## **Supporting Information**

## Fully imitation synaptic metaplasticity based on memristor device

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Figure S1. I-V characteristics with the using of same voltage value during the consective



negative sweep.

**Figure S2.** The test flow of the metaplasticity. The red pulse indicates the different priming stimulus.



**Figure S3.** a) The Ca<sup>2+</sup> levels affecting the plasticity. i) The basal state of the synapses. ii) Synapses are strengthened in LTP when AMPA receptors (which bind to negatively-charged glutamate) are increased, allowing more calcium ions to enter the cell, causing a higher excitatory response. iii) LTD occurs when the AMPA receptors are decreased, which decreases the amount of calcium ions entering the cell, weakening the synaptic response to the release of neurotransmitters. c) Illustration of growth of conductive filament in the memristor device in various states. i) Pristine state. ii) LRS. iii) HRS.



**Figure S4.** Illustration of growth of conductive filament in the memristor device in various states. a) Pristine state. b) LRS. c) HRS



Figure S5. The variation of the CFs of conventional LTD and MFLTD.



**Figure S6.** (a) and (b) Schematic diagram for a pulse train. (c-e) Variations in  $\Delta W$  with respect to  $\Delta t$  when applied different priming stimulus to induce metaplasticity for the STDP (MILTP, MFLTP and MFLTD, respectively) in the memristor.

The pulse trains consisting of the priming stimulus, the pre spikes and the post spikes, it used to induce metaplasticity for the STDP in RRAM. The priming stimulus to induce MILTP, MFLTP and MFLTD are -1 V /1 us, 1 V /1 us and -1 V /1 us, respectively. The pre-spikes consisted of four P-spikes with the amplitude gradually increased from 1.3 V to 1.6 V and a D-spike of -1.6 V. When the pre-spikes precede the post-spikes ( $\Delta t$ >0), the net spikes (Vpost-Vpre) induced the synaptic potentiation, on the contrary, if the post-spikes prior to the pre-spikes ( $\Delta t$ <0), the synaptic depression occurs. Figure S6 shows the STDP based on the MILTP, MFLTP and MFLTD, respectively. These results indicate that the metaplasticity in the potentiation and depression is exhibited in the STDP of the memristor device.



Figure S7. A schematic illustration of major process flow. (see the method section in detail)