Synaptic Plasticity Selectively Activated by Polarization-Dependent Energy-Efficient Ion Migration in an Ultrathin Ferroelectric Tunnel Junction

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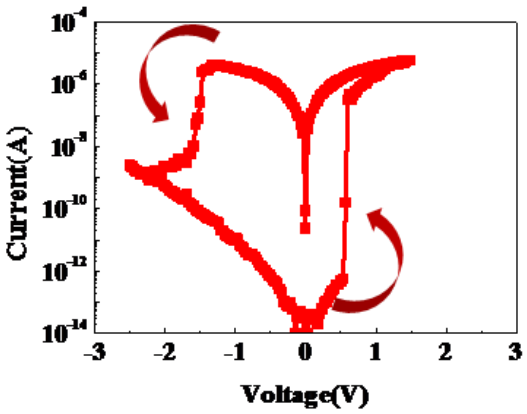

Figure 1: Resistive switching behaviour.

Abstract

Selectively activated inorganic synaptic devices, showing a high on/off ratio, ultrasmall dimensions, low power consumption, and short programming time, are required to emulate the functions of high-capacity and energy-efficient reconfigurable human neural systems combining information storage and processing.
Here, we demonstrate that such a synaptic device is realized using a Ag/$PbZr_{0.52}Ti_{0.48}O_3$ (PZT)/$La_{0.8}Sr_{0.2}MnO_3$ (LSMO) ferroelectric tunnel junction (FTJ) with ultrathin PZT (thickness of ~4 nm). Ag ion migration through the very thin FTJ enables a large on/off ratio (107) and low energy consumption (potentiation energy consumption = ~22 aJ and depression energy consumption = ~2.5 pJ). In addition, the simple alignment of the downward polarization in PZT selectively activates the synaptic plasticity of the FTJ and the transition from short-term plasticity to long-term potentiation.