ARTICLE

Resistance state evolution under constant electric stress on MoS_2 non-volatile resistive switching device†

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MoS_2 has been reported to exhibit resistive switching phenomenon in vertical metal-insulator-metal (MIM) structure and attracted much attention due to its ultra-thin active layer thickness. Here, the resistance evolutions at high resistance state (HRS) and low resistance state (LRS) are investigated under constant voltage stress (CVS) or constant current stress (CCS) on MoS_2 resistive switching devices. Interestingly, compared with bulk transition metal oxides (TMO), MoS_2 exhibit an opposite characteristic in the fresh or pre-RESET device at "HRS" that the resistance will increase to an even higher resistance after applying CVS, a unique phenomenon only accessible in 2D-based resistive switching devices. It is inferred that instead of at the highest resistance state, the fresh or pre-RESET devices are at an intermediate state with a small amount of Au embedded in the MoS_2 film. Inspired by the capability of both bipolar and unipolar operation, positive and negative CVS measurements are performed and show similar characteristics. In addition, it is observed that the resistance state transition is faster by using higher electric stress. Numerical simulations have been perfomed to study the temperature effect with small-area integration capability. These results can be explained by a modified conductive-bridge-like model based on Au migration, uncovering the switching mechanisms in the ultrathin 2D materials and inspiring future studies in this area.

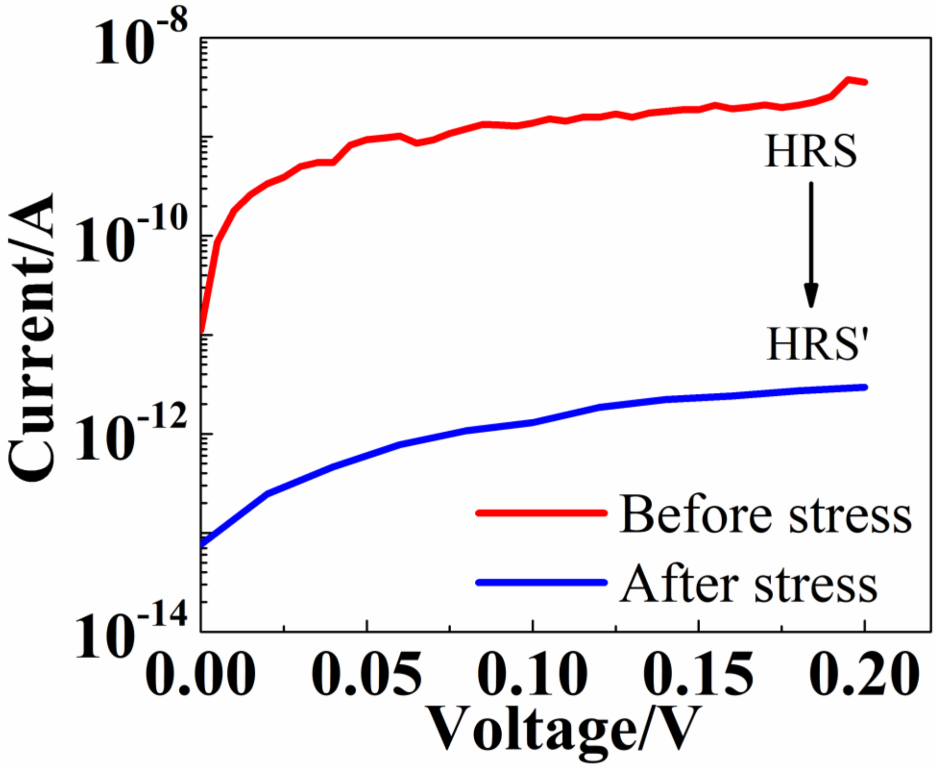

Fig. S1. READ I-V curves (to measure the device resistance at a low voltage) before and after CVS on working devices at HRS. It is shown that the device is switched from HRS to a higher resistance state (HRS') after applying CVS and this resistance state transition can be sustained without external stress.

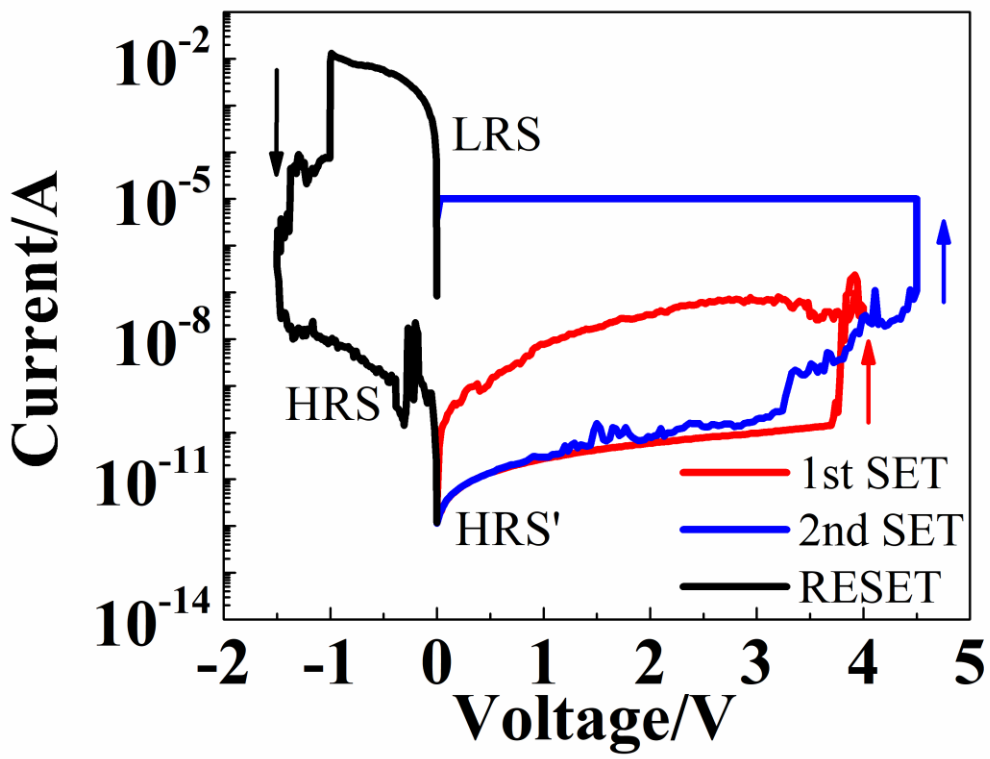

Fig. S2. Voltage-sweep switching I-V curves after CVS on working devices at HRS. The 1st SET curve starts from HRS' (consistent with the CVS result from HRS to HRS') and the device is switched to an intermediate state first at ~3.8V. Then, 2nd SET process shows that the device is switched from HRS' to LRS at higher voltage (~4.5V). It can be inferred that the intermediate state is not stable after the 1st SET. Subsequently, a negative voltage sweep is applied to the device and RESET the device to HRS. It is noted that the HRS after RESET is at the same level as the intermediate state after 1st SET process. This I-V switching curves after CVS test indicate that the device can still work after CVS treatment. By voltage sweeping, the device can be switched between LRS and HRS, while the higher resistance state (HRS') is achievable by CVS.

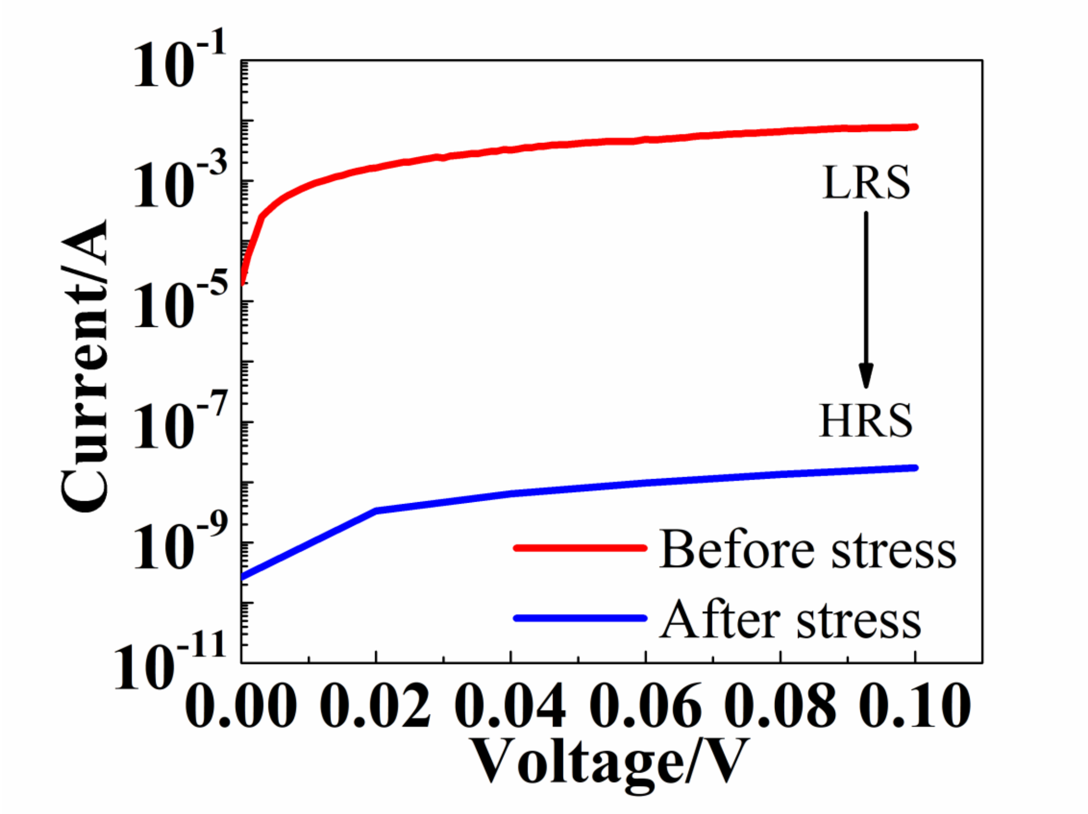

Fig. S3. READ I-V curves before and after CVS on working devices at LRS. It is shown that the device is switched from LRS to HRS after applying CVS and this resistance state transition can be sustained without external stress.

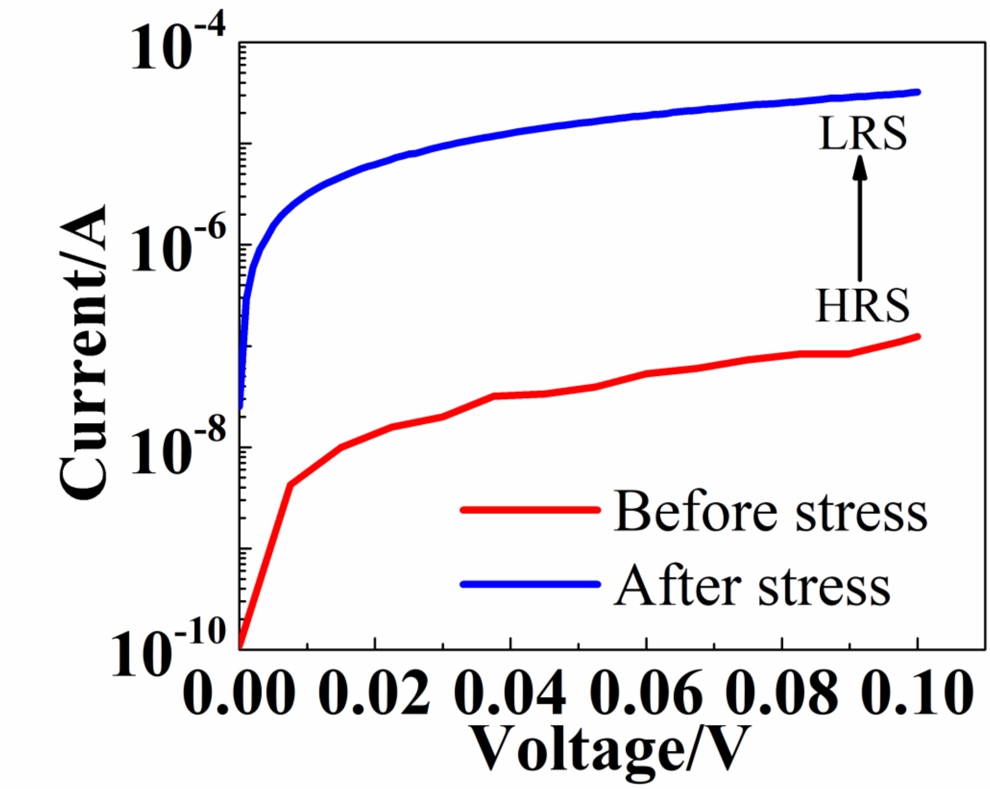

Fig. S4. READ I-V curves before and after CCS on working devices at HRS. It is shown that the device is switched from HRS to LRS after applying CCS and this resistance state transition can be sustained without external stress.