



	Experiment title: Current-driven metal-insulator transition in Cr-doped SrTiO₃	Experiment number: HE-1623
Beamline: ID26	Date of experiment: from: 4-12-2003 to: 9-12-2003	Date of report: 18-2-2004
Shifts: 15	Local contact(s): Dr. T. Neisius	<i>Received at ESRF:</i>
Names and affiliations of applicants (* indicates experimentalists): Dr. G.I. MEIJER* and Dr. J.G. BEDNORZ IBM Research, Zurich Research Laboratory, CH-8803 Rueschlikon Dr. U. STAUB* and Dr. M. JANOUSCH Paul Scherrer Institute, Swiss Light Source, CH-5232 Villigen PSI		

Electronic charge localization in 3d transition-metal oxides has attracted considerable interest in the past. These localization phenomena, which lead to metal-insulator transitions, play a crucial role in such materials as high- T_c cuprates and giant magneto-resistive manganites. Recently, we have found a current-driven insulator-metal transition with a memory effect in SrTiO₃ with 0.2 mol% Cr doping [1]. We speculated that the transition is occurring due to a change in valency of the Cr dopant from Cr³⁺ to Cr⁴⁺ or Cr⁵⁺, thereby providing free carriers that induce the insulator-metal transition.

To gain more information on the role played by the valence state of Cr, we have collected X-ray absorption near edge structure (XANES) data on an electrically formed Cr-doped SrTiO₃ crystal, in which a current pulse can switch the electronic states between high resistance and low resistance and vice versa, and on Cr-doped SrTiO₃ standards (H₂ and O₂ annealed).

Fig. 1 shows the XANES of the Cr K-edge of the Cr-doped SrTiO₃ crystals annealed in H₂ and O₂ (standards). A clear difference in the Cr XANES and correspondingly in the Cr valence is observed. The absence of a strong pre-edge gives evidence that the Cr ions are not tetrahedral coordinated but rather found in an octahedral environment. This indicates that Cr is just replacing Ti without strongly affecting the local structure. Comparison with Cr valence standards LaCrO₃, Sr₂CrO₄, and SrCrO₄ indicated that the valency of Cr in H₂ and O₂ annealed Cr-doped SrTiO₃ is 3+ and 5+, respectively.

Fig. 2 shows the Cr K-edge XANES spectra of the electrically formed crystal which is in the metallic state. The XANES spectra in the gap between the electrical contacts and in the region below the cathode are similar to that of the H₂ annealed crystal (Figs. 2b and 2c).

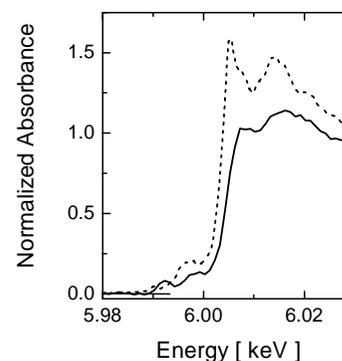


FIG. 1. Cr K-edge XANES of Cr-doped SrTiO₃ annealed in H₂ (dashed line) and O₂ (solid line).

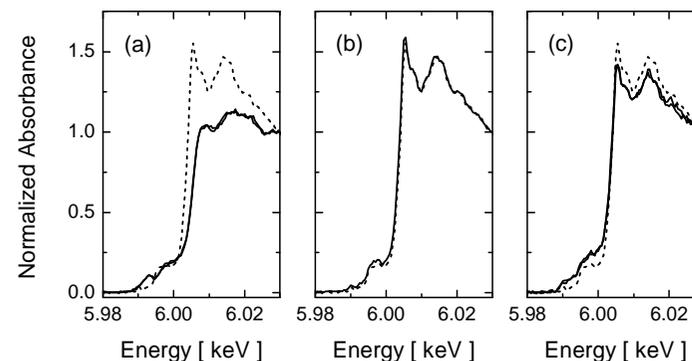


FIG. 2. K-edge XANES of Cr-doped SrTiO₃ after electrical forming at different positions on the electrodes and in the gap between the electrodes; (a) on the anode, (b) in the gap between the electrodes, (c) on the cathode. The dashed lines are XANES spectra of Cr-doped SrTiO₃ before electrical forming.

A significant change of the Cr K-edge XANES is observed below the anode. The XANES is essentially identical to that found for the oxidized crystal (Fig. 2a). This supports the idea that the current induced insulator transition is caused by the internal doping due to a change of the Cr valence states from 3+ to 5+ [2].

[1] Y. Watanabe, J. G. Bednorz, A. Bietsch, Ch. Gerber, D. Widmer, A. Beck, and S. J. Wind, Appl. Phys. Lett. **78**, 3738 (2001).

[2] G. I. Meijer, U. Staub, J.G. Bednorz, M. Janousch, and T. Neisius, unpublished.