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

Supporting Information

An excellent pH-controlled resistive switching memory based on self-colored $(C_7H_7O_4N)_n$ extracted from lichen plant

Shouhui Zhu, Bai Sun,* Yuanzheng Chen* Li Tao, Guangdong Zhou, Hongbin Zhao, Weiwei Mao, Yong Zhao*

*E-mail: bsun@swjtu.edu.cn; cyz@calypso.org.cn; yzhao@swjtu.edu.cn.

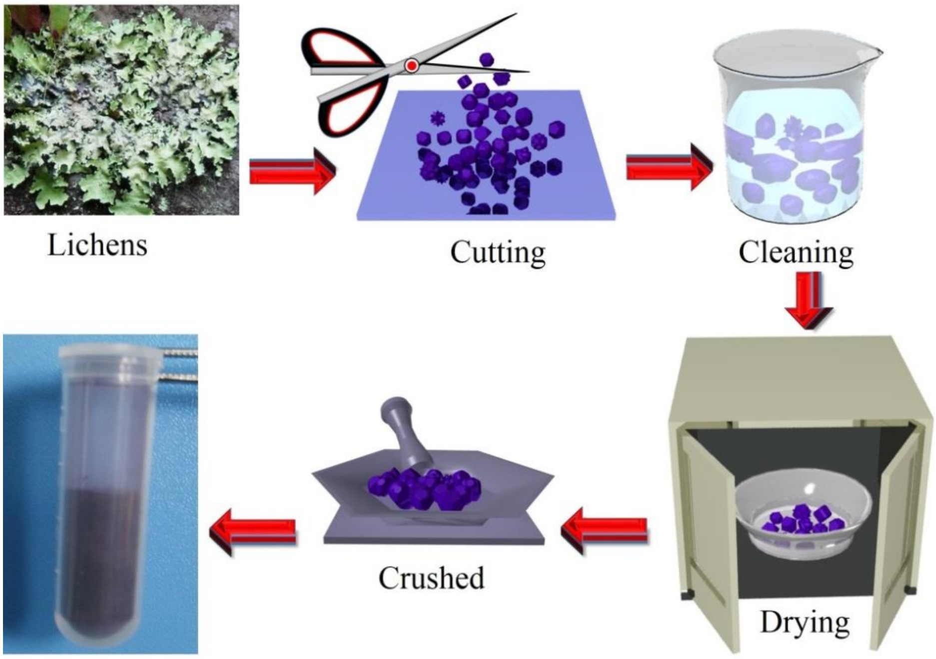

Fig. S1 Extraction of $(C_7H_7O_4N)_n$ from lichens plant.

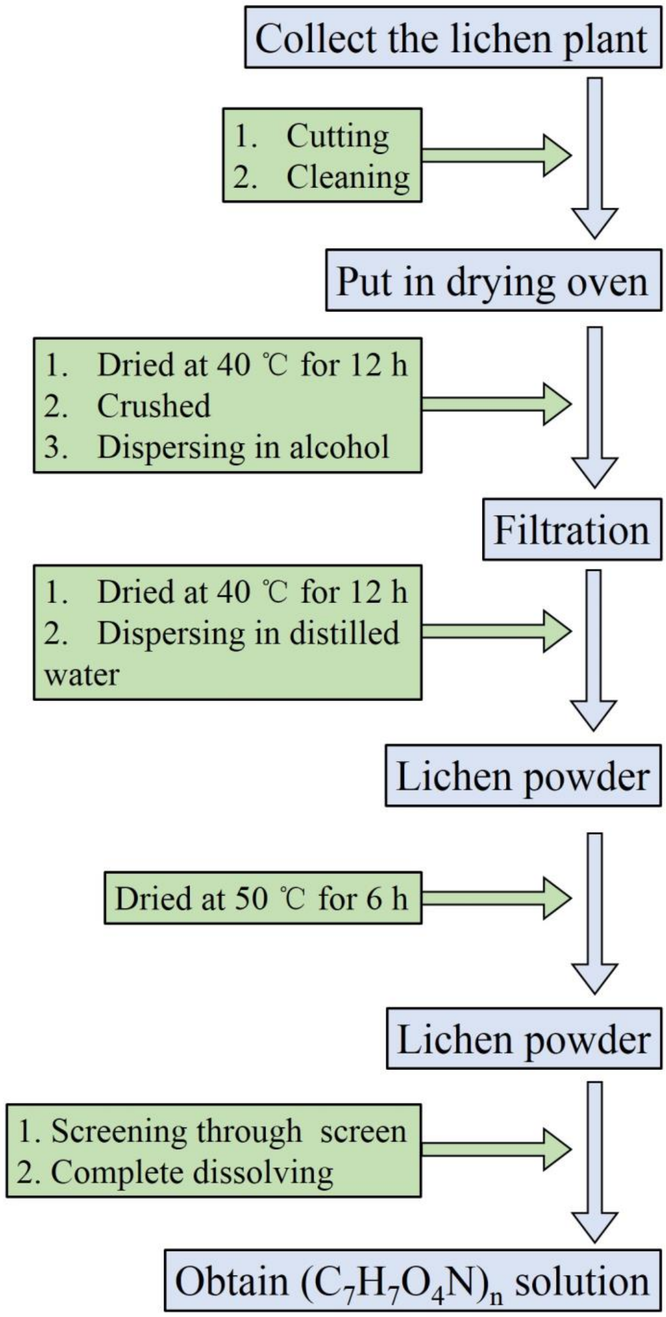

Fig. S2 Flow chart for $(C_7H_7O_4N)_n$ extraction from lichens plant.

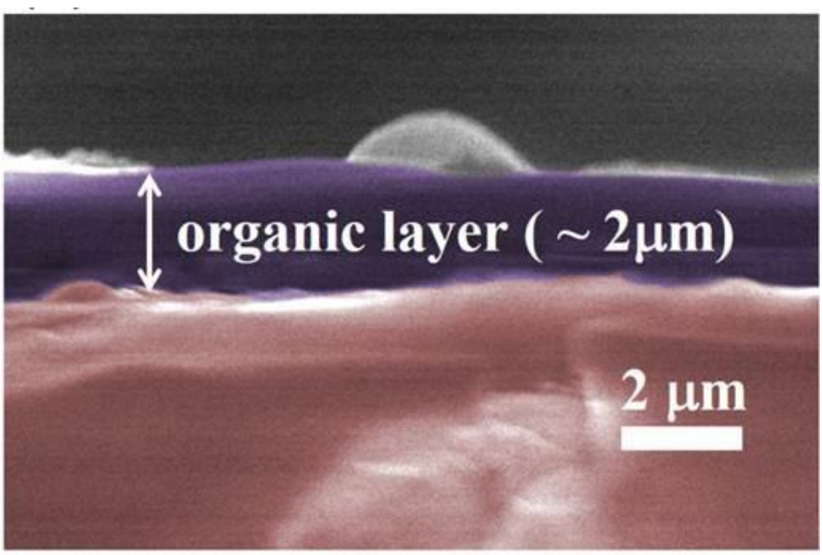

Fig. S3 The cross-sectional SEM images of device.

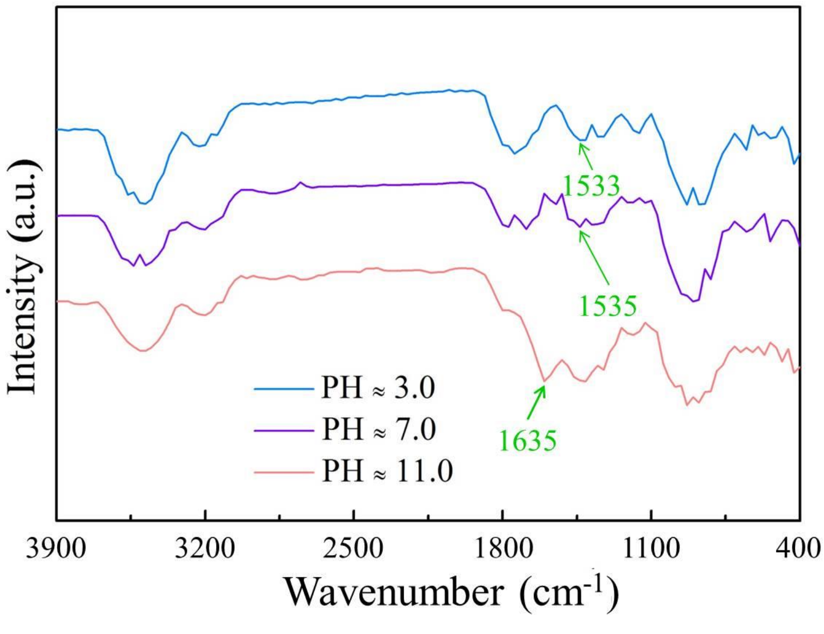

Fig. S4 FTIR spectra of $(C_7H_7O_4N)_n$.

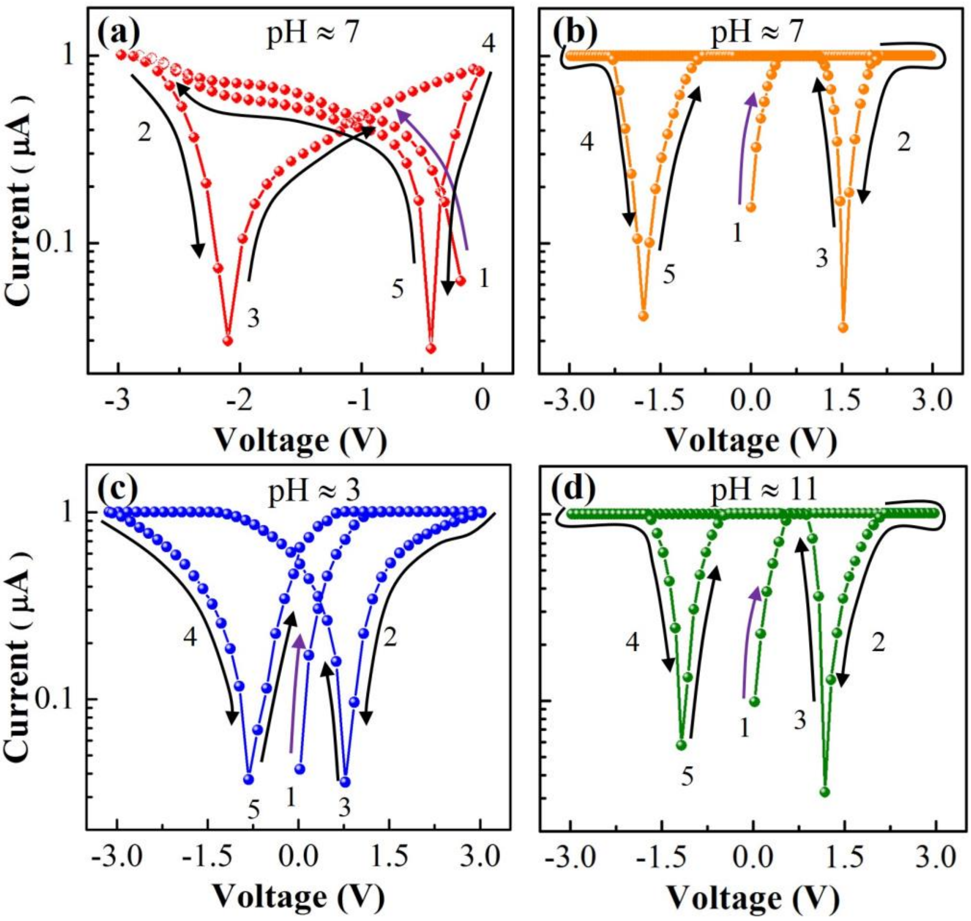

Fig. S5 The first sweeping cycle current-voltage (I–V) curves on a logarithmic scale. (a) For Ag/($C_7H_7O_4N$)$_n$/FTO device at pH = 7.0, the voltage sweeping directions from 0 → -3.0 V → 0. (b) Corresponding test results under neutral conditions (pH = ~7.0) at 3.0 V loop amplitude. (c) pH = ~3.0. (d) pH = ~11.0.

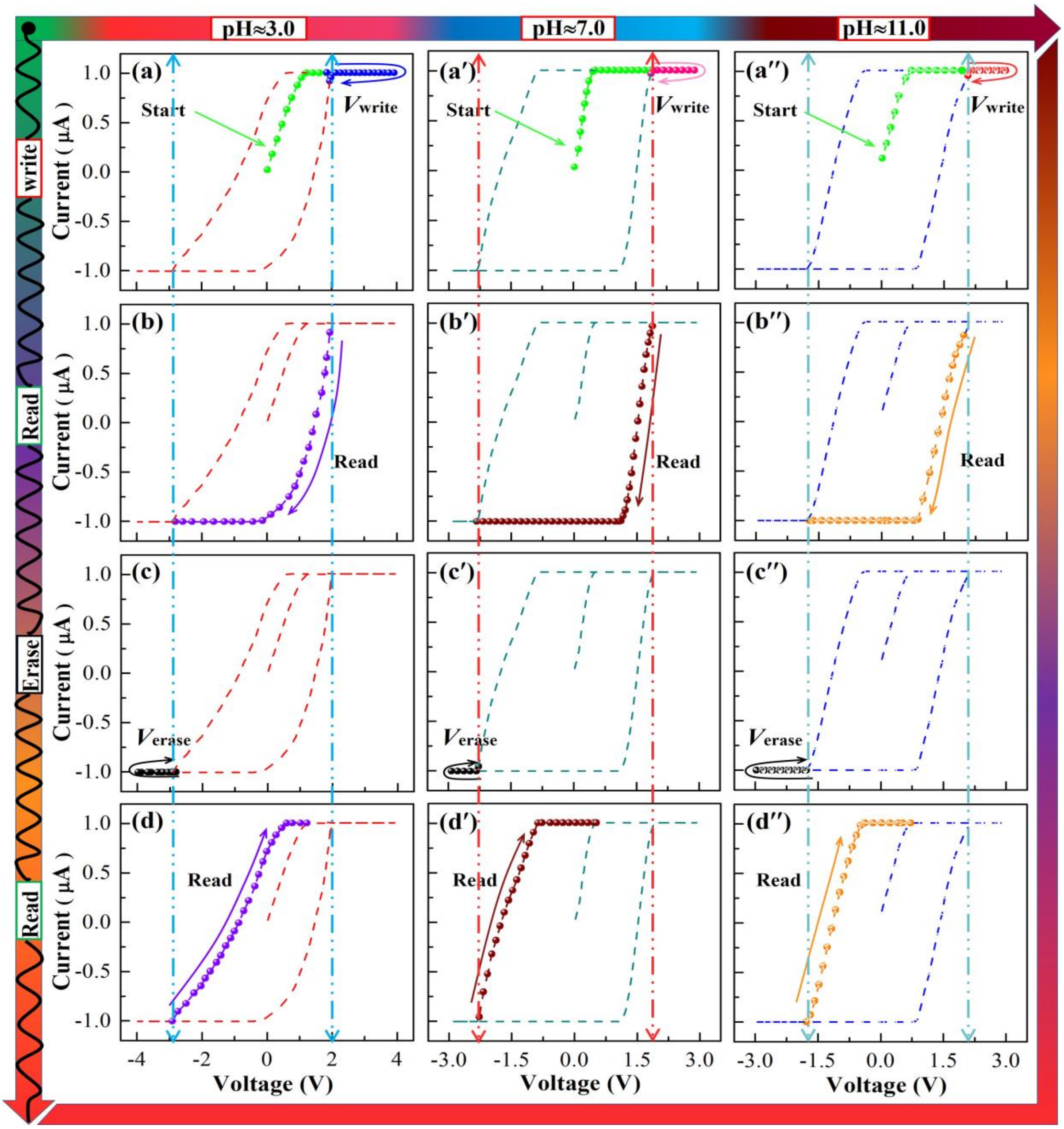

Fig. S6 The I–V hysteresis behaviors corresponding sequential operations of write, read, erase and read in the Ag/$(C_7H_7O_4N)_n$/FTO device under different pH conditions.

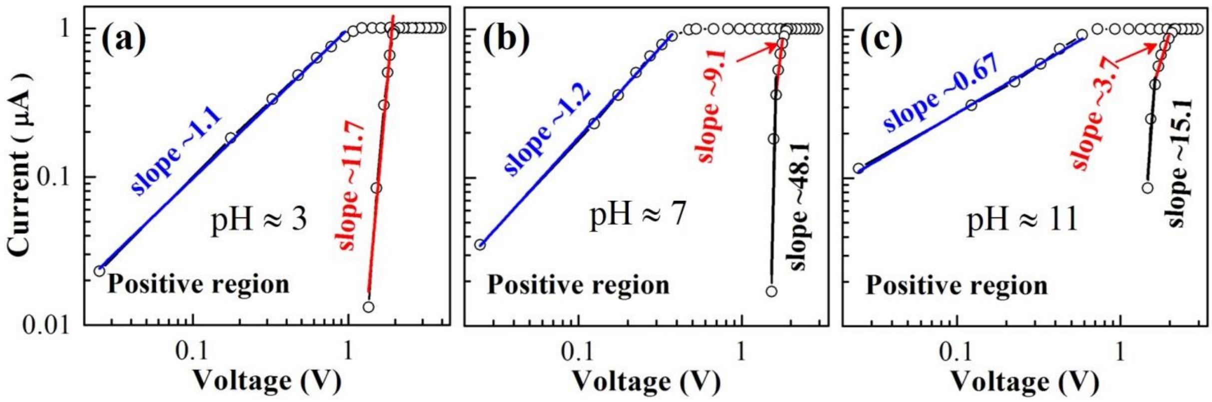

Fig. S7 The I–V curves in log–log scale for Ag/($C_7H_7O_4N$)$_n$/FTO structure in the positive voltage region, the straight line is the curve fitted by the theoretical model. (a) pH = ~3.0, (b) pH = ~7.0. (c) pH = ~11.0. At pH = ~3.0 and pH = ~7.0, the slope of start in the positive voltage sweep range are close to ~1.0 (slope ~1.1, ~1.2), corresponding to the Ohmic behaviors (I $\propto$ V). When PH = ~11.0, the slope of start is ~0.67. They have a large slope when read state in the positive voltage sweep range. Thses curves are mainly comprised of two regions, namely, low voltage Ohmic region (I~V) and current steep increase region (I~$V^{>2}$) in the region of HRS. According to the space-charge-limited current (SCLC) model, the current density can be described as follows:

$$J \propto V^{m+1}/d^{2m+1}$$

Where V is the applied external voltage, d is the thickness of ($C_7H_7O_4N$)$_n$ active layer, m is the fitting index ($m \geq 0$). For the fitting index m = 0 or > 1, J is proportional to ~V or ~$V^{>2}$, demonstrating the Ohmic-like characteristics in the region of HRS. The fitting results imply that the SCLC (i.e., ions migration) may dominate the charge behaviors in this region. In the region of LRS, the fitting of I~V indicates that the Ohmic conduction (i.e., the Ag metallic filaments) dominates the LRS region. Applying a positive voltage between the Ag active electrode and the counter electrode leads to an oxidation of Ag electrode's material and to a deposition of Ag metal. Owing to the high electric field, the Ag metallic deposit propagates in a filamentary form and short circuits the cell, thus defining a low-resistive "ON" state.

Meanwhile, it means that the filament can be dissolved by applying a voltage of opposite polarity to return the cell to a high-resistive "OFF" state. Notably, here the measured electrical I–V of the device shows an obvious non-zero-crossing I–V characteristic, which strongly suggests that in this device a capacitor with dedicated emf voltages.

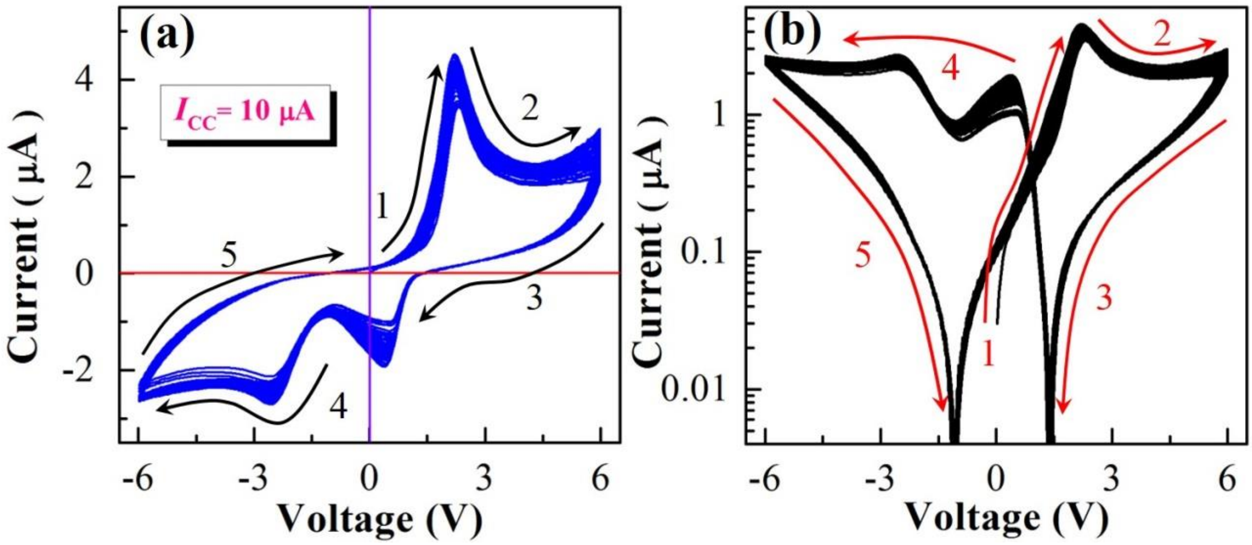

Fig. S8 (a) The typical I–V curve of continuously 100 cycles for Ag/$(C_7H_7O_4N)_n$/FTO device at 6.0 V loop amplitude at a compliance current of 10.0 μA. (b) The 100 cycles I–V curves on a logarithmic scale.

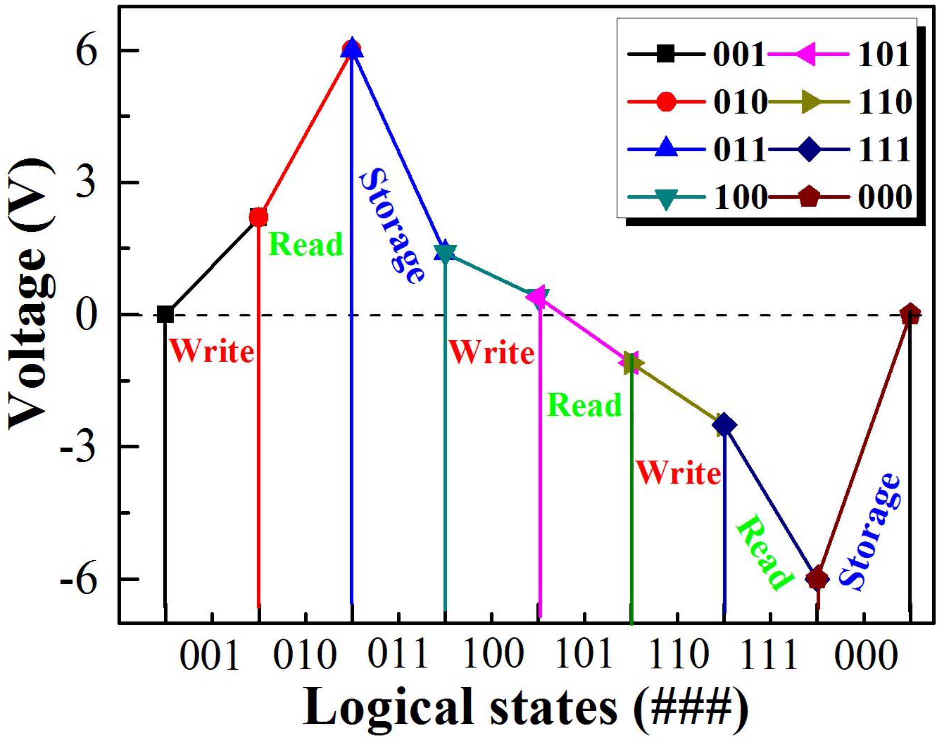

Fig. S9 The eight resistance states corresponding to eight three-binary numbers.

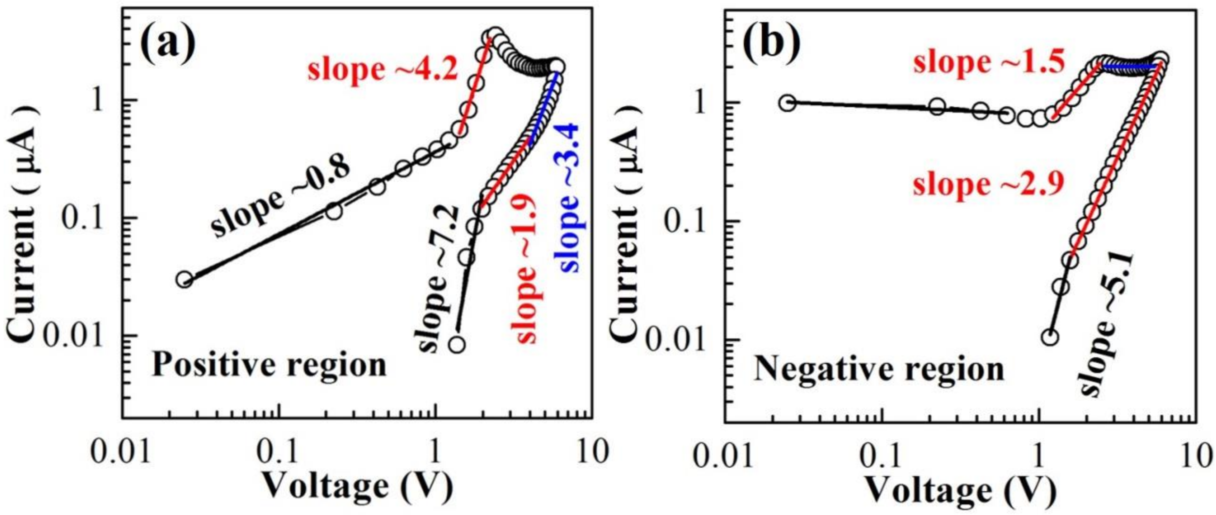

Fig. S10 (a, b) The I–V curves in log–log scale in the positive and negative voltage sweep regions respectively.

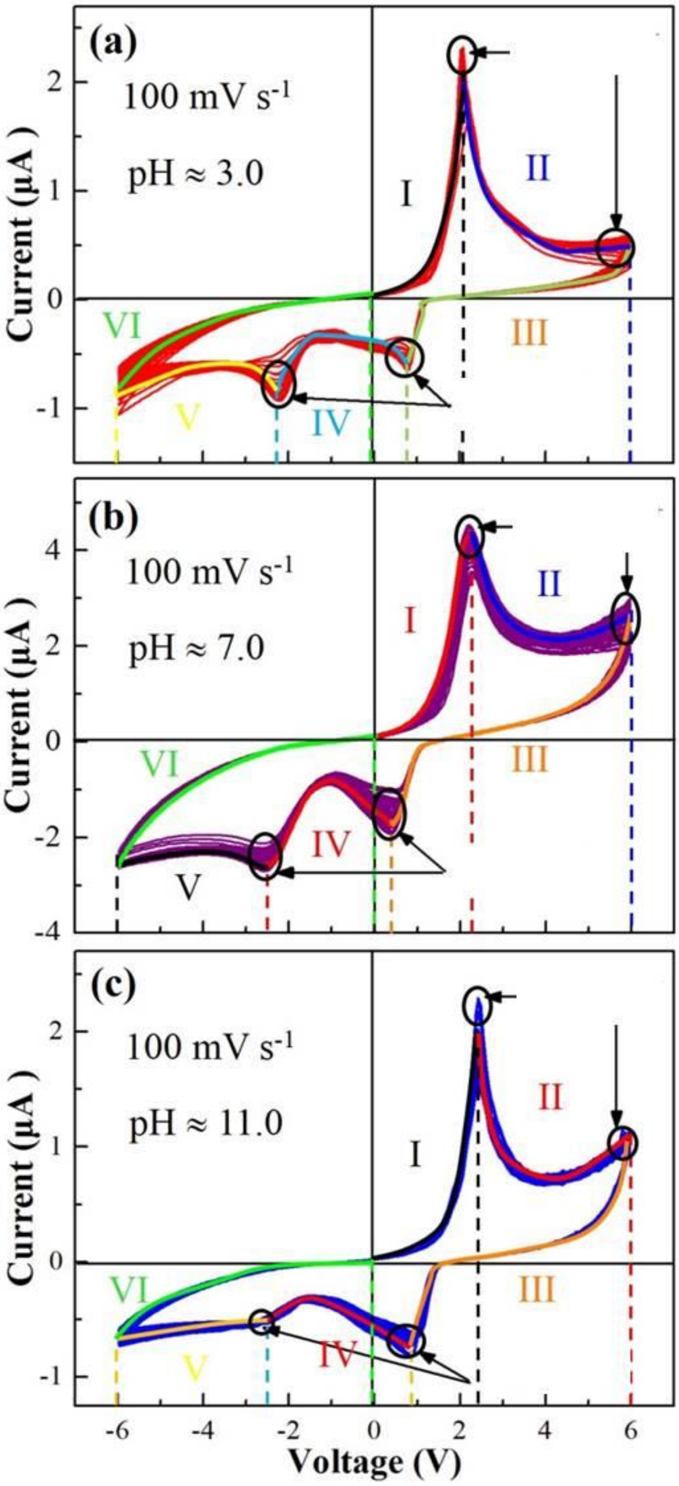

Fig. S11 Typical I–V characteristics curve of our device was measured at the scanning rate of 100 mV s^{-1} under at ph= ~3 (a), ~7 (b), and 11 (c).