Resistive Switching in oxide non-volatile electronique memories

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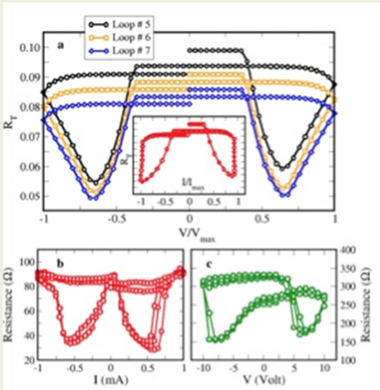
Resistive switching [RS] refers to the physical phenomena where a dielectric suddenly changes its (two terminal) resistance under the action of a strong electric field or current [1]. The change of resistance is non-volatile and reversible. Typical resistive switching systems are capacitor like devices, where the electrode is an ordinary metal and the dielectric a transition metal oxide (TMO). An important application of resistive switching is the fabrication of novel non-volatile resistive random-access memories (RRAM).

During the past few years of intense research a consensus has emerged on the notion that the phenomenology of RS phenomena in TMO can be roughly classified in two types, unipolar or bipolar memory effect. Unipolar systems are mainly simple binary TMO. Examples are NiO, CuO, CoO, Fe_2O_3 , HfO, $TiO_2Ta_2O_5$, Nb_2O_5. Bipolar resistive switching has been observed in a variety of ternary oxides with perovskite structure such as $SrTiO_3$ (STO), $SrZrO_3$, and also in more complex systems such as the 'colossal' magnetoresistive manganites LSMO, LCMO, PCMO, PLCMO, and even in cuprate superconductors YBCO and BSCCO.

The physical origin of the mechanism behind the resistive switching effect is still a matter of intense debate, and different groups have emphasized a variety of physical ingredients. In this context input from theoretical model is crucial. An early model of the RS effect in bipolar TMOs was proposed by Rozenberg et al. in 2004. More recently, we introduced a more advanced model [2], which incorporates many features whose relevance has been revealed in experiments. They include the inhomogeneous conductive paths, active regions near the interfaces forming Shottky barriers, and particularly, the role of oxygen vacancy migration.

One of the main successes of this model [2], as shown in the figure, is to capture a peculiar R-V characteristic, termed the "table with legs", which was experimentally observed in two different symmetric devices, one with a PLCMO dielectric and another with YBCO. This study provided strong support to the mechanism of electric-field-enhanced migration of oxygen vacancies at the nanoscale for bipolar type resistive switching and provided useful guidance for actual memory device implementations.



Resistance – Voltage characteristics. Top panel shows results from simulations with the model introduced in ref.[2]. The bottom panels show experimental results on a manganite PLCMO (left) and a cuprate YBCO (right) system.

[1] M. J. Rozenberg *"Resistive switching"*, Scholarpedia, 6(4) :11414 (2011)

[2] M. J. Rozenberg, M. J. Sánchez, R. Weht, C. Acha, F. Gomez-Marlasca, and P. Levy, *"Mechanism for bipolar resistive switching in transition-metal oxides"*, Phys. Rev. B 81, 115101 (2010).