Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.


**Electronic Supplementary Information**

# Coexistence of resistance switching and negative differential resistance in $\alpha$-$Fe_2O_3$ nanorod film

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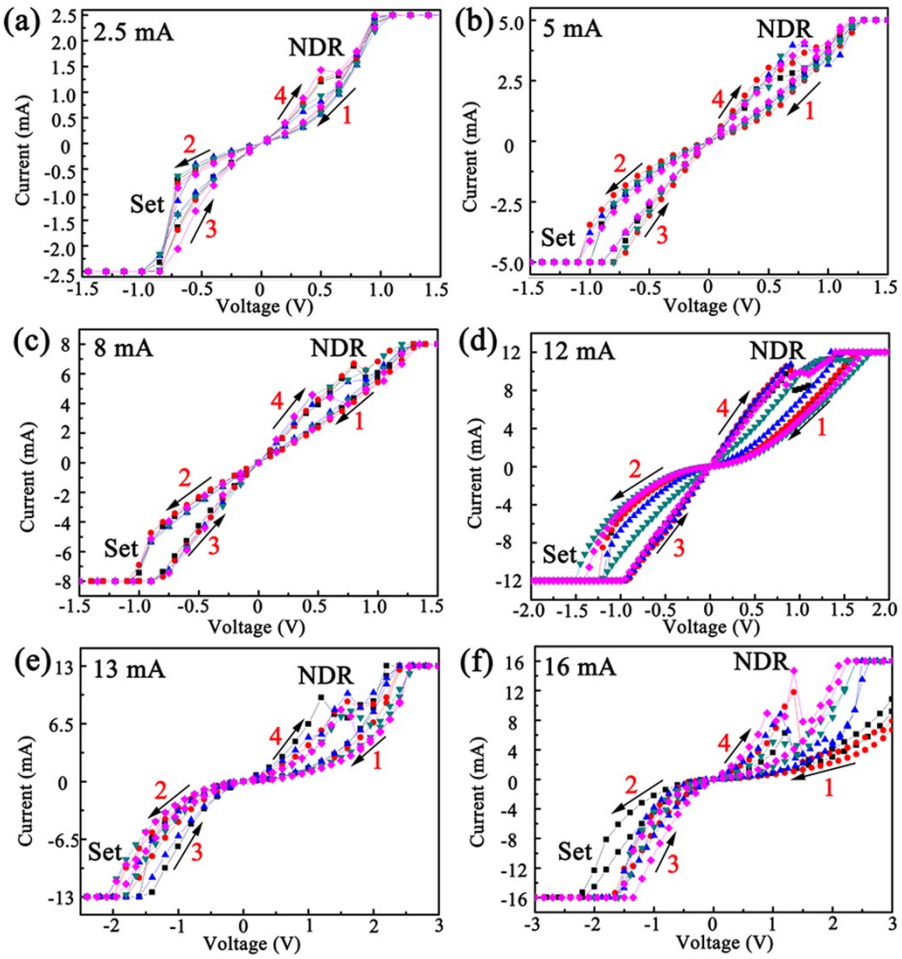


**Fig. S1** I-V tests sweeping from +2 V to −2 V and then back to +2 V under various CC levels: (a) 2.5 mA, (b) 5 mA, (c) 8 mA, (d) 12 mA, (e) 13 mA, (f) 16 mA.

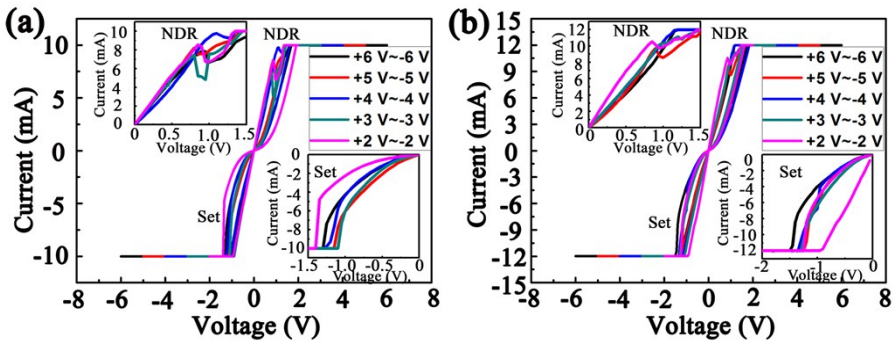


**Fig. S2** I-V tests sweeping between ±2 V, ±3 V, ±4 V, ±5 V and ±6 V under various CC levels: (a) 10 mA, (b) 12 mA.

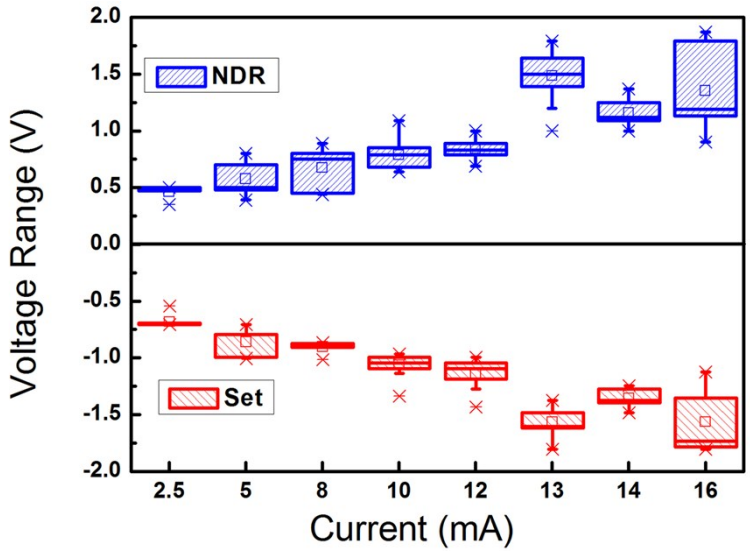


**Fig. S3** Box plots of distribution of "Set" voltages and NDR peak voltages under various CC levels (open squared dot within the box indicates the mean value; horizontal lines in the boxes represent 25, 50 and 75% of values; error bars indicate 1 and 99% of these values, while the upper and lower short lines outside the box stand for the min and the max values respectively.).

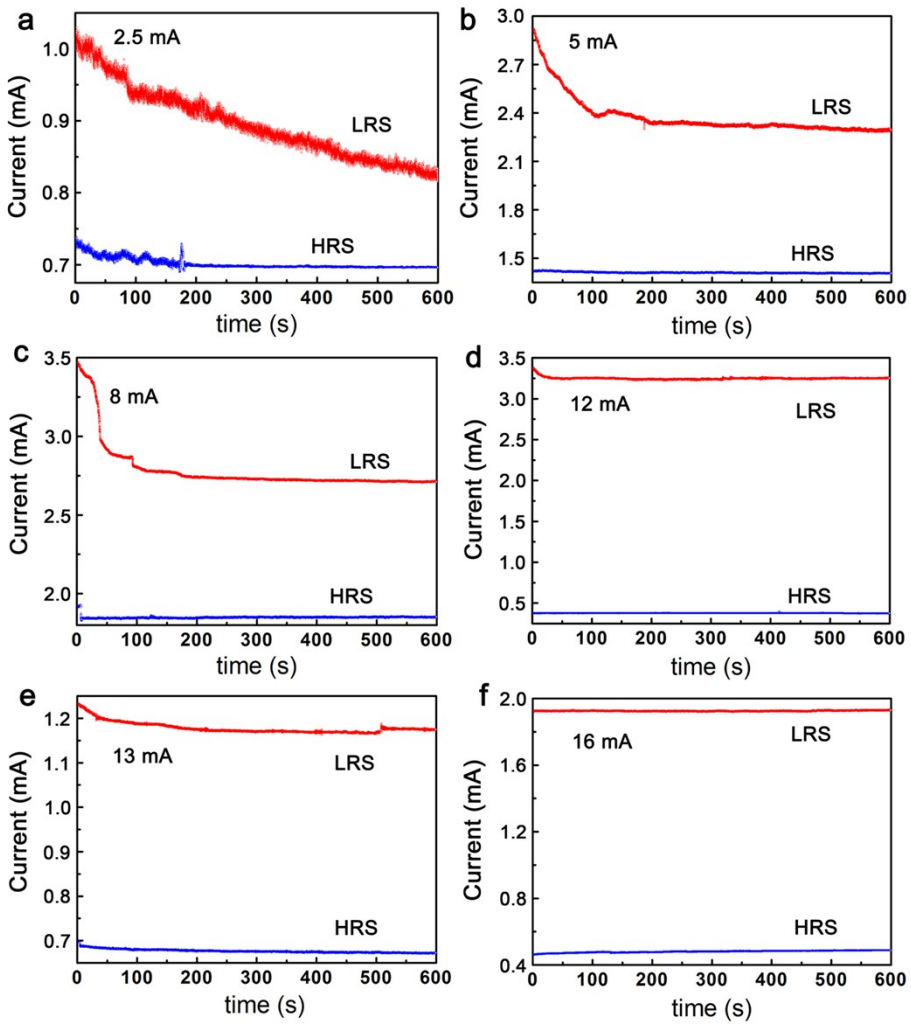


**Fig. S4** Current-time curves of HRS and LRS read at +0.5V under different CC levels: (a) 2.5 mA, (b) 5 mA, (c) 8 mA, (d) 12 mA, (e) 13 mA, (f) 16 mA.

**Preparation of α-$Fe_2O_3$ nanofilm**: 80 mmol/L $FeCl_3$ solution was prepared by dissolving $FeCl_3 \cdot 6H_2O$ in deionized water. FTO glass substrate was also pre-cleaned with acetone, followed by ethanol and water. The $FeCl_3$ solution was drop-deposited onto the FTO substrate and blow-dried with compressed air after 30 seconds. The dried FTO substrate was subsequently heated on a hotplate in air at 200 °C for 5 min. This deposition-annealing procedure is denoted as one "DA cycle". The film thickness was controlled by the number of DA cycles as well as the $FeCl_3$ precursor concentration. The as-prepared film was then further annealed in air at 550 °C for 4 hours (more details could be seen: *Nano Lett.*, 2011, 11, 3503). Such formed film was labeled as "α-$Fe_2O_3$ nanofilm".

**Characterization of α-$Fe_2O_3$ nanofilm**:

The top and side morphologies of the comparative α-$Fe_2O_3$ nanofilm were both shown in Fig. S5. It was fabricated by many irregular nanoparticles accumulated tightly. The average thickness of the film was about 400 nm. XRD patterns of such α-$Fe_2O_3$ nanofilm and nanorod film were contrasted in Fig. S6. Because the intensity of the strongest diffraction peak at 35.6º jumped largely, the preferential growth direction along with (110) plane of α-$Fe_2O_3$ should change. However, it was still well indexed to rhombohedral hematite (JCPDS 33-0664). So, the two films had the same crystal phase, but different microscopic morphologies.

The I-V tests were also conducted to the comparative α-$Fe_2O_3$ nanofilm under the same conditions with those in tests of α-$Fe_2O_3$ nanorod film. Although slight hysteresis of current during voltage sweeping was found, the relationship between current and voltage was consistent with exponential rule in semiconductor. It couldn't observe obvious "Set" process and NDR behavior in Fig. S7. The I-V curves were almost the same under different CC levels from 2.5 mA to 16 mA. It was possible due to the different microscopic structures which would give rise to various transport rules of carriers in transition metal oxides. It's interesting to find such difference between electrical features of the two α-$Fe_2O_3$ nano film, and the detailed study of the reason of such difference should be further discussed in the future. Here, we could

demonstrate that the I-V features of α-$Fe_2O_3$ film with various nanostructures cannot be conclude totally in one experiment, and the electrical characteristics of our α-$Fe_2O_3$ nanorod film is really distinctive.

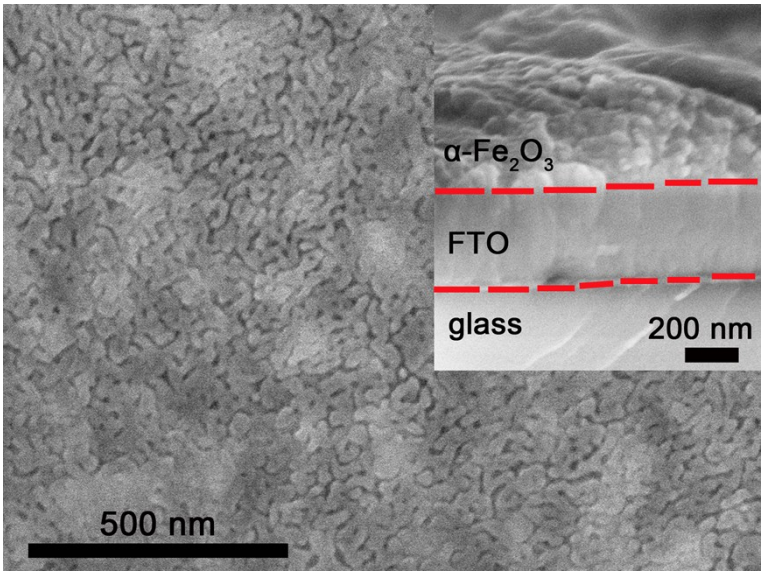


**Fig. S5** FESEM images of top and side (inset plot) morphologies of the comparative α-$Fe_2O_3$ nanofilm.

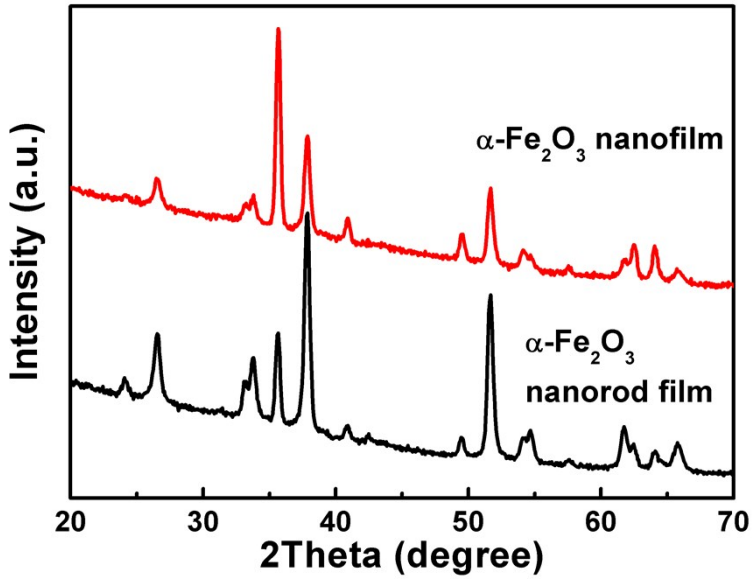


**Fig. S6** XRD patterns of α-$Fe_2O_3$ nanorod film and the comparative α-$Fe_2O_3$ nanofilm.

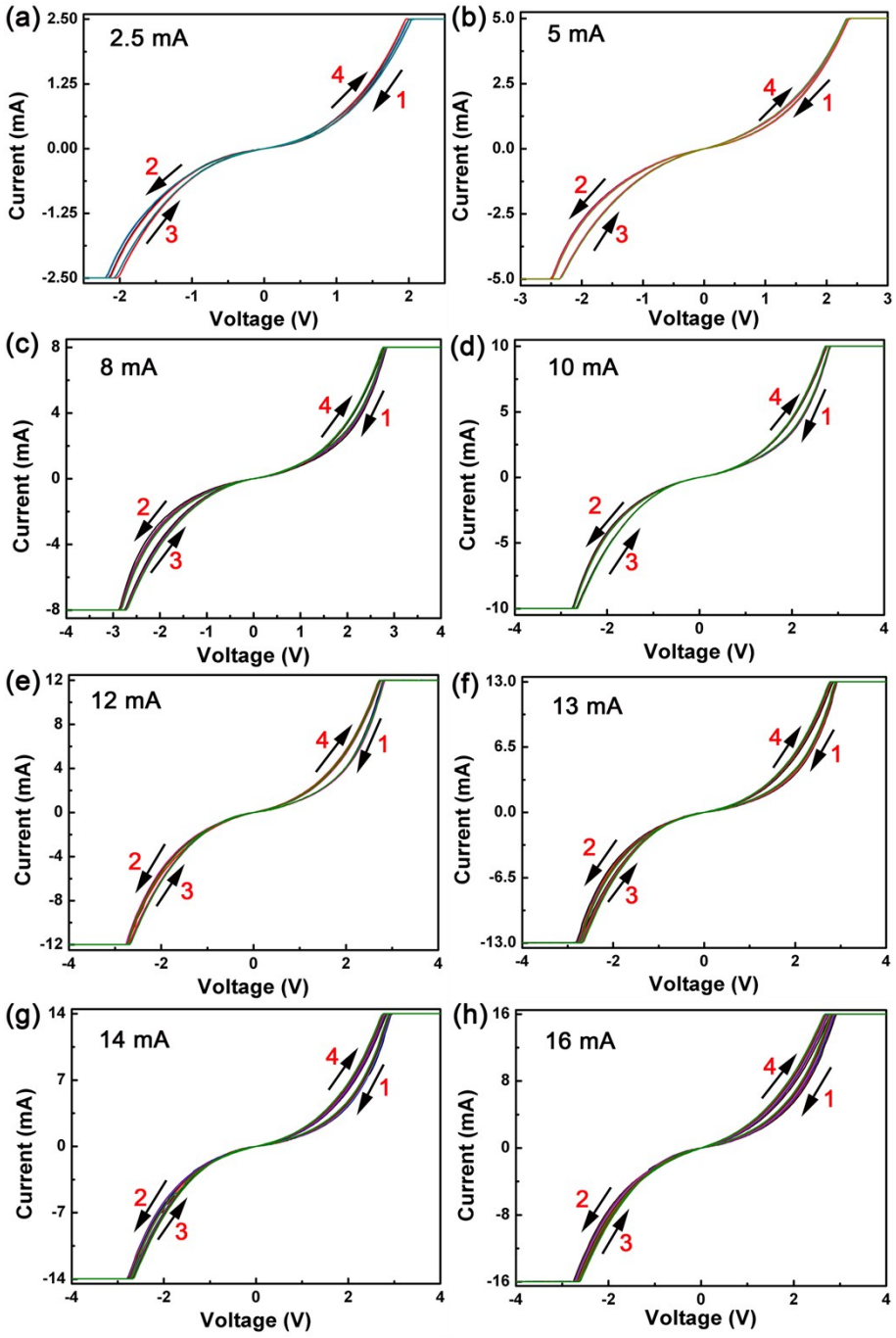


**Fig. S7** I-V tests of the comparative α-$Fe_2O_3$ nanofilm sweeping from $+V_{max}$ to $-V_{max}$ and then back to $+V_{max}$ under various CC levels: (a) 2.5 mA, (b) 5 mA, (c) 8 mA, (d) 10 mA, (e) 12 mA, (f) 13 mA, (g) 14 mA, (h) 16 mA.