Supplementary Information

Electrical Properties and Biological Synaptic Simulation of Ag/MXene/SiO_2/Pt RRAM Devices

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Supplementary Figures 1-7

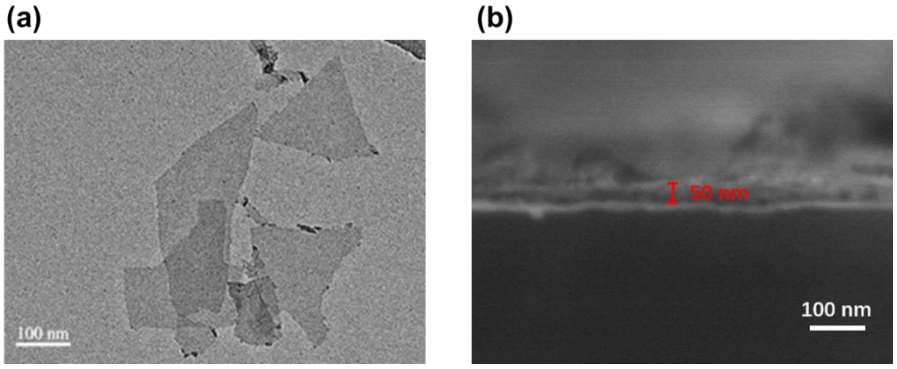

Figure S1. (a) A single layer or few-layered MXene on glass slide by ultrasonic method after etching from Ti_3AlC_2. **(b)** The cross-sectional SEM image indicates the thickness of the MXene film is 50 nm, prepared by etching Ti_3AlC_2 with HF, was deposited by spin-coating at 500 rpm for 60 s.

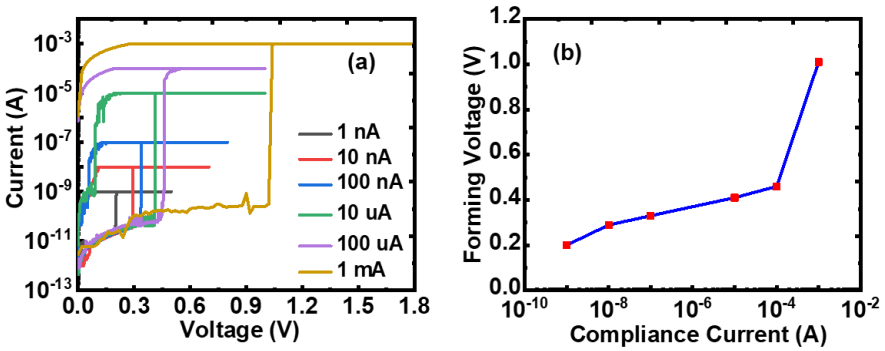

Figure S2. (a) The forming processes under different compliance current limits. **(b)** The relationship between the forming voltage and the compliance current limit.

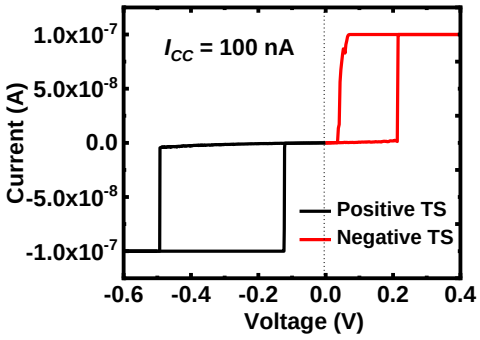

Figure S3. The threshold switching (TS) behaviors in both positive and negative bias directions under the compliance current limit of 100 nA, indicating the nonpolar TS behaviors under relatively low compliance current limits (i.e. approximately from 1 nA to 500 nA).

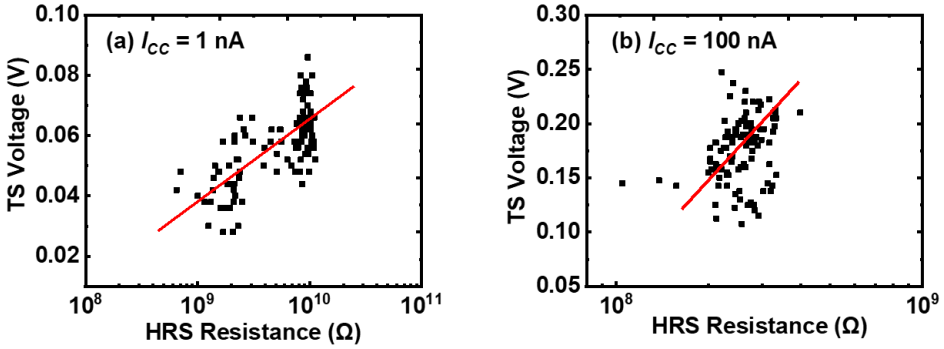

Figure S4. The statistics of TS voltages versus the initial HRS resistances under the compliance current limits of **(a)** 1 nA and **(b)** 100 nA, respectively. According to the statistics results, we can see that TS voltage is proportional to the HRS resistance, which means that the HRS resistances have a strong impact on TS parameters.

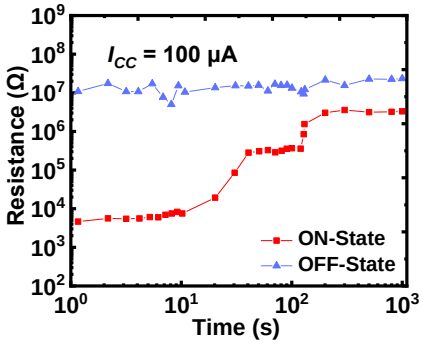

Figure S5. The retention measurement under the compliance current limit of 100 μA. The degradation of LRS resistances can also be observed and faster than the compliance current of 500 μA. The reason behind this phenomenon may be because a thicker and more stable conductive filaments would be formed under a relatively high compliance current limit of 1 mA, which means that the stronger the electrical stimulation, the longer the data retention. This phenomenon is consistent with the LTP characteristic of biological synapses, which is regarded as the basis of learning and memory.

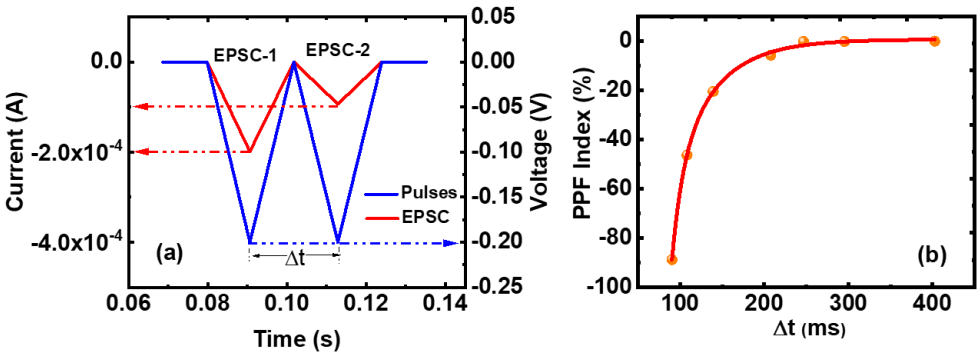

Figure S6. (a) The blue curve is a pair of identical spikes applied to the top electrode with the pulse amplitude of -0.2 V and pulse width of 25 ms. The red curve is the corresponding responses of the PPF characteristic in the Reset process. **(b)** The relationship between the index of PPF and pulse intervals Δt in the Reset process, also displaying an exponential decrease.

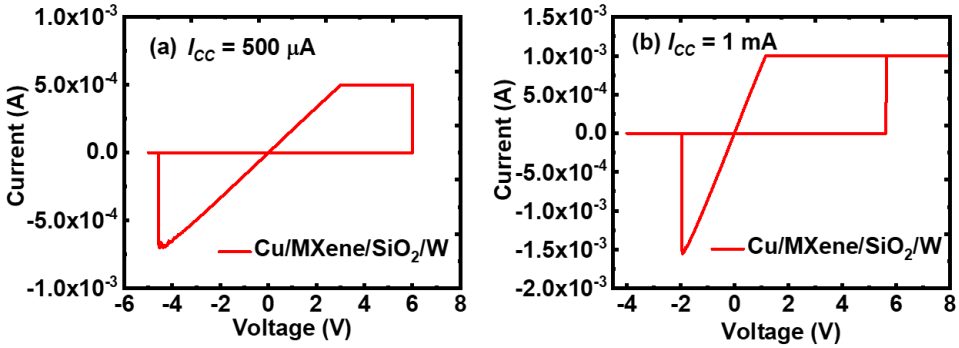

Figure S7. The typical *I-V* curves of Cu/MXene/SiO_2/W RRAM device under the compliance current limits of **(a)** 500 uA and **(b)** 1 mA, respectively. The experimental results further demonstrate our proposed resistance switching (RS) mechanism in the manuscript where the RS processes are determined by oxidation-reduction reactions of Cu or Ag ions in SiO_2 layer, meanwhile rule out the phase transition characteristic of MXene material.