

## SYRS 3: Resistive switching I (jointly organized by DS, DF, KR, HL)

Time: Friday 9:30–10:45

Location: H 0111

SYRS 3.1 Fri 9:30 H 0111

**Ab-initio studies of metal-insulator transitions in defective perovskites** — ●GUSTAV BIHLMAYER and KOUROSH RAHMANIZADEH — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Resistive switching in perovskite materials can be triggered by a variety of external stimuli, like electric fields or oxygen partial pressure. While the role of oxygen defects for the electronic transport is in many cases established, the nature of the metal-insulator transition has still to be explored. Density functional theory calculations including strong correlation effects on a model level can help to gain an understanding here.

We investigate the transition between an insulating state of a correlated, localized level and a partially filled conductive band as function of electron concentration. The band filling can be controlled in a chemical way or via electric fields. A ferroelectric polarization can screen or enhance the effects at the boundaries of a ferroelectric material. We study the localization of defect states in model systems of structurally simple perovskites like SrTiO<sub>3</sub> or PbTiO<sub>3</sub> to gain a coherent picture of the conductive states that are manipulated in the resistive switching process.

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SYRS 3.2 Fri 9:45 H 0111

**Elucidation of the resistive switching in SrTiO<sub>3</sub> MIM-structures by  $\mu$ XANES** — ●CHRISTIAN LENSER<sup>1,2</sup>, ALEXEI KUZMIN<sup>3</sup>, ALEXANDR KALINKO<sup>3</sup>, JURIS PURANS<sup>3</sup>, RAINER WASER<sup>1,2,4</sup>, and REGINA DITTMANN<sup>1,2</sup> — <sup>1</sup>Peter Grünberg Institut 7, Forschungszentrum Jülich, 52425 Jülich, Germany — <sup>2</sup>Jülich-Aachen Research Alliance, Section Fundamentals of Future Information Technology (JARA-FIT), Germany — <sup>3</sup>Institute of Solid State Physics, University of Latvia, Kengaraga Street 8, LV-1063 Riga, Latvia — <sup>4</sup>Institut für Werkstoffe der Elektrotechnik, RWTH Aachen, 52056 Aachen, Germany

The resistive switching effect in Fe-doped SrTiO<sub>3</sub> thin films is investigated on 100  $\mu\text{m}^2$  metal-insulator-metal (MIM) structures by chemical mapping in the  $\mu\text{m}$  regime. X-ray absorption fine structure (XAFS) - measured at beamline ID03, ESRF - with a x-ray beam focused to several  $\mu\text{m}$  provides information about the absorption fine structure modulations at the Fe K-edge. The increase of pre-edge intensity characteristic of oxygen vacancies in the first coordination shell of the transition metal dopant shows the films to be highly oxygen deficient after growth. In addition to an increase of the Fe-V<sub>O</sub>•• concentration over the whole electrode area after electroforming,  $\mu\text{m}$ -sized mapping of a MIM-structure reveals the location of the conducting filament by a strong local change in the absorption edge, which is localized to a size of the order of 1  $\mu\text{m}$ . The change of the absorption characteristics is interpreted with full multiple-scattering XANES simulations, suggesting oxygen vacancy clustering around Fe as the likely explanation.

SYRS 3.3 Fri 10:00 H 0111

**A ferroelectric switchable tunnel junction: KNbO<sub>3</sub>/SrTiO<sub>3</sub>** — ●KOUROSH RAHMANIZADEH, GUSTAV BIHLMAYER, DANIEL WORTMANN, and STEFAN BLÜGEL — Peter Grünberg Institut (PGI-1) & Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The properties of thin oxide films and multilayers are strongly influenced by defects and, therefore, can be controllably tuned by the defect concentration at the interface. For example, due to the charge discontinuity at the SrTiO<sub>3</sub>/KO-KNbO<sub>3</sub>-NbO<sub>2</sub>/SrTiO<sub>3</sub> interface only one direction of polarization in KNbO<sub>3</sub> film is stable. A switchable polarization in KNbO<sub>3</sub> can be realized by creating (oxygen) defects at the interfaces.

We carried out density functional theory (DFT) calculations based

on the full potential linearized augmented planewave (FLAPW) method as implemented in the FLEUR code [1] for studying the polar interface SrTiO<sub>3</sub>/KNbO<sub>3</sub> and a SrRuO<sub>3</sub>/SrTiO<sub>3</sub>/KNbO<sub>3</sub> tunnel junction. The electronic transport properties of the switchable multiferroic SrRuO<sub>3</sub>/SrTiO<sub>3</sub>/KO-KNbO<sub>3</sub>-NbO<sub>2</sub>/SrTiO<sub>3</sub>/SrRuO<sub>3</sub> heterostructure have been investigated using an embedded Green-function approach [2]. A strong dependence of the (magneto electric) transport properties on the polarization is observed. The work was conducted under the auspices of the IFOX consortia under grant agreement NMP3-LA-2010-246102.

[1] <http://www.flapw.de>

[2] D. Wortmann, H. Ishida, and S. Blügel, PRB **66**, 075113 (2002)

SYRS 3.4 Fri 10:15 H 0111

**Resistive switching in different forming states of Ti/Pr<sub>0.48</sub>Ca<sub>0.52</sub>MnO<sub>3</sub> junctions** — ●CHANWOO PARK<sup>1</sup>, ANJA HERPERS<sup>1</sup>, RAINER BRUCHHAUS<sup>1</sup>, JOHAN VERBEECK<sup>2</sup>, RICARDO EGOAVIL<sup>2</sup>, FRANCESCO BORGATTI<sup>3</sup>, GIANCARLO PANACCIONE<sup>4</sup>, FRANCESCO OFFI<sup>5</sup>, and REGINA DITTMANN<sup>1</sup> — <sup>1</sup>PGI-7, FZ Jülich — <sup>2</sup>EMAT, University of Antwerp, Belgium — <sup>3</sup>ISMN-CNR, Bologna, Italy — <sup>4</sup>Laboratorio Nazionale TASC-INFN-CNR, Trieste, Italy — <sup>5</sup>CNISM and Dipartimento di Fisica, Università Roma Tre, Rome, Italy

We investigated the resistive switching (RS) characteristics of Ti/Pr<sub>0.48</sub>Ca<sub>0.52</sub>MnO<sub>3</sub> (PCMO) junctions. RS characteristics were observed after a first forming (1stF) procedure, which changes the initial resistance state to a high resistance state (HRS) which shows a clear area dependence. By performing Hard X-ray Photoelectron Spectroscopy for different resistive states, we found a change of the Ti2p peak intensity after the 1stF which is associated with the formation of TiO<sub>2</sub> at the interface. Moreover, the shape and position of the Mn2p peak hints on the reduction of Mn. The formation of TiO<sub>x</sub> at the Ti/PCMO interface after the 1stF was confirmed by cross-sectional Transmission Electron Microscope investigations. The results indicate that the 1stF step is related to a redox process at the Ti/PCMO interface. Moreover, we were able to perform a second forming step which changes the HRS to the low resistance. The area dependence disappeared after the second forming. This implies that conducting filaments might form at the Ti/PCMO interface.

SYRS 3.5 Fri 10:30 H 0111

**Remanent resistance changes in metal-PrCaMnO-metal sandwich structures** — ●MALTE SCHERFF, BJOERN MEYER, JULIUS SCHOLZ, JOERG HOFFMANN, and CHRISTIAN JOOSS — Institute of Materials Physics, University of Goettingen, Germany

The non-volatile electric pulse induced resistance change (EPIR) seems to be a rather common feature of oxides sandwiched by electrodes. However, microscopic mechanisms are discussed controversially. We present electrical transport measurements of sputtered Pr<sub>0.7</sub>Ca<sub>0.3</sub>MnO<sub>3</sub> films sandwiched by metallic electrodes with variation of electrode materials, device geometry and PCMO deposition parameters. Cross-plane transport measurements have been performed as function of temperature and magnetic field. Specifically, the transition from dynamic resistance changes due to non-linear transport to remanent switching is analyzed. By analyzing changes of magneto-resistance at low temperatures in different resistance states we aim for separation between interface and film contributions to switching. Comparing switching behavior in symmetric and asymmetric electrode configuration allows for identification of the active, single interface in the switching process and the origin of an observed switching polarity inversion[1]. The influence of excitation field and power on the switching characteristics of different noble metal electrodes is discussed. Samples from macroscopic devices and in situ stimulated sandwich structures were studied in a transmission electron microscope in order to investigate the induced structural, chemical and electronic changes. [1] M. Scherff et al, J.Appl.Phys. 110, 043718 (2011)