DS 33: Focus session: Resistive Switching by Redox and Phase Change Phenomena IV (Kinetic in oxides and phase change)

Time: Wednesday 16:45–18:15 Location: CHE 89

DS 33.1 Wed 16:45 CHE 89

Evidence for power-dependent SET kinetics in valence change memories — •Stephan Menzel[1,2], Karsten Fleck[2,3], Ulrich Böttger[2,3], and Rainer Waser[1,2,3] — [1]Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Institut für Werkstoffe der Elektrotechnik II, RWTH Aachen University, Germany — [3]JARA - Fundamentals of Future Information Technology, Jülich, Germany

Resistively switching thin oxide films based on the valence change mechanism (VCM) have attracted great attention for the potential use in future nonvolatile information storage. The oxide thin film resistance can be tuned by applying appropriate voltages, where the different resistance state encodes the digital information. The VCM cell stack typically consists of Metal-Insulator-Metal structure, whereas the I-layer is a thin oxide layer, e.g. TiOx, HfOx, TaOx or SrTiOx. The resistance change is initiated by migration of ions such as oxygen vacancies within the oxide layer and a subsequent valence change in the cation sublattice. It takes place locally along nanoscale filaments within the I-layer. VCM cells exhibit a highly nonlinear switching kinetics which origins in the temperature accelerated drift of oxygen vacancies. In this paper switching kinetics data of SrTiOx based devices at varying ambient temperature are presented that cover >10 orders of magnitude in switching time. The switching kinetics data is analyzed using a multidimensional electro-thermal simulation model. It is demonstrated that the switching kinetics are driven by the electric power rather than the applied voltage or electric field. The electric power is dissipated as Joule heat that accelerates the ion movement.

DS 33.2 Wed 17:00 CHE 89

Memristive tunnel junctions — •Mirko Hansen, Martin Ziegler, and Hermann Kohlstedt — Nanoelektronik, Technische Fakultät, Christian-Albrechts-Universität zu Kiel, Germany

We present results on a device concept which consists of a tunnel barrier and a thin titanium oxide layer in between two metal electrodes. In our device, oxygen vacancies are supposed to be confined between the tunnel barrier and the top electrode. This limits the distance of the oxygen vacancy drift under an applied electric field to the thickness of the titanium oxide. We discuss results on junctions with the layer sequence $Nb/Al/Al_2O_3/TiO_{2-x}/TE$ and the influence of different top electrode (TE) materials. First electrical measurements indicate a homogenous change in resistance without the formation of a conductive filament. These samples were prepared on $4''$ wafers using standard optical lithography, (reactive) DC sputtering and reactive ion/wet etching.

DS 33.3 Wed 17:15 CHE 89

Doping and resistive switching effects induced by carrier injection in high temperature superconductors — •Irina Lazareva[1], Yilmaz Simsek[1], Yury Koval[1], Paul Müller[1], Sabine Wurmehl[2], Bernd Büchner[2], Tobias Stürzer[3], and Dirk Johrendt[3] — [1]Universität Erlangen-Nürnberg, Erlangen, Deutschland — [2]IFW, Dresden, Deutschland — [3]LMU, München, Deutschland

Doping by current injection was investigated in various high temperature superconductors. Only by injection of large currents along the c-axis we were able to change carrier concentration in $Bi_2Sr_2CaCu_2O_{8+\delta}$ cuprate as well as in $LaO_{1-x}F_xFeAs$ and $Ca_{10}(FeAs)_{10}(Pt_4As_8)$ pnictides. The doping effect is persistent and reversible resembling the resistive-memory switching phenomena observed in various oxides. The mutual influence of chemical doping and change of the charge carrier concentration by current injection is analyzed. The general tendency of carrier doping by trapped electrons is discussed.

DS 33.4 Wed 17:30 CHE 89

Optical and structural dynamics of the phase transition of GST phase change materials — •Lutz Waldecker[1], Timothy Miller[2], Roman Bertoni[1], Simon Wall[2], and Ralph Ernstorfer[1] — [1]Fritz-Haber-Institut der MPG, Berlin, Germany — [2]ICFO - Institut de Ciències Fotòniques, Castelldefels (Barcelona), Spain

The phase change material $Ge_2Sb_2Te_5$ (GST) exhibits large changes in its optical properties across the structural phase transition between its amorphous and crystalline phases. We investigate the transient behavior of the optical properties of GST after laser excitation below and above the threshold for persistent switching of the crystalline phase of the material by applying femtosecond transient reflectivity spectroscopy. In addition, we measure the electron-lattice coupling with time-resolved electron diffraction for separating electronic from structural contributions to the optical response. The combination of these two techniques allows for investigating the correlation between structure and function and addressing the question whether the phase transition is driven thermally or non-thermally.

DS 33.5 Wed 17:45 CHE 89

Ab initio molecular dynamics simulations of crystallization of AIST — •Wei Zhang[1], Ider Ronneberger[1], Peter Zalden[2,3], Martin Salinga[2], Matthias Wuttig[2,4], and Riccardo Mazzarello[1,4] — [1]Institute for Theoretical Solid State Physics, RWTH Aachen University, D-52056 Aachen, Germany — [2]I. Physikalisches Institut (IA), RWTH Aachen University, D-52056 Aachen, Germany — [3]School of Medicine, Stanford University, Stanford, CA 94305, USA — [4]JARA, RWTH Aachen University, D-52056 Aachen, Germany

Chalcogenide phase change materials (PCMs) are of great interest for both industrial applications and fundamental research, owing to their remarkable properties. The ultrafast switching capability between amorphous and crystalline state together with the pronounced property contrast between the two states has led to applications in optical data storage as well as electronic non-volatile memories. In this work, we investigate the fast crystallization process of Ag, In-doped Sb2Te (AIST) using ab initio molecular dynamics (AIMD). We find a good match between the computed growth velocities and recent time-resolved reflectivity measurements at high temperature (550K-600K), while large deviations are present at lower temperature. We suggest that the large deviations are due to the different quenching rates and the high fragility of AIST in the supercooled phase. Besides, we identify the role of impurities (Ag/In) in the crystallization process of AIST at high temperature.

DS 33.6 Wed 18:00 CHE 89

Ab initio metadynamics simulation of phase change materials — •Ider Ronneberger, Wei Zhang, and Riccardo Mazzarello — Institute for Theoretical Solid State Physics, RWTH Aachen University

The microscopic description of the fast crystallization mechanism of phase change materials (PCMs) at elevated temperatures remains a challenge to both experimentalists and theorists. The computational limitation of ab initio Molecular Dynamics (AIMD) simulations in terms of system size and time scale can be partly overcome by the aid of enhanced sampling methods such as Metadynamics (MTD), which accelerates the exploration of the phase space and extracts estimations of the free energy changes involved in the process of interest. We study the crystallization of prototypical PCMs by means of AIMD and Well-Tempered MTD. MTD is used to enforce the formation of supercritical crystalline nuclei. The growth of the nuclei is subsequently investigated in unbiased AIMD runs.