KR 11: SYRS: Symposium Resistive Switching (joint symposium DS, DF, KR, HL – Organizers: Gemming, Dittmann)

Time: Thursday 15:00–17:30 Location: H 0105

Invited Talk KR 11.1 Thu 15:00 H 0105

Redox-based resistive memories - recent progress — •Rainer Waser — Forschungszentrum Jülich, 52425 Jülich, and IWE2, RWTH Aachen University, 52056 Aachen, Section Fundamentals of Future Information Technology (JARA-FIT), Germany

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 (ReRAM). A range of systems exist in which ionic transport and redox reactions on the nanoscale provide the essential mechanisms for memristive switching. In two classes, the so-called electrochemical metallization memories, ECM, and the so-called valence change memories, VCM, the electrochemical nature of these memristive effects triggers a bipolar memory operation. In yet another class, the thermochemical effects dominate over the electrochemical effects in metal oxides (so-called thermochemical memories, TCM) which leads to a unipolar switching as known from the phase-change memories. In all systems, the defect structure turned out to be crucial for the switching process. The presentation will cover recent progress in understanding the fundamental principles in terms of microscopic processes, switching kinetics and retention times, as well as device reliability of bipolar ReRAM variants. Despite exciting results obtained in recent years, several challenges have to be met before these physical effects can be turned into a reliable industrial technology.

Invited Talk KR 11.2 Thu 15:30 H 0105

Electric Formation of Metal/$SrTiO_3$ Junctions and its Correlation to Multi-Dimensional Defects — •Dirk C. Meyer[1], Hartmut Stöcker[1], Juliane Hanzig[1], Florian Hanzig[1], Matthias Zschornak[1,2], Barbara Abendroth[1], and Sibylle Gemming[2] — [1]TU Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Str. 23, 09596 Freiberg — [2]Helmholtz-Zentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, Bautzner Landstr. 400, 01328 Dresden

Regarding the successful use of strontium titanate with different doping within resistive switching memory cells, the presence of crystallographic defects seems to be an important prerequisite. Standard explanations for resistive switching rely on the redistribution of oxygen vacancies, however, this motion can be enhanced or prevented by higher-dimensional defects. Intrinsic defects in crystalline $SrTiO_3$ include point defects such as oxygen or strontium vacancies, line defects, stacking faults like Ruddlesden-Popper phases and precipitates (TiO_2, SrO etc.). Electric formation of the metal/oxide/metal cells is widely used as an initial step to enable resistive switching, but the interaction of the multi-dimensional defects during this treatment remains questionable. This talk will present several measurements that were performed in situ, i.e. during the application of an electric field, to investigate the effects of the electric formation on the real structure.

Invited Talk KR 11.3 Thu 16:00 H 0105

The Connecting between the Properties of Memristive Material Systems and Application Requirements — •Thomas Mikolajick[1,2], Stefan Slesazeck[1], and Hannes Mehne[1] — [1]NaMLab gGmbH, Nöthnitzer Str. 64, 01187 Dresden — [2]Chair of Nanoelectronic Materials Technische Universitaet Dresden

In the last years large progress has been made to identify switching mechanisms in resistive switching materials and connect these to the materials systems used. The different switching mechanisms result in significantly different I-V characteristics of the switching behavior. As an example the switching can be bipolar or unipolar, abrupt or continuous etc. Additionally parameters like switching power, retention and endurance may show a characteristic fingerprint. In this talk the main mechanisms like thermo-chemical switching, valence change switching or electrochemical switching are compared to the requirements for different types of semiconductor memories like nonvolatile RAM, high density data memories or embedded memories and an assessment of the prospects of the different mechanisms for each system is given. Non-memory applications of memristive switching like xeromorphic circuits will also be taken into consideration.

Invited Talk KR 11.4 Thu 16:30 H 0105

Mechanism of resistive switching in bipolar transition metal oxides — •Marcelo Rozenberg — CNRS - LPS, Universite de Paris-Sud, 91405 Orsay, France

Resistive random access memories (RRAM) composed of a transtition metal oxide dielectric in a capacitor-like structure is a candidate technology for next generation non-volatile memory devices. We introduce a model that accounts for the bipolar resistive switching phenomenom observed in many perovskite transition metal oxides. The numerical study of the model predicts that strong electric fields develop in the highly resistive dielectric-electrode interfaces, leading to a spatially inhomogeneous distribution of oxygen vacancies and a concomitant non-volatile resistance memory effect. The theoretical results of the model are validated by successful comparison with non-trivial resistance hysteresis loops measured in cuprate YBCO and manganite PCLMO samples. Insights from the model simulations are used to propose a novel multi-level and non-volatile memory cell. We shall present results for an implementation of a 6-bit multi-leve memory cell device.

Invited Talk KR 11.5 Thu 17:00 H 0105

Resistive switching memories: Mechanisms, modeling and scaling — •Daniele Ielmini — Dipartimento di Elettronica e Informazione and IUNET, Politecnico di Milano, Piazza L. da Vinci 32, 20133 Milano, Italy

Resistive switching memory (RRAM) devices are proposed as next mainstream technology for nonvolatile memories below the 10-nm node. However, to speed up the industrial development of RRAM, the research must still address several open issues, such as identifying a suitable select device, understanding the switching mechanism and predicting the device scalability.

In this talk, I will show experimental results for bipolar RRAM devices based on metal oxides (mostly HfO_x), evidencing that the switching mechanism is a temperature and field-activated ion migration. Based on these experimental evidences, I will provide an analytical model for resistive switching which can be applied to oxide-based RRAM and chalcogenide-based conductive bridge RAM (CBRAM). The model allows for space, time and energy extrapolation for future RRAM generations. The extension of the analytical approach to a self-consistent numerical model for ion migration will be shown. The scaling tradeoff with reliability, e.g. random telegraph noise and data retention, will be finally discussed.