Electrochemical interfaces in redox-based resistive switching devices

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A potential leap beyond the limits of Flash (with respect to write speed, write energies) and DRAM (with respect to scalability, retention times) emerges from nanoionic redox-based switching effects encountered in metal oxides (*redox-based resistive random access memories*, **ReRAM**).

A range of systems exist in which ionic transport and redox reactions on the nanoscale provide the essential *mechanisms* for resistive switching. One class relies on mobile cations which are easily created by electrochemical oxidation of the corresponding electrode metal, transported in the insulating layer, and reduced at the inert counterelectrode (so-called **electrochemical metallization memories, ECM**). Another important class operates through the migration of anions, typically oxygen ions, towards the anode, and the reduction of the cation valences in the cation sublattice locally providing metallic or semiconducting phases (so-called **valence change memories, VCM**). The electrochemical nature of these memristive effects triggers a *bi*polar memory operation, showing an internal emf effect as well as a highly non-linear switching kinetics.

The physical process which may be the origin of this nonlinearity will be discussed. In general, several of these processes are present in a ReRAM device, but the kinetics is determined by the slowest one. Thus the rate-limiting process in a single ReRAM device can change depending on the electrical (applied voltage) and ambient conditions. The rate limiting processes can be (i) the ionic transport within the I-layer, (ii) an electron transfer reaction, which might occur at the MI-interface, (iii) a nucleation process prior to the formation of a new phase, and (iv) a phase transformation occuring in the I-layer.

The presentation will cover fundamental principles in terms of microscopic processes, switching kinetics and retention times, and device reliability of bipolar ReRAM variants.