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Supporting Information

Reversible Alternation between Bipolar and Unipolar Resistive Switching in Ag/MoS_2/Au Structure for Multilevel Flexible Memory

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Reversible alternation of resistive switching between different compliance currents (I_{CC}s of 7mA and 3mA). As shown in **Fig. S1**(a) and (c), the device can be switched from 7 mA I_{CC} operation to 3 mA I_{CC} operation and sustained each of LRS after 50 cycles (see Fig. S1 (b) and (d)).

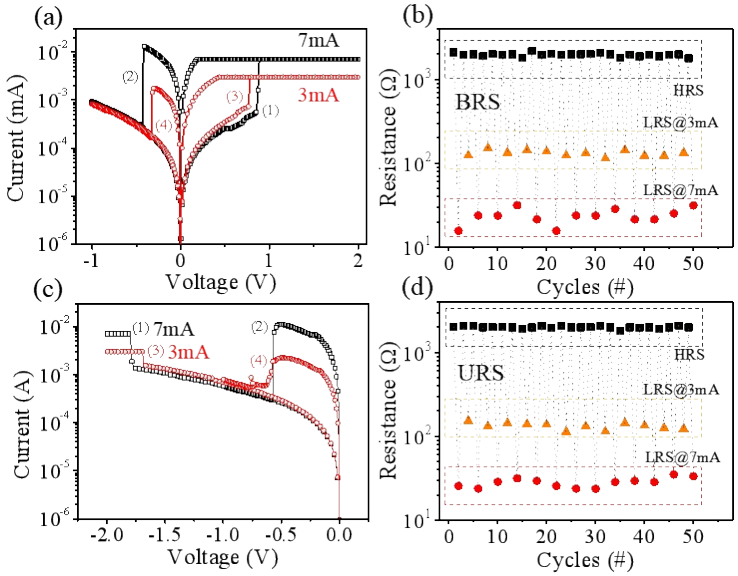

Fig. S1. I-V curves of Ag/MoS_2/Au memory with I_{CC} from 7mA to 3mA in (a) BRS and (c) URS modes. The HRS and LRS during cycling switching between these two I_{CC}s are presented in (b) and (d).

Measurement of the activation energy for Ag- and sulphur-migration in MoS_2. The activation energy values for Ag- and sulphur-migration were determined by measuring the switching time as a function of temperature in a pulse model. A

schematic diagram of the test circuit was presented in Fig. 3(a). The switching time can be estimated by the delay between "Input signal" and "Output signal" in the set process. More details on this test method can be found in previous works.[1,2] the switching time t decreased exponentially following the Arrhenius relation: [3]

$$t \propto \exp(-E_a / k_B T)$$

where E_a is the activation energy, k_B is the Boltzmann constant and T is temperature. As shown in Fig. S2, the activation energy for Ag- and sulphur-migration can be extracted from the slope of the Arrhenius plots as 0.58eV and 1.13eV, respectively.

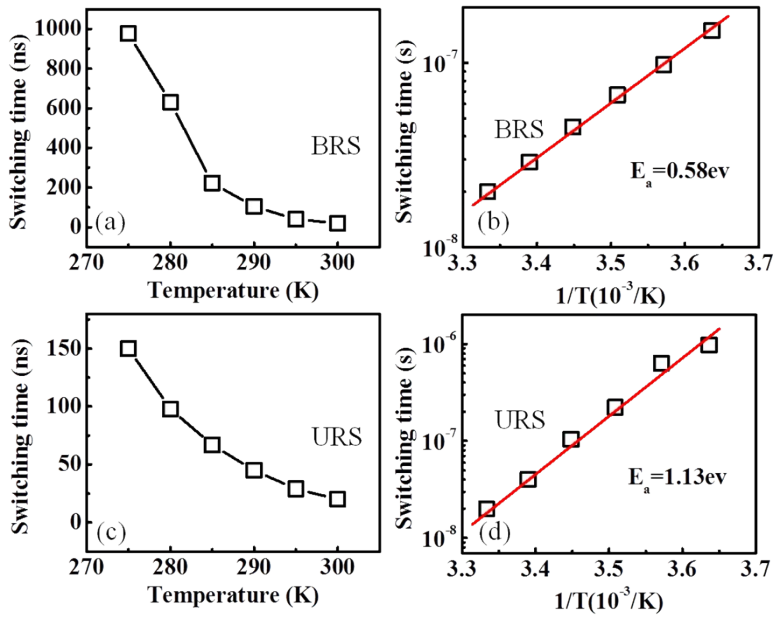

Fig. S2. Temperature dependence of the switching time for Ag/MoS_2/Au memory in (a) BRS and (c) URS mode. The Arrhenius plots and the extracted activation energy (E_a) values are shown in (b) and (d).

Temperature dependent LRS resistances of the memory at three different compliance currents (I_{CC}s of 3 mA, 5 mA, and 7 mA) in BRS and URS modes. As shown in Fig. S3, all LRSs display metallic-type conduction behavior in which resistance increase linearly with increasing temperature. Based on the linear fit to data points, the temperature coefficients (α) for U-LRSs are all 10 times smaller than that of B-LRSs, which further indicates that sulphur-migration and Ag-migration are responsible for URS and BRS modes at 3 different I_{CC}s. Note that α decreases for decreasing the I_{CC} in each of modes, which may be attributed to the reduction of the conductive filament size. The similar trend has also been observed in metal-oxides based RRAM in previous literatures. [4] It can be understood that as decreasing the

filament size, the temperature effect would fade (decreasing of α values) due to the arising of the size effect from surface diffuse scattering. [5] Therefore, it is believed that the conductive filament size is responsible for different LRS resistances at various I_{CC}s and this has also been reported in other reports. [6-7]

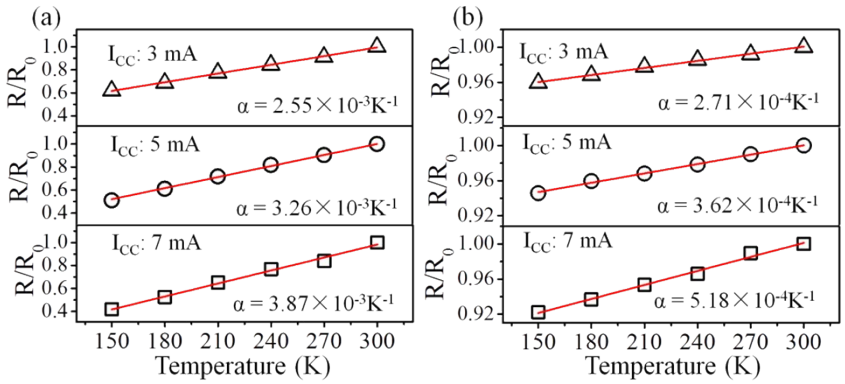

Fig. S3. Temperature dependent LRS resistances at three different compliance currents (I_{CC}s) in (a) BRS and (b) URS modes.

References

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