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In situ Examination of Lanthanum Strontium Manganate (LSM) with Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS)

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YSZ (yttria stabilized zirconia) and perovskite-type (La,Sr)MnO_3 are widely used as electrolyte and cathode materials in SOFCs (solid oxide fuel cells) [1]. Despite of intensive research [2] there still exist a lot of open questions regarding the system YSZ/LSM/O_2. These include morphological changes such as degradation or delamination of the electrode under cathodic and anodic polarization and a possible change of the compound (*e.g.*, decomposition, segregation) under electrochemical polarization, and thereby, a variation of the electrochemical behaviour of the cell.
In the present work the surface composition of the cathode under various oxygen pumping conditions at approximately 500 °C and an oxygen partial pressure of $p(O_2) = 5 \times 10^{-7}$ mbar are analyzed by XPS (X-ray photoelectronspectroscopy), PEEM (photoelectron emission microscopy) and SIMS (secondary ion mass spectroscopy). Therefore, we designed a cathode model system via PLD (pulsed laser deposition). The morphology and structure of the model electrode were characterized by HREM (high resolution scanning electron microscopy), AFM (atomic force microscopy) and via XRD (X-ray diffraction).

SIMS measurements performed during heat treatment under ultra high vacuum conditions show the decomposition of the LSM at the LSM/YSZ interface even without polarization. Mn diffuses onto the YSZ surface and Sr accumulates at the three phase boundary between electrolyte, electrode and gas phase. By applying an electrical potential, either cathodic or anodic, direct diffusion processes take place. Depending on the applied potential we found either enrichment or depletion of Mn on the LSM.
With a specially designed sample holder for our ToF-SIMS 5 (ION-TOF GmbH, Münster) we are able to investigate in situ the diffusion process of the different species at elevated temperatures. Heating up to a certain temperature and then cooling down the samples quickly inside the ToF-SIMS vacuum chamber allows the investigation of the elemental distributions of Sr, Mn, La, Y and Zr on the surface as they are at elevated temperatures.

As an additional possibility, samples can be polarized inside the chamber. The combination of heating and polarization with the advantage of immediate ToF-SIMS investigations allows a closer look at the processes taking place at the surface, the three phase boundary and the electrolyte surface.

The opportunity to investigate the electrode processes and elemental diffusion processes *in situ* instead of *ex situ* measurements with several investigation methods helps to understand more of the underlying reactions at the three-phase-boundary.

Fig. 1 shows an exemplary ToF-SIMS image of the three phase boundary of an LSM electrode on a YSZ (111) oriented sample. The whole sample was split into four smaller samples which were annealed for different times [3] without electrochemical polarization.

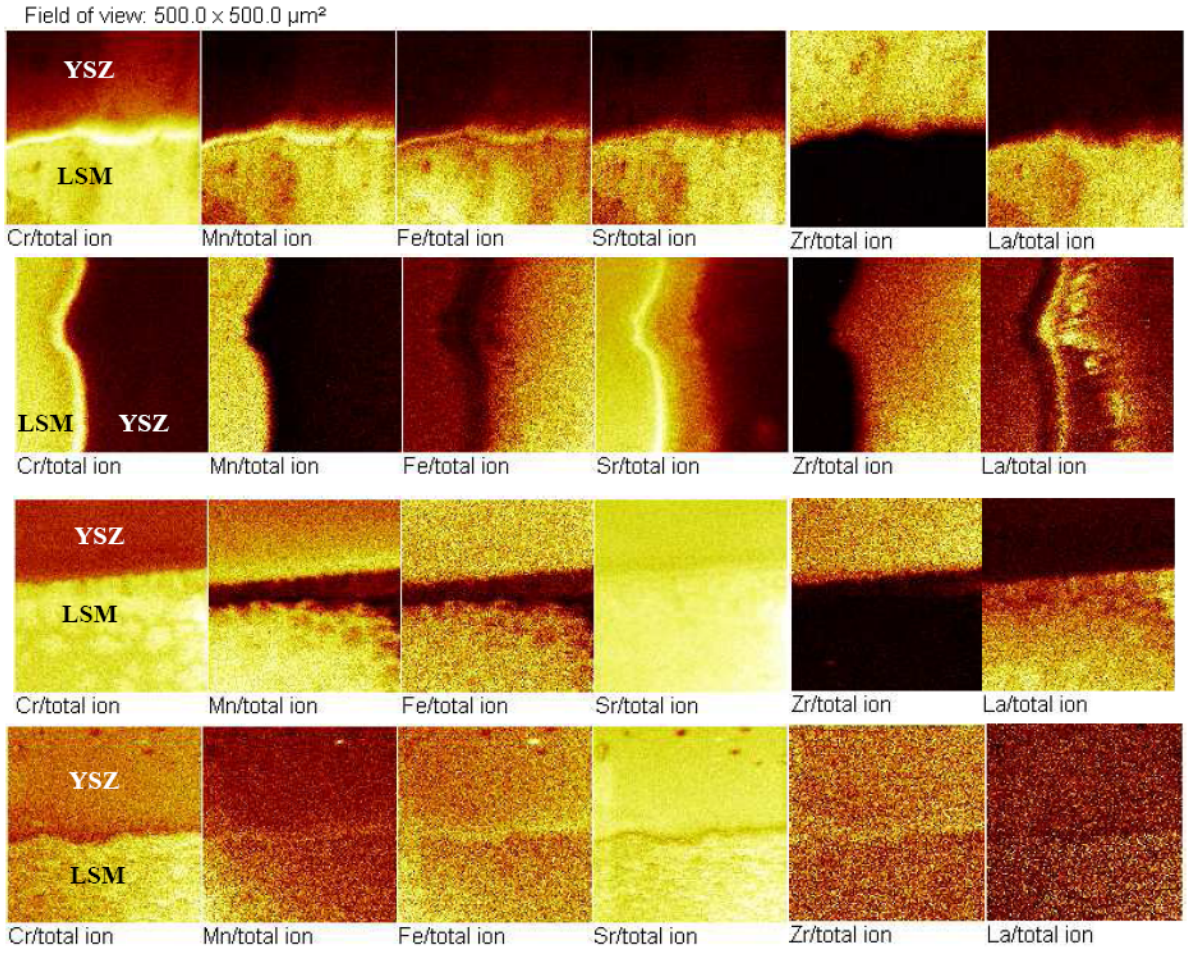

Fig. 1 ToF-SIMS images of an LSM electrode on a YSZ sample. The whole sample was split into four smaller samples. Each quarter was annealed for different times at 1000 °C. The first line shows the sample as prepared without annealing. The other lines show the annealed quarters after 10 hours, 30 hours and 100 hours. Electrochemical polarization was not performed [3].

References

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