Grain boundaries driven bipolar resistive switching in multilayer hexagonal boron nitride

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During the last decade, the research of 2D material has attracted massive attention in the field of electronic devices due to their diverse advanced properties [1]. However, despite great progress has been achieved for the 2D metallic (graphene) and semiconductor (MoS_2, $MoSe_2$, BP etc...) materials, the research of 2D insulators, is still quite scarce. As one of the most promising 2D insulators, *h*-BN exhibits superior chemical stability, thermal conductivity and excellent thermal heat dissipation, qualities that are very attractive for building electronic devices [2]. Furthermore, its super flat surface and its enhanced reliability (compared to transitional transition metal oxides like HfO_2, Al_2O_3, *etc.*) are also very attractive dielectric properties necessary in real devices. [3]. In this work, we investigate one novel property of multilayer *h*-BN stacks: the presence of resistive switching (RS). We have fabricated Ti/*h*-BN/Cu resistive random access memory (RRAM) devices by growing the *h*-BN via chemical vapor deposition (CVD) on Cu, an top electrode patterning using an electron beam evaporator and a shadow mask. No transfer process is involved during the fabrication procedure, which greatly reduces the risk of the damage to the 2D material and polymer residues. Moreover, the use of experimental and non scalable techniques, such as electron beam lithography has been intentionally avoided [4]. When exposed to electrical stresses of different polarities, the devices showed reproducible RS. Cross-sectional transmission electron microscopy coupled with simultaneous electron energy loss spectroscopy indicates that RS is driven by the vertically aligned grain boundaries (GBs) in the CVD-grown stack, which can reversibly generate boron vacancies and attract metallic ions from adjacent layers, leading to the formation and disruption of a conductive filament. The I_{LRS}/I_{HRS}, the need of forming an the switching voltages can be tuned by simply modifying the *h*-BN stack thickness and grain size [5].

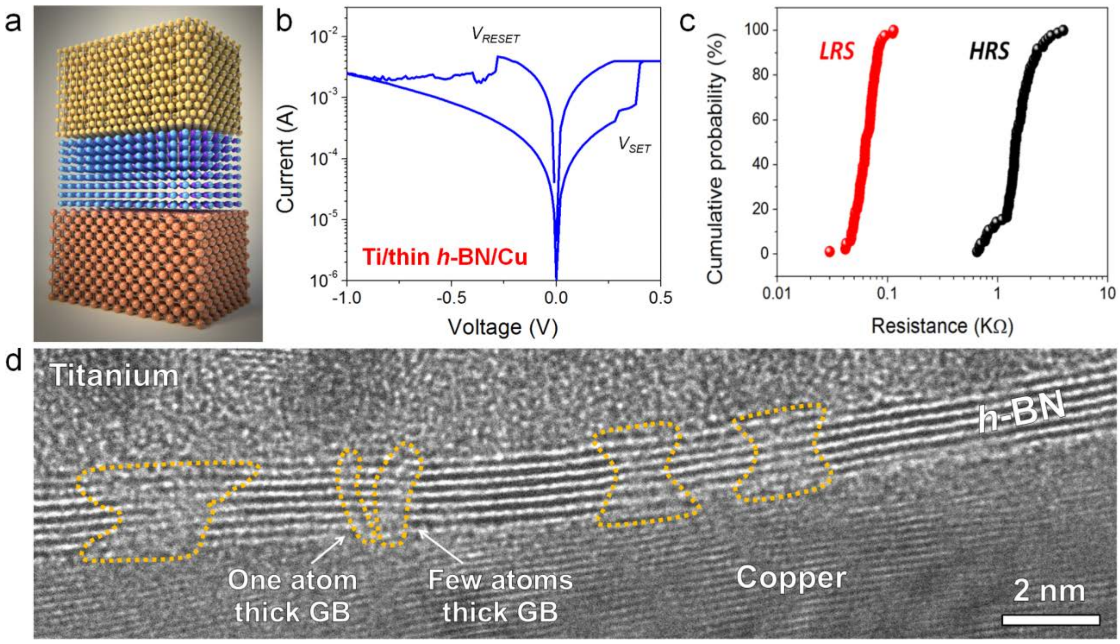

Figure 1. **a**, Schematic of the Ti/h-BN/Cu RRAM device. **b**, Typical I-V curves in a 100 µm x 100 µm device showing bipolar RS. **c**, Cumulative distribution of the resistance per cycle in HRS and LRS read at 0.1 V. **d**, Cross-sectional TEM image showing many atomically thin defective paths through *h*-BN.

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