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MASS AND CHARGE TRANSPORT PROPERTIES OF Fe-DOPED $SrTiO_3$ THIN FILMS AND THEIR DEPENDENCE ON DC VOLTAGE

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Introduction

On the one hand, $SrTiO_3$ acts as a kind of model material for defect chemical investigations of perovskite-type materials with large band gap. On the other hand, $SrTiO_3$ thin films recently became highly important for application in memristors, i.e. in resistive switching devices. There, field driven defect motion is suggested to play a key role in the switching process [1]. Therefore it is of high relevance to understand defect chemistry in such films, including defect chemical changes under applied DC field.

In this work, the first aim was to analyze DC voltage effects in $SrTiO_3$ thin films by using bias dependent impedance spectroscopy. The second aim was to compare conductivity data from the electrical measurements with the results obtained from ^{18}O tracer experiments.

Experiments

The investigated Fe-doped $SrTiO_3$ thin films were deposited via pulsed laser deposition (PLD). For the electrical part of the experiments a conductive substrate (Nb-$SrTiO_3$) was used. Micro-structured, oxygen permeable LSC ($La_{1-x}Sr_xCoO_{3-\delta}$) electrodes on top of the layers allowed numerous impedance measurements perpendicular to the surface of one and the same layer (see Fig. 1).

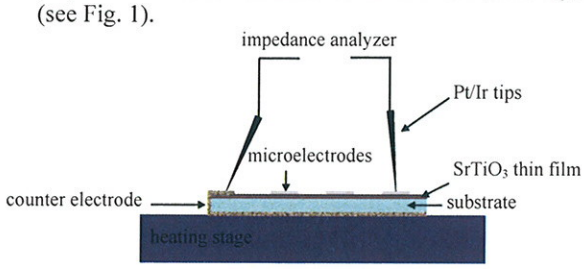

Fig. 1 Experimental set-up for across-plane measurements

Layers with different thicknesses were characterized in a temperature range of 450°C to 650°C and for bias voltages up to a few 100mV. In order to take micro-structural effects into account, samples were also analyzed after a heat-treatment at 920°C.

In addition to the impedance measurements the ionic mass transport was investigated by thermally induced ^{18}O tracer diffusion experiments and subsequent secondary ion mass spectrometry (SIMS) [2]. For these tracer experiments $SrTiO_3$ layers were deposited on different substrates (Al_2O_3, $LaAlO_3$ and Nb-$SrTiO_3$ single crystals).

Results and Discussion

(1) Electrical measurements

The $SrTiO_3$ layers showed two partly overlapping arcs in the complex impedance plane (see Fig. 2). Both arcs are characterized by very reproducible and asymmetric bias dependence.

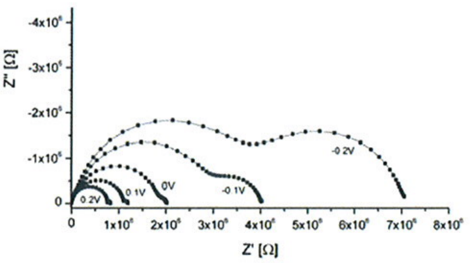

Fig. 2 Bias dependent behavior of the $SrTiO_3$ thin films at 484.6°C

The resistance and the capacitance of the high and the low frequency part were evaluated, including characteristic time dependences to reach steady state condition. It is discussed how far the bias dependent response of the layer is due to Wagner-Hebb polarization of the material, i.e. stoichiometry polarization using an ion blocking electrode, and thus how far a determination of partial conductivities is possible.

(2) ^{18}O tracer diffusion experiments

The ^{18}O tracer diffusion profiles showed a reproducible sharp concentration drop close to the surface, indicating a near-surface space charge layer. The dependence of profiles on substrate, temperature and pre-annealing time is discussed.

The evaluated tracer diffusion coefficients D* are compared with the results from the electrical measurements.

Conclusion

Correlation of bias-dependent impedance measurements, using ionically reversible LSC electrodes and tracer diffusion studies, allows a detailed analysis of transport properties of $SrTiO_3$ thin films and clarifies effects of applied DC voltage.

References

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