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Two important physical models for resistance switching phenomena

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Resistance switching (RS) phenomena refer to reversible resistance changes between two metastable resistance states driven by an external voltage. Recently, there has been a flurry of investigations into RS due to their inherent scientific interest and potentials for memory applications. In spite of extensive efforts, the basic mechanisms of RS still remain to be elucidated. One of the reasons is that RS usually occurs in very dirty materials, where defects should play important roles. In this talk, I will present two models for RS phenomena, which are material independent and can be used to make quantitative predictions. The first model is for unipolar RS, where the corresponding current-voltage ($I-V$) curves are quite symmetric. We introduced a new kind of percolation model, called the random circuit breaker (RCB) network model, which allows reversible changes between two resistance states. This model can describe the formation of conducting channels due to dielectric breakdown and make quantitative predictions especially for scaling behaviors. We will show that collective behavior of conducting channels plays an important role in most aspects of unipolar RS, including the wide distribution of set and reset voltages, scaling behaviors, and large $1/f$ noise. The second model is for bipolar RS, where the corresponding $I-V$ curves are quite asymmetric. We introduced a quantitative model which can describe motion of mobile defects under electric field. We will show that oxygen vacancy migration near the interface region could determine important features of bipolar RS, including two switching directions of $I-V$ curves. We also showed that important aspects of these two models can be combined successfully in a unified scheme by putting interface effects into the RCB network model.