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Interface Engineering via MoS_2 Insertion Layer for Improving Resistive Switching of Conductive-Bridging Random Access Memory

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Research Topic

Conductive-bridging random access memory (CBRAM), dominated by conductive filament (CF) formation/rupture, has received much attention due to its simple structure and outstanding performances for nonvolatile memory, neuromorphic computing, digital logic, and analog circuit. However, the negative-SET behavior can degrade device reliability and parameter uniformity. And large RESET current increases power consumption for memory applications. By inserting 2D material, molybdenum disulfide (MoS_2), for interface engineering with the device configuration of Ag/ZrO_2/MoS_2/Pt, the negative-SET behavior is eliminated, and the RESET current is reduced simultaneously. With the ion barrier property of MoS_2, the CF can probably not penetrate the MoS_2 layer, thus eliminating the negative-SET behavior. And with the low thermal conductivity of MoS_2, the internal temperature of the device would be relatively high at RESET, accelerating probably redox reactions. As a result, the RESET current is reduced by an order of magnitude. This interface engineering opens up a way in improving the resistive switching performances of CBRAM, and can be of great benefit to the potential applications of MoS_2 in next-generation data storage.

Research Results

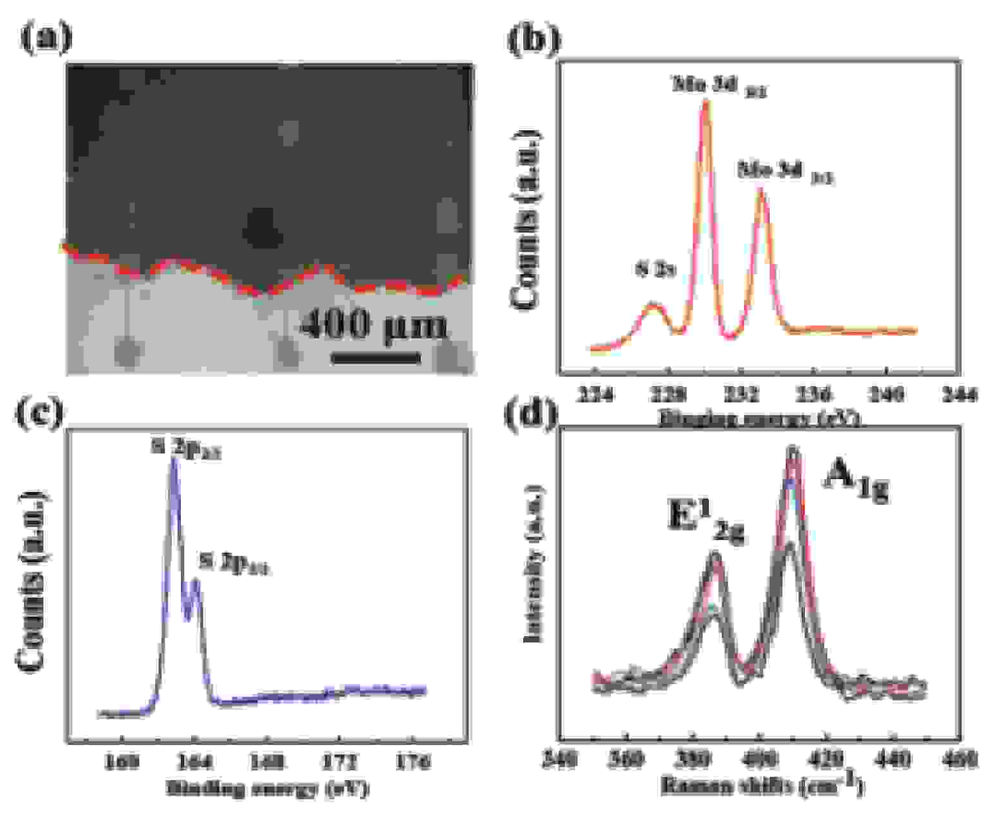
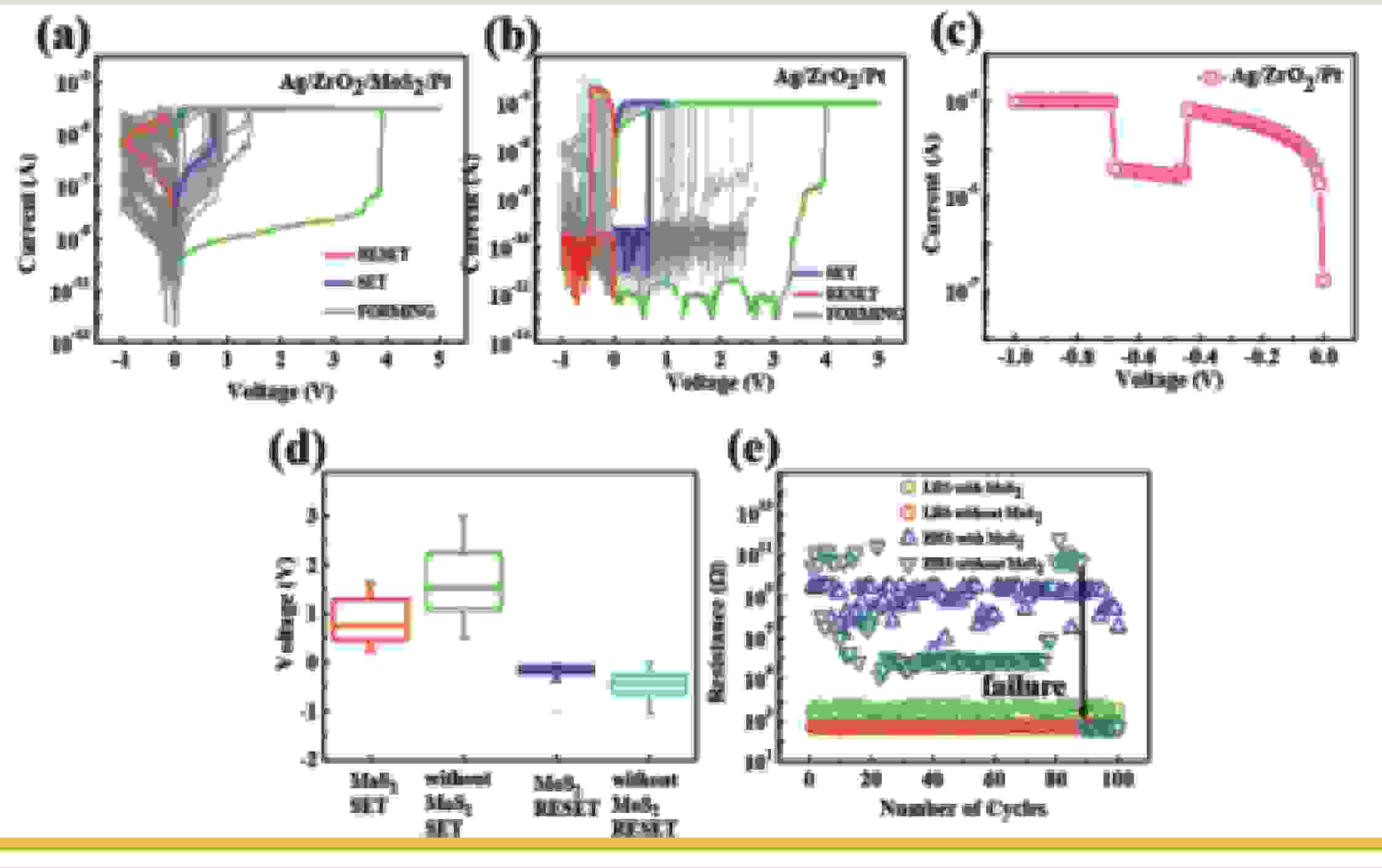


Figure 1. (a) SEM image of transferred MoS_2, in which the MoS_2 show consecutive film (dark region). The red dashed line is boundary. Scale bar is 400 µm. (b) The Mo 3d and S 2s and (c) S 2p XPS peaks of the transferred MoS_2, indicating no oxidation occurs. (d) MoS_2 Raman spectra of 6 positions, the characteristic peak position matches the data of ref [39] well.

Figure 2. Typical *I-V* curves of (a) the Ag/ZrO_2/MoS_2/Pt devices and (b) the Ag/ZrO_2/Pt devices. (c) Negative-SET behavior in the Ag/ZrO_2/Pt devices. (d) Statistical distributions of the SET and RESET voltages extracted from 10 switching cycles of 10 Ag/ZrO_2/Pt devices and 10 Ag/ZrO_2/MoS_2/Pt devices. (e) Endurance test of first 100 RS cycles under pulse mode (SET pulse (4 V, 500 ns), RESET pulse (−4 V, 500 ns) and read pulse (0.2 V, 500 ns)).



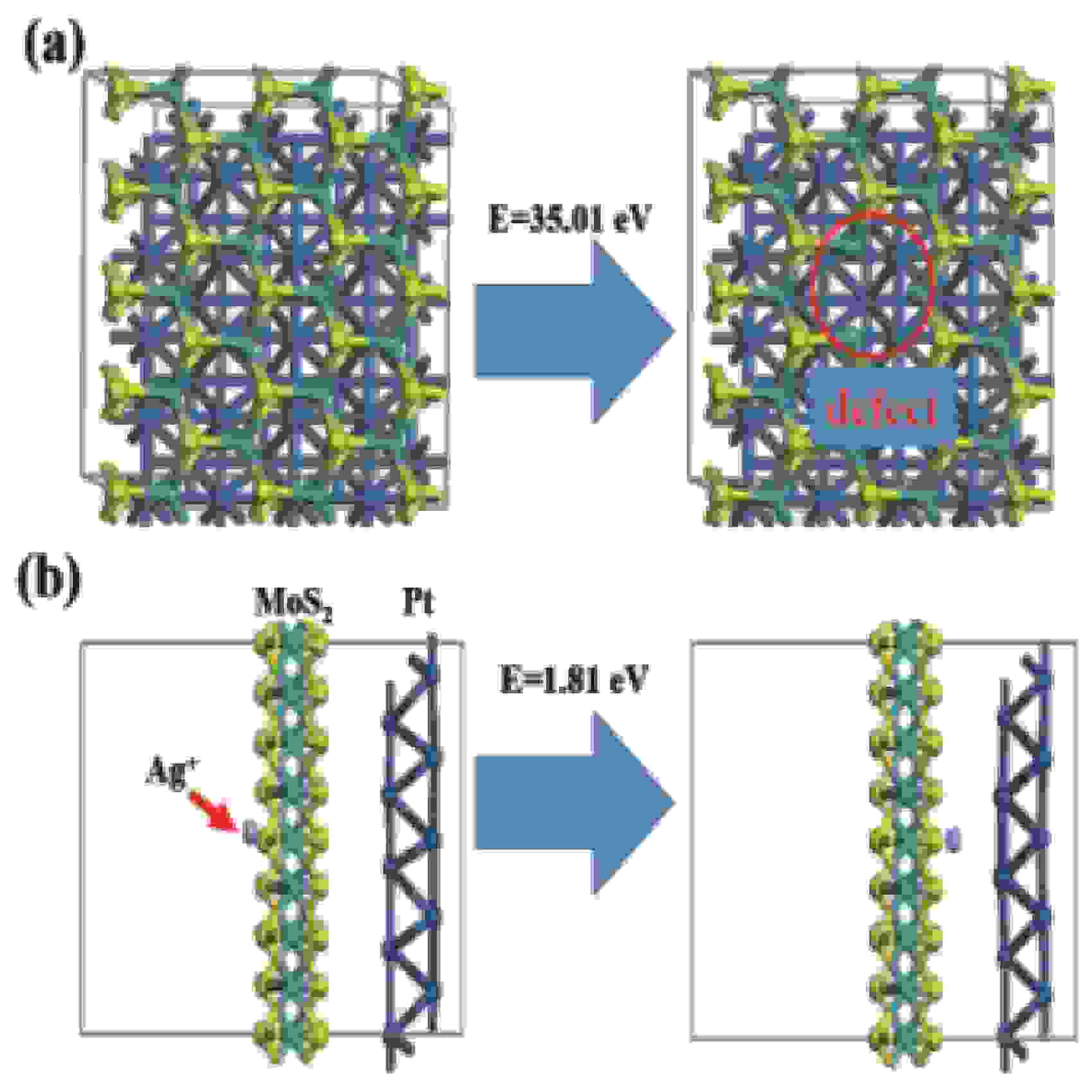


Figure 3. First principle calculation of the Ag migrating energy of penetrating single layer MoS_2. (a) The defect structure and defect formation energy of single layer MoS_2 lattice. (b) The energy of Ag penetrating single layer MoS_2 defect.

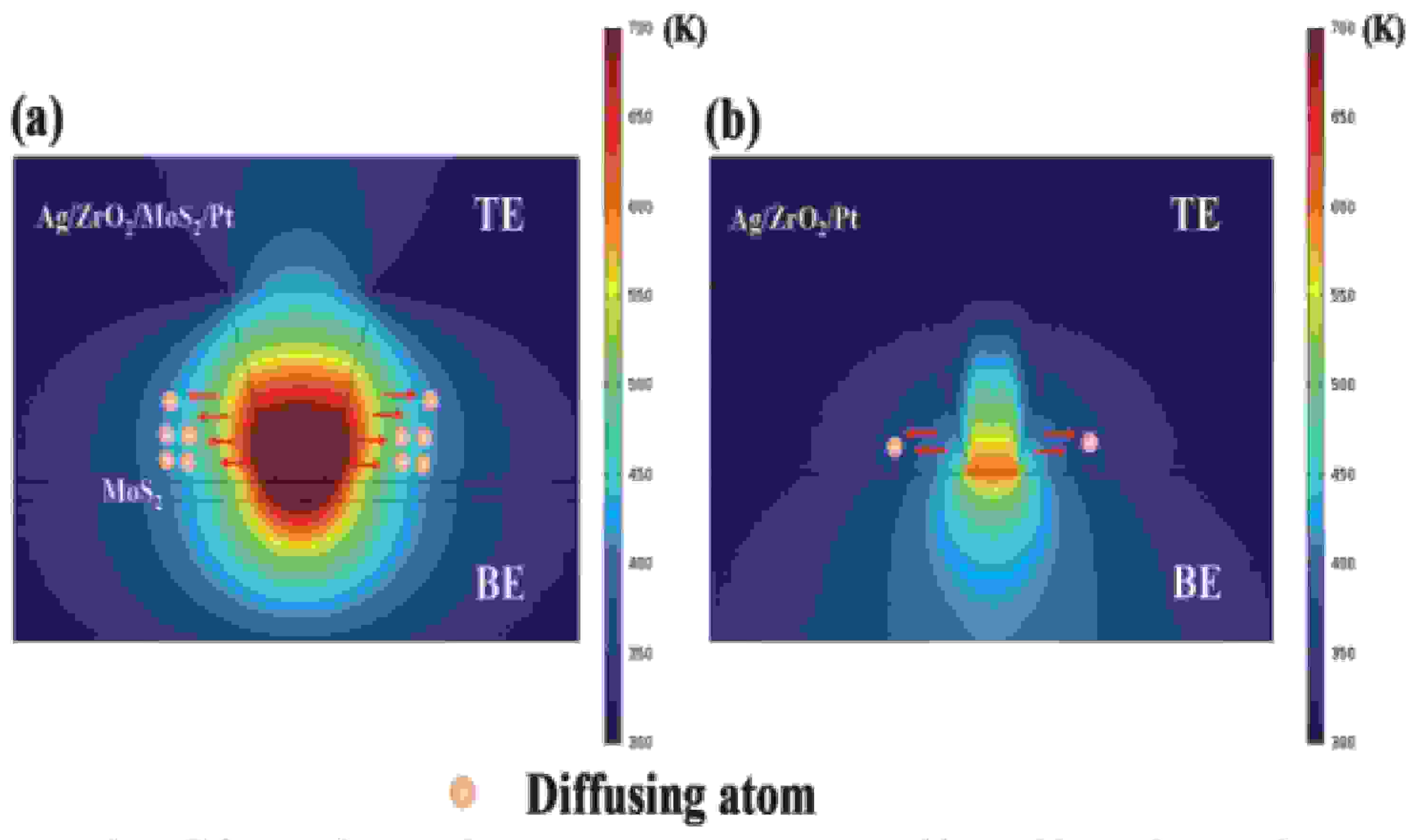


Figure 4. Simulated temperature distribution in RS region at LRS: (a) Ag/ZrO_2/MoS_2/Pt device and (b) Ag/ZrO_2/Pt device. With the MoS_2 interface engineering, the internal temperature is high.

Research Experience

Human society is entering the 5G era, and the era of big data challenges data storage. Therefore, I chose to devote myself to the next generation memory RRAM investigation, hoping to contribute a little to the progress of society. Although I have encountered many difficulties during my Ph.D. in National Chiao Tung University, I know that the road to scientific research is not smooth and I will continue to work hard with a positive and optimistic attitude. It is hoped that the commercialization of RRAM will be realized one day earlier, bringing convenience to human life.