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Electronic Supplementary Information

Multilevel Resistive Switching Memory Behaviors Arising from Ions Diffusion and Photoelectron Transfer in α-Fe_2O_3 Nano-island Arrays†

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1. Experiment Section

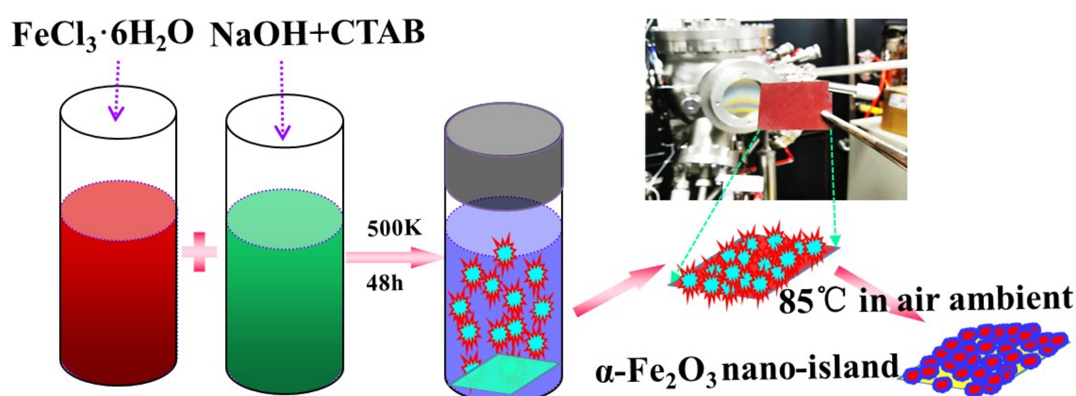
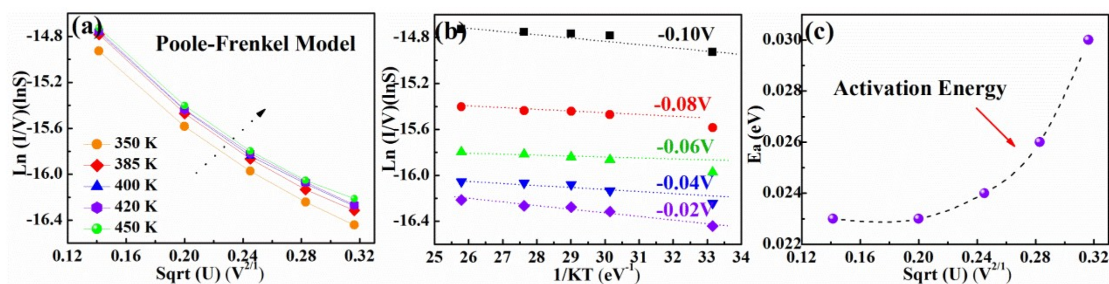


Fig S1. α-Fe_2O_3 preparation and the inset is the optical image of Ti|Fe_2O_3.

The metal Ti substrate was processed in 10% HF for 60 seconds in order to remove the natural redox layer. The 0.1 mol $FeCl_3 \cdot 6H_2O$ powders and 0.3 mol NaOH were orderly dissolved into 50 mL deionized water to fabricate mixed solution. A 0.05 cationic surfactant cetyltrimethylammonium bromide (CTAB) was added into the mixed solution and room temperature stirring for 24 hours to prepare precursor solution at room temperature. The precursor solution was transferred into 50 mL sealed Teflon-lined stainless steel autoclave and the processed Ti substrate with the size of 2 ×2 cm^2 was vertically placed into the autoclave. After reaction at 200°C for 48 hours, the sample of Ti|Fe_2O_3 was obtained after cleaning by deionized water and dried at 85°C for 18 hours in air ambient. Top Ag electrode arrays with diameter of 200 μm and 50 nm were sputtered at 20 W and 0.5 Pa Ar. A white light lamp was employed in this work. Fig. S1 has presented the preparation process and the Ti substrate has been put on the bottom of the Teflon-lined stainless steel autoclave.

Crystal structure, morphology and UV absorption were characterized by the X-ray diffraction (XRD, Shimadzu XRD-7000), ultraviolet spectrometer (SP-500) and Feld emission scanning electron microscopy (FE-SEM, JSM-6510), respectively. The RS memory behaviors were measured by integrated test system including probe station (Lake Shore, TTPX) and electrochemical workstation (660D).

2. Activation Energy (E_a)



FigS2. (a) Ln (I/V) *versus* Sqrt (U) for the Pool-Frenkel Model. (b) Ln(I/V) *versus* 1/KT under different bias voltage. (c) E_a *versus* Sqrt(U) extracted from (b).

The relations Ln (I/V) *versus* Sqrt(U) has been plotted for the Poole-Frenkel Model, as shown in above FigS 2a. One can see that the conductance is increasing as the temperature increase from 350 to 450 K. In addition, the 1/KT versus Ln (I/V) has been made under different bias voltage of -0.02, -0.04, -0.06, -0.08 and -0.1 V in order to extract the activation energy (E_a), as shown in FigS 2b. According to the slope of 1/KT *versus* Ln (I/V), the E_a can be obtained under under different bias voltages. For that, the E_a *versus* Sqrt (U) can be obtained according the slope values of FigS 2b. It illustrates that the E_a has shown increasing tendency as the bias voltage increase (0.023 eV ~0.030 eV) when the bias voltage range from -0.02 to 0.1 V, as shown in FigS. 2c. Therefore, the charges stored the defect energy level are possibly triggered and then easily contributes to the current increase of our memory device.