Thin Films and Coatings

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Influence of persistent resistance changes on structure and chemical composition of metal-$Pr_{1-x}Ca_xMnO_3$-metal thin film heterostructures observed by TEM techniques

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Resistive switching phenomena are observed in many metal-oxide-metal thin film heterostructures. Application of an external voltage of the order of one volt between the facing metallic top and bottom electrode can change the initial virgin state resistance (VS) of the heterostructure to a high resistance (HRS) or a low resistance state (LRS). The induced resistance change is persistent, i.e. the HRS or LRS remains after removing the applied bias. In order to microscopically explain the resistance changes, various models have been proposed, e.g., Mott transitions, Schottky barrier effects, trapping controlled space charge limited currents, or electro-chemical effects related to migration of oxygen cation vacancies.

We will show investigations of structural and chemical responses on electrical stimulation corresponding to different resistance states. For this purpose we use a FEI Titan 80-300 ETEM which has just been successfully installed. It is equipped with an imaging aberration corrector and a high-resolution Gatan Imaging Filter (GIF), allowing experiments with sub-1Å resolution. The monochromator enables spectroscopy with 0.2 eV energy resolution. This allows high resolution TEM, selected area diffraction or scanning TEM images for structural analysis as well as electron energy loss spectrometry (EELS) and energy filtered transmission electron microscopy (EFTEM).

We have selected the colossal resistance manganite $Pr_{1-x}Ca_xMnO_3$ (PCMO) sandwiched by precious metal electrodes (Pt, Au, Ag) or niobium doped $SrTiO_3$ (Nb:STO) as a model system for resistive switching. From the viewpoint of bulk properties, PCMO belongs to the class of perovskites, where the interplay of electron-electron, magnetic exchange and electron-phonon correlations gives rise to the formation of a rich variety of different structural and electronic phases.