**Supplementary Information for**

**A dual-mode image sensor using an all-inorganic perovskite nanowire array for standard and neuromorphic imaging**

*Zhenghao Long1, Yucheng Ding1, Xiao Qiu1, Yu Zhou1, Shivam Kumar1, Zhiyong Fan1,2,3,4,*

1Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology; Clear Water Bay, Kowloon, Hong Kong SAR, China.

2State Key Laboratory of Advanced Displays and Optoelectronics Technologies, HKUST, Clear Water Bay, Kowloon, Hong Kong SAR, China

3Department of Chemical and Biological Engineering, The Hong Kong University of Science and Technology; Clear Water Bay, Kowloon, Hong Kong SAR, China.

4Shanghai Artificial Intelligence Laboratory, Shanghai, P.R. China.

\*Corresponding author: eezfan@ust.hk

**Methods**

**Materials.** All the chemicals were purchased from Sigma-Aldrich and used as received without further purification.

**Preparing PAM with Pb nanoclusters.** A PAM was fabricated on a flattened aluminum substrate. Then we used a two-step hard anodization process to prepare PAM with 20 *μ*m thickness. ~100 nm channel diameter and ~200 nm pitch between the nanowires. Both the anodization processes were performed in 0.1 M oxalic acid aqueous solutions. The voltage gradually increased to 80 V, and then stayed at 80 V for 1 h. The first anodization layer was etched away in a mixture of phosphoric acid (6 wt% H3PO4 and 1.8 wt% CrO3) at 98 °C for 1 h. Pb nanoclusters were deposited at the bottom of the PAM channels via a barrier thinning and following electrochemical deposition processes. Barrier thinning is a voltage-ramping-down (from 80 to 4 V) process that was carried out to thin down the barrier layer at the bottom of PAM nanochannels. Subsequently, the PAM with Pb nanoclusters was lifted off from the aluminum substrate via a wet etch process in HgCl2 solution.

**Perovskite nanowire array growth.** TheCsPbI3 nanowire array was grown by a two-zone chemical vapor deposition (CVD) process. The source was prepared by mixing CsI and PbI2 powder with a molar ratio of 3 : 1 and annealed at 450 ℃ in high- purity Ar gas (99.999%) for 1 h. The CVD process was conducted in a vacuum environment with a pressure of 0.55 torr. 10 g source was heated to 460 ℃ and the source vapor was carried by 120 sccm high purity Ar gas (99.999%). The reaction happened at 370 ℃ for 5 h with 20 min temperature rising time.

**SnO2 electron transporting layer deposition.** ~20 nm tin oxide (SnO2) layer was also deposited by ALD method. The oxygen source and Sn precursor are O3 and C8H24N4Sn, respectively. The C8H24N4Sn was contained in a bubbler at 70 ℃ and admitted into the ALD reactor with N2 carrier gas (20 sccm). High purity N2 gas was used as the carrier and purge gas. The SnO2 ALD pulse sequence followed C8H24N4Sn injection (800 ms)/wait (5 s/purge (10 s)/O3 (800 ms)/wait (5 s)/purge (10 s) steps at 250 °C. The thickness was controlled by ALD recipe cycles. 200 cycles SnO2 were deposited on the top of CsPbI3 nanowire arrays and the shell of PAM channels. The retina was annealed at 300 °C for 1 h. Finally, a 5 min ion milling processes with Ar ion beam energy of 1000 eV was performed on both front and back surfaces of the retina to remove top surface SnO2 film and avoid cross-talking.

**ITO electrode deposition.** The crossbar ITO electrodes are deposited via a standard sputtering method with a speed of ~0.1 nm / s.

**Photo response characterization.** The photo response of the device was measured with a source meter unit (Keithley 2450).

**Imaging demonstration.** The optical pattern was generated by a projector. The 10 × 10 crossbar device was connected to 2 multiplexers (PXI2530B, National instruments) which are installed inside of a chassis (PXI1031, National instruments). The photo current was read by a source meter unit (Keithley 2450).