UNDERSTANDING OXYGEN ANIONIC-ELECTRONIC DEFECTS UNDER HIGH ELECTRIC FIELDS: RESISTIVE SWITCHES DEVICES

Jennifer L.M Rupp, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
jennifer.rupp@mat.ethz.ch
Will Bowman, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Sören Boyn, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Roman Korobko, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Felix Messerschmitt, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Andreas Nenning, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Rafael Schmitt, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Sebastian Schweiger, ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland
Eva Sediva**,** ETH Zurich, Department of Materials, Electrochemical Materials, Switzerland

Nanoscale resistive switches (ReRAMs) were recently proposed as new class of non-volatile memories by switching non-linearly between low- and high-resistance values through application of voltage pulses in the ns-range. Through this paper we firstly introduce the topic of resistive switching oxides under high electric fields, their charge transport mechanism and often named memristive characteristics; and critically address open questions. In the second part we turn, to innovative new approaches in making of doped oxides and interface designs to novel device structures for oxide-based switches based on own results:

Here, we will firstly discuss a mixed anionic electronic conductor model experiment, being a Gd-doped ceria series with tuned doping concentration to affect the defect association and mobility of the oxide switching bits in a systematic manner. We find a clear correlation between concentration and mobility of oxygen ionic carriers and resistive switching response, and discuss those down to the changes in the near order structures connected therein.

Secondly, we exemplify the switching characteristics based on either compressively or tensely strained $Gd_{0.1}Ce_{0.9}O_{2-x}$ heterostructures modulated by Er_2O_3 or Sm_2O_3 layers, respectively, and discuss directly the device implication. Thereby, we present a new type of a model material device concept entitled "a strained ReRAM". Here, new material engineering of oxides beyond doping is discussed to control resistive switching device properties like retention, R_{off}/R_{on} ratios and power consumption by "interfacial strain engineering of mixed conducting oxide".

Thirdly, we grow nanoscopically-flat $LaFeO_3$ switching bits and demonstrate in a model experiment for amorphous and epitaxially grown films the implication of grain-boundary free but varying defect levels of the structures on resistive switching.

Fourthly, we turn to the role of electric field and frequency dependencies of $SrTiO_3$-based ReRAMs. Here, electrochemical impedance spectroscopy, cyclic voltammetry and chronoamperometry are used to investigate optimum operation concerning fast switching and stable retention with high resistance modulation. We show that two different switching mechanisms can be individually addressed depending on electric field strength and switching times. The "Memristor-based Cottrell analysis" is used to successfully determine diffusion constant characteristics of the materials and separating capacitive and memristive contributions.

Finally, we conclude on the role of oxygen anionic-electronic carriers and transfer for oxide-based switches, and discuss the applicability for bits and circuits of potential memory and logic applications.

References

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