Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supplementary Information

2D layered metal-halide perovskite/oxide semiconductor-based broadband optoelectronic synaptic transistors with long-term visual memory

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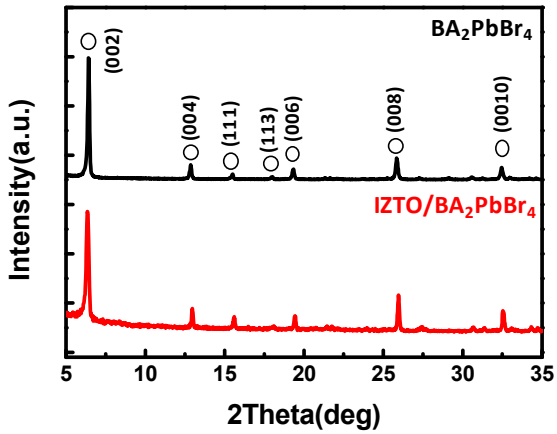

Fig. S1 XRD patterns of the BA_2PbBr_4 films (a) before and (b) after deposition of IZTO.

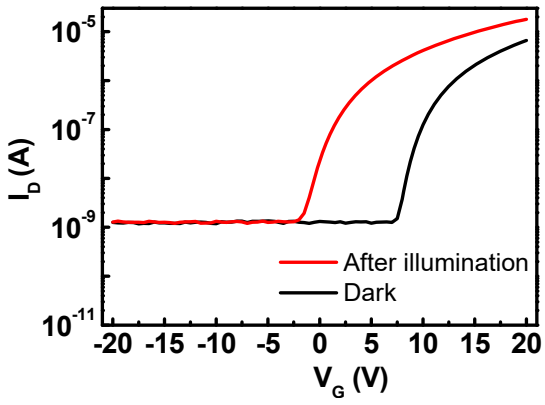

Fig. S2 Transfer characteristics under 'dark' and 'after illumination' (365 nm, 100 μW/cm^2, 30 s) of the device composed of IZTO. Transfer characteristic of 'after illumination' state is measured 30 s after application of optical pulse (365 nm, 100 μW/cm^2, 30 s) under V_G sweep from -20 to 20 V.

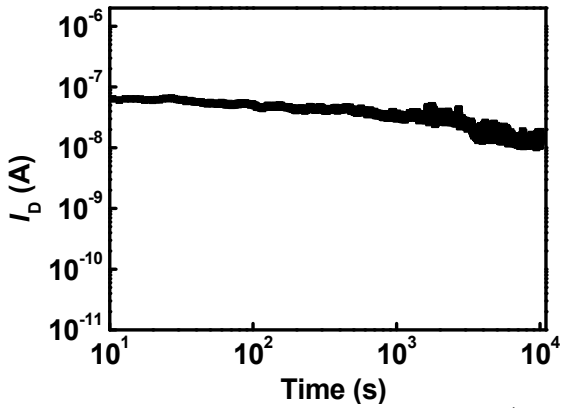

Fig. S3 Retention properties of IZTO/2D layered OIHP for 10^4 s after illumination for 30 s.

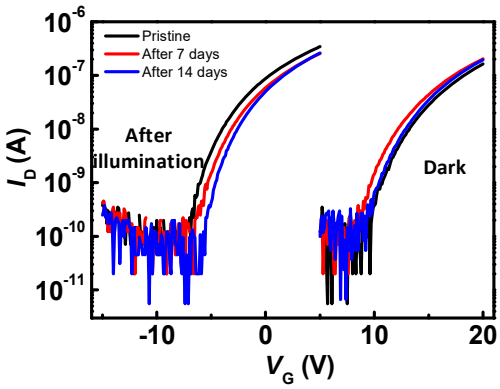

Fig. S4 Transfer characteristics of the device in 'dark' and 'after illumination' operation after 14 d in ambient air. Transfer characteristics of 'dark' state are measured under V_G sweep from 5 to 20 V, whereas transfer characteristics of 'after illumination' state are measured 30 s after application of optical pulse (365 nm, 100 μW/cm^2, 30 s) under V_G sweep from -15 to 5 V.

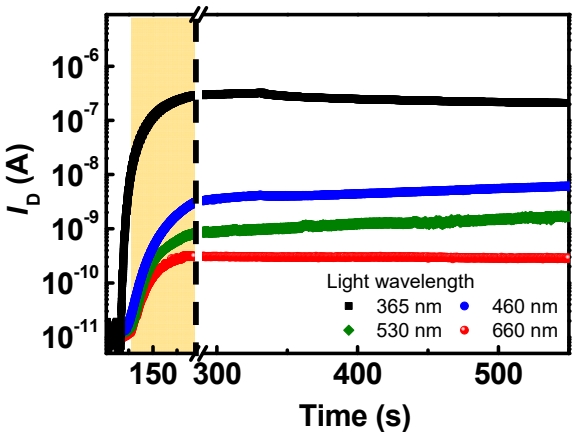

Fig. S5 Retention characteristics after long-term potentiation by application of optical spikes (100 μW/cm^2, 200 s) at wavelengths of 365, 460, 530, and 660 nm.

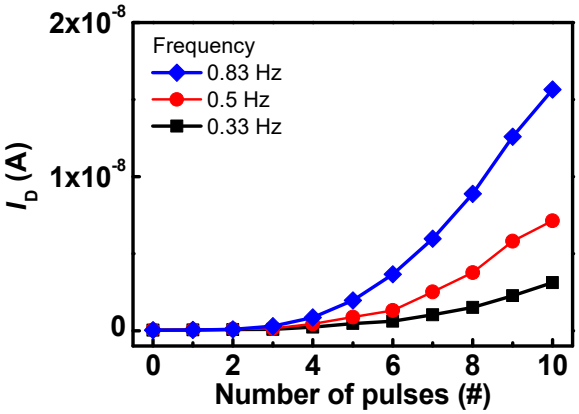

Fig. S6 Change of I_D by applying the 10 consecutive optical spikes (365 nm, 100 μW/cm^2, 1 s) with different frequencies (0.83 Hz, 0.5 Hz, 0.33 Hz).

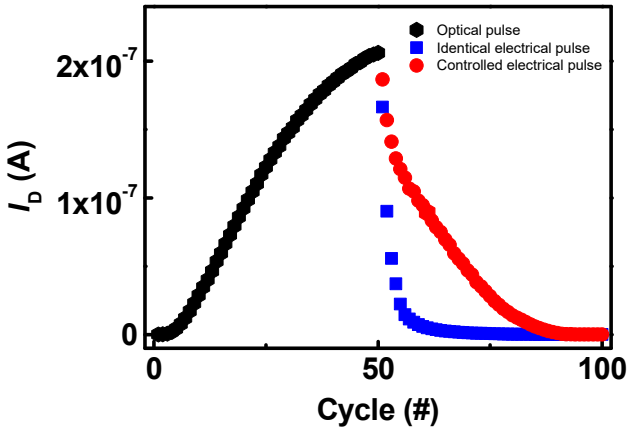

Fig. S7 Potentiation and depression characteristics by adjusting the applied electrical pulses. Fifty consecutive pulses (20 V, 2 s) were applied for identical pulse condition, whereas fifty consecutive pulses with incremental amplitudes of V_G pulses from 10 V to 29.6 V (increment: 0.4 V) for controlled pulse condition.

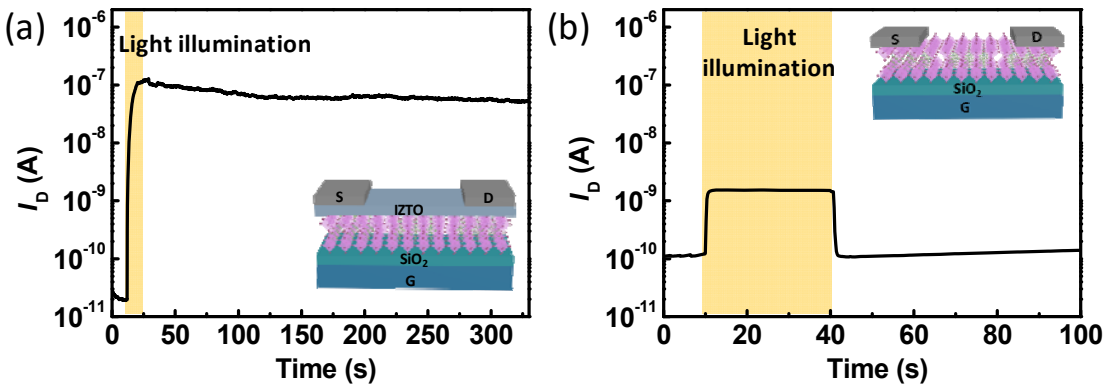

Fig. S8 (a) Change of current level of (a) IZTO/2D layered OIHP-based device and (b) 2D layered OIHP-based device under illumination (365 nm, 100 μW/cm^2, 30 s).

Artificial neural networks simulation

Artificial neural network simulations using MNIST datasets were performed in the Linux system with GCC, GNU, and CNU C libraries by using C++ codes.[1] The simulated multi-layer perceptron neural network was composed of 400 input neurons, 100 hidden neurons, and 10 output neurons. The 400 input neurons corresponded to the 20 × 20 MNIST image, and the 10 output neurons corresponded to 10 classes of digits.

1. P. Chen, X. Peng and S. Yu 2017 IEEE International Electron Devices Meeting (IEDM), 2-6 Dec. 2017; pp 6.1.1-6.1.4.