3 precipitated in 15 ml of MeOAc and then centrifuged at 9000 rpm for 5 minutes. In addition, the quantum dots CsPbBr3 of each centrifuge tube were wet pellets in 1 ml of redispersed hexane with the same volume of MeOAc and reprecipitated at 9000 rpm for 5 min. Quantum dots are redispersed in 2 ml of anhydrous toluene or hexane.

Characterization:

The PL spectrum was recorded with an Edinburgh instrument (FLS 920) at 550 nm excitation and the scatter excitation light was blocked using a cut-off filter (455 nm). And the UV-visible spectra were recorded on an ultraviolet-visible spectrophotometer (Agilent Cary 60). The prepared $CsPbBr_3$ quantum dots were characterized by high resolution transmission electron microscopy (HRTEM, Tecnai F30). All nanoelectronic measurements were made at room temperature using the Bruker size icon AFM. SCM-PIT conductive sheet (Bruker; platinum rhodium coating;

frequency: 60 - 100 kHz). Scan, scan rate 10 µm × 10 µm 0.8 Hz, respectively. What`s more, the top surface distance of all samples was measured at a surface distance of 75 nm (resolution: 256 pixels x 256 pixels) and the charge trapping ability of pentacene thin films was studied by atomic force microscopy (AFM) technique in combination with contact mode and KPFM mode. There are two steps for each measurement: two-dimensional charge injection and surface potential measurement. First, in the contact mode, the scan rate of 0.8 Hz, the 6 V bias is a technique applied to the injection of conductive electrons (scan area: 1 µm × 1 µm; resolution: 256 pixels × 256 pixels). Injection of the well is achieved by biasing the tip of a + 6v at different scanning zones. Then, the AFM system is converted to KPFM amplitude modulation mode for on-site surface potential measurement. Scan, scan rate 10 µm × 10 µm 0.8 Hz, respectively. The top surface distance of all samples was measured at a surface distance of 75 nm (resolution: 256 pixels x 256 pixels). Finally, the electrical characteristics of all devices were measured using the Keysight B2902A Precision Source/Measurement Unit and the Keysight 4200-SCS Parameter Analyzer. All device tests were performed at room temperature.

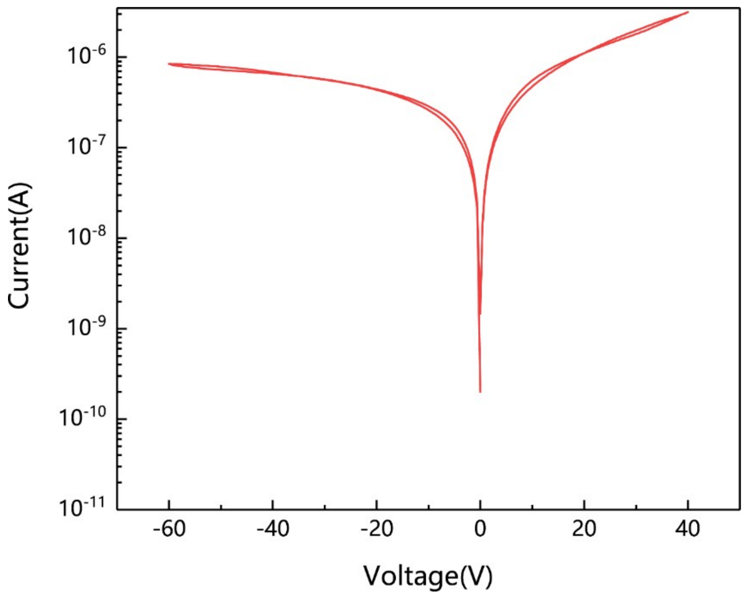

Figure S1. I-V hysteresis loop of $CsPbBr_3$ QDs-based memristor with symmetrical electrode.

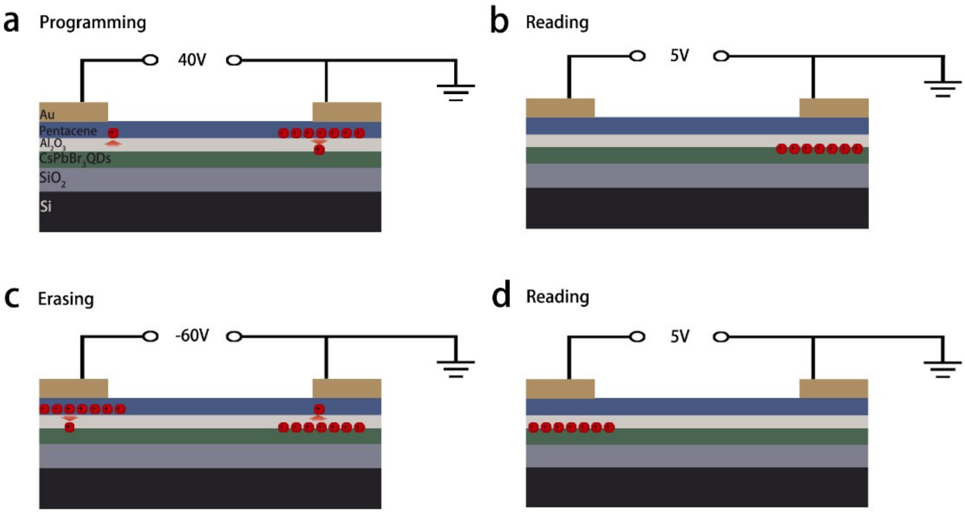

Figure S2. Four symmetrical electrode device states under different bias:
(**a**) Programming at 40 V, (**b**) Off-state Reading at 5 V, (**c**) Erasing at –60 V, and (**d**) On-state Reading at 5 V.

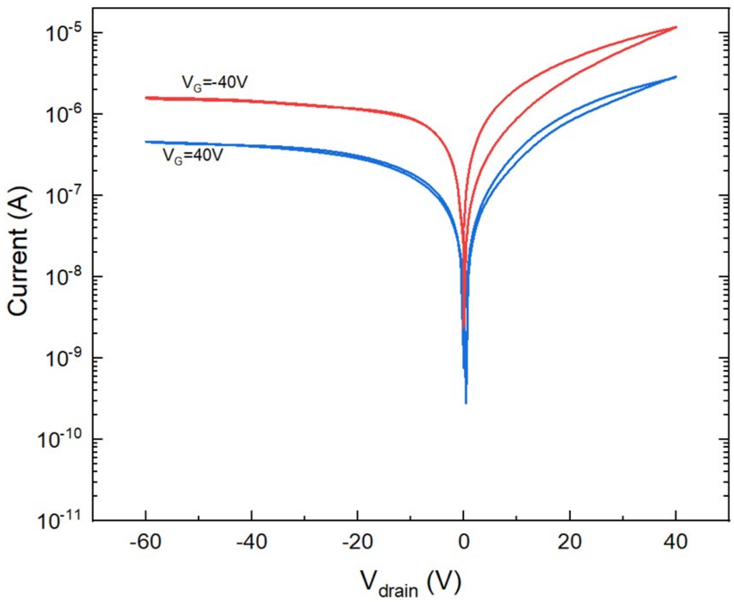

Figure S3. I_{DS}-V_{DS} curve with 40v and -40v applied to the gate, respectively.

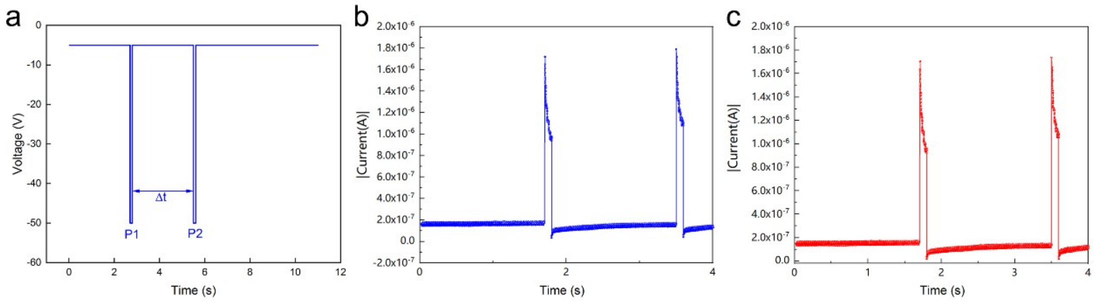

Figure S4. a, b, c) EPSCs trigged by a pair of electric pulses (-50V/2s). A_1 and A_2 are the EPSC values at the end of the first and the second pulse a), respectively. Among them, b) uses gate to regulate, however c) applies voltage to short Au electrodes for regulation.

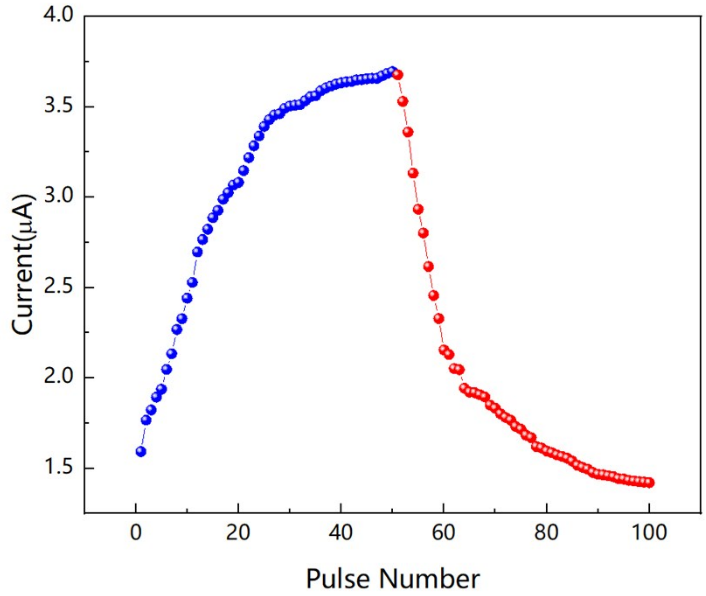

Figure S5. Current change when continuous pulse (-50 V / 0.5 s) and suppression pulse (35 V / 0.5 s) are used, intermittent reading is 5 V. The voltage bias was applied to the short Au electrode, respectively.

Notes and references

1. Loredana Protesescu, Sergii Yakunin, Maryna I. Bodnarchuk, Franziska Krieg, Riccarda Caputo, Christopher H. Hendon, Ruo Xi Yang, Aron Walsh, and Maksym V. Kovalenko, Nano Lett. 2015, 15, 3692−3696.

2. Abhishek Swarnkar, Ashley R. Marshall, Erin M. Sanehira, Boris D. Chernomordik, David T. Moore, Jeffrey A. Christians, Tamoghna Chakrabarti, Joseph M. Luther, Science, 2016, 354 (6308), 92-95.