

RESEARCH ARTICLE

Reconfigurable memristor based on SrTiO₃ thin-film for neuromorphic computing

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Supporting Information

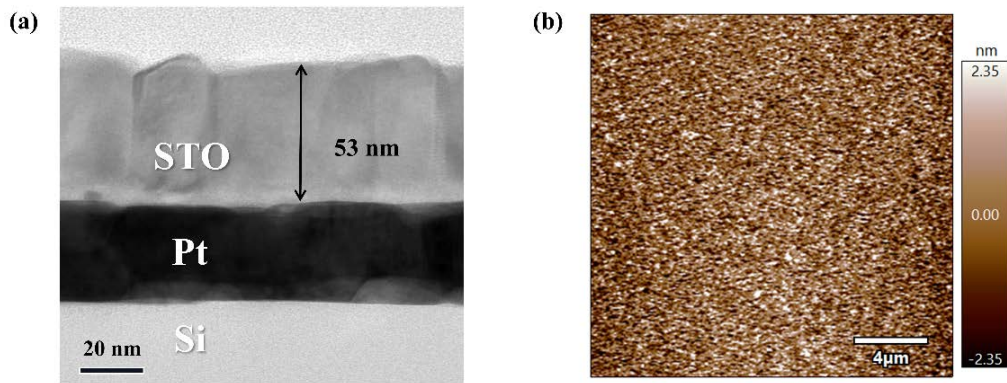


Fig. S1 Morphology of Ag/STO/Pt device.

As the value of I_{cc} increases to 1×10^{-5} A, the I - V test shows the “Forming” process in Fig. S2a, which lays the foundation for obtaining the bipolar resistance switching. In Fig. S2b, when $I_{cc} = 1 \times 10^{-4}$ A, the bipolar I - V test plot can be obtained, but the stability is not strong. Figure S2c shows the physical conversion mechanism of the electrochemical metalized conductive filament formation theory of the device in the STO functional layer [1,2]. When a positive voltage is applied to the Ag electrode, Ag is oxidized to Ag^+ and moved into the STO film. Ag^+ migrates to the bottom Pt electrode under the action of the electric field, and it is reduced to an Ag atom when it encounters the reverse electron. Ag atoms move and generate electrochemical reactions to complete the deposition at the bottom. As the applied voltage increases, the Ag atoms gradually move to the top. When the Ag atoms are connected to the Ag electrode at the top, the conductive filament of metal is formed. When $I_{cc} = 1 \times 10^{-6}$ A, the conductive filament formed is weak, and the weakening of the applied electric field will make the filament spontaneously break and complete the transition of resistance state. When increasing the I_{cc} , the phenomenon in Fig. S2a corresponds to the formation of the thick Ag filament in Fig. S2c. Because the conductive filament is too strong to break spontaneously, a negative voltage needs to be applied to turn it off. When $I_{cc} = 1 \times 10^{-4}$ A and $I_{cc} = 1 \times 10^{-3}$ A, the forward voltage puts the device in the open state, and only when the external voltage of opposite polarity is applied, the conductive filament gradually dissolves, and the device is in the relatively closed state. It can be seen that the formation of bipolar can not break the thick filament completely, and the change of the resistance state depends on the thickness of the Ag wire.

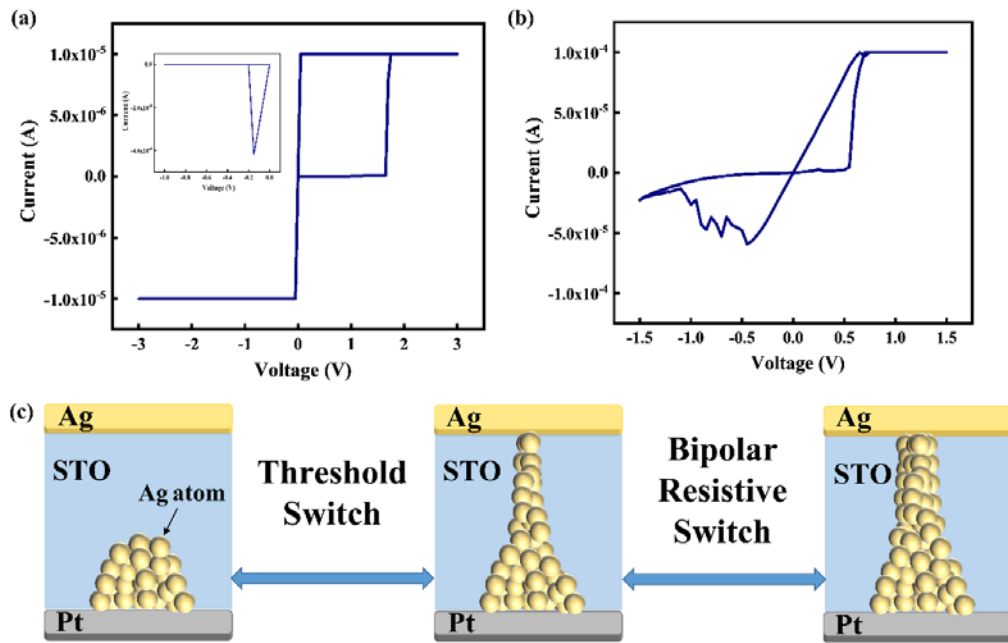


Fig. S2 (a) The test result of the I - V curve at $I_{cc}=1\times 10^{-5}$ A. (b) The test result of the I - V curve at $I_{cc}=1\times 10^{-4}$ A. (c) The physical mechanism of resistance transition in Ag/STO/Pt device.

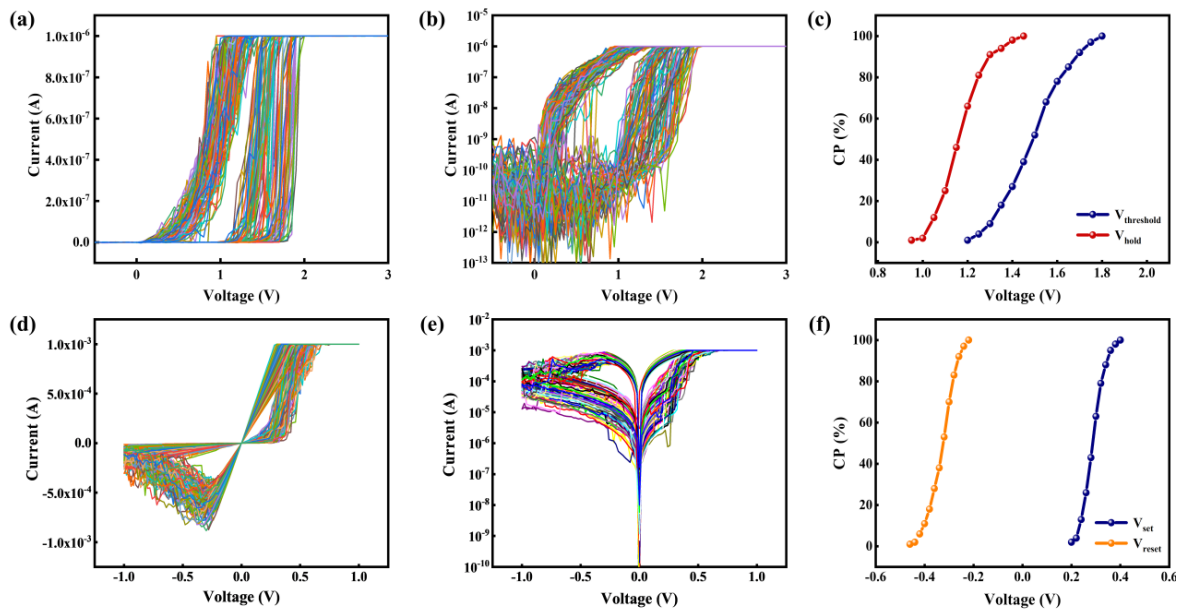


Fig. S3 (a) $I_{cc}=1\times 10^{-6}$ A, I - V curve of 100 scanning cycles. (b) Logarithmic representation of the I - V curve of 100 scanning cycles when the device is in the volatile threshold switching. (c) Cumulative probability statistics of V_{th} and V_{hold} . (d) $I_{cc}=1\times 10^{-6}$ A, I - V curve of 100 scanning cycles. (e) Logarithmic representation of the I - V curve of 100 scanning cycles when the device is in nonvolatile bipolar switching. (f) Cumulative probability statistics of V_{set} and V_{reset} .

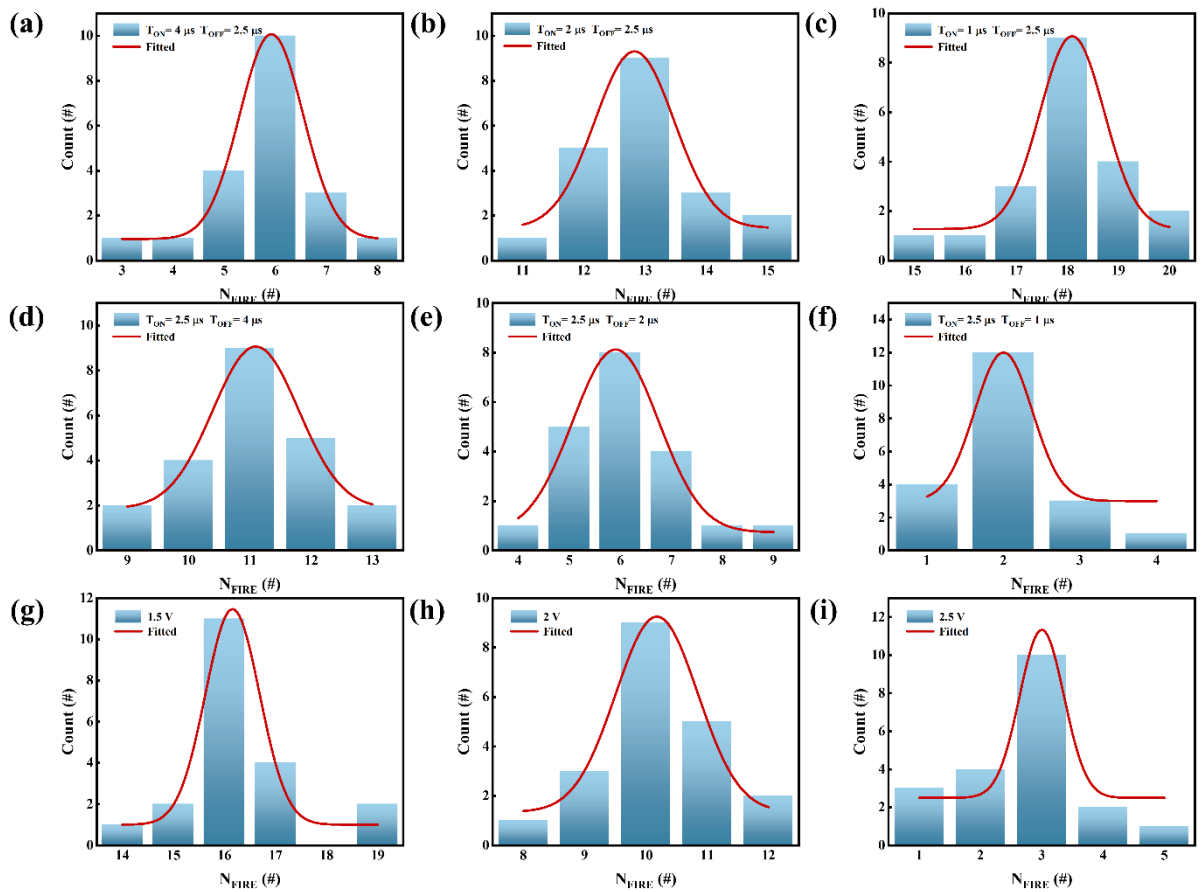


Fig. S4 Data statistics of pulses are required by FIRE. **(a-c)** Number of pulses required for FIRE with different pulse durations. **(d-f)** Number of pulses required for FIRE at different intervals. **(g-i)** Number of pulses required for FIRE with different amplitudes.

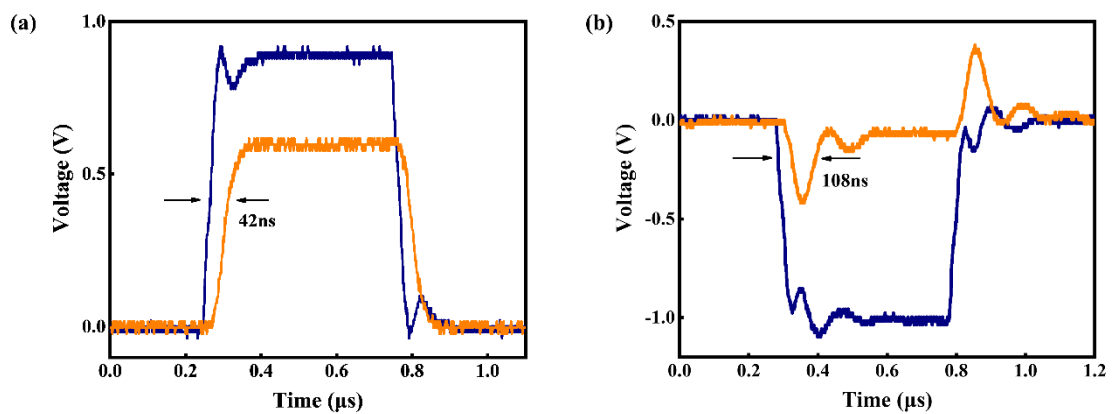


Fig. S5 Statistics of switching speed during bipolar resistance switching. **(a)** The device opens at a speed of 42 ns. **(b)** The device is turned off at 108 ns.

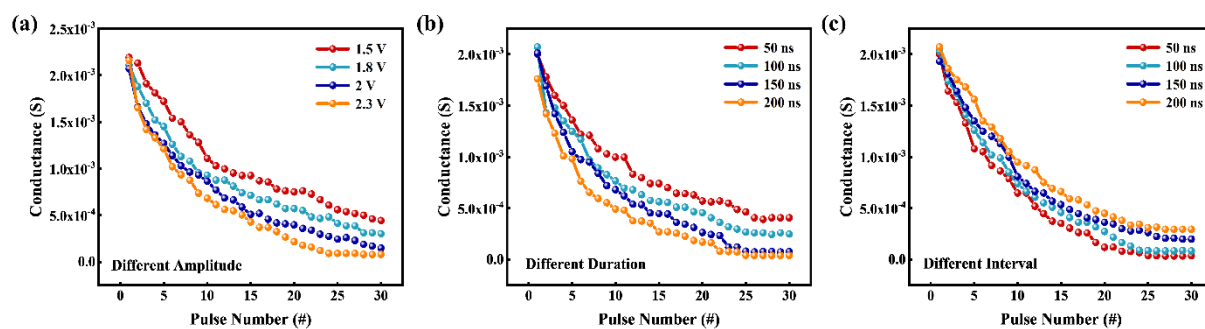


Fig. S6 Influence of negative pulses of different amplitudes, durations, and intervals of 30 cycles on conductivity modulation.

References

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