SPEM studies of the surface chemistry of operating SOFC electrodes - Knowledge gained from experimentation at low pressure and gaps encountered compared to real systems operating at high pressure

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Solid Oxide Fuel Cells (SOFC) do not reach the expected theoretical performance and undergo strong degradation during longtime operation. The key driver is in many cases the surface chemistry of electrolyte, cathode and anode catalysts and their changes during SOFC processing and operation. While the electrochemical performance can be tested for the building blocks of the SOFC in great detail under different operation conditions, it is very difficult to assess the surface chemistry in operating systems at 500-800C in presence of air, fuel and possible pollutants. Ex-situ spectroscopy at room temperature in high vacuum is only of limited value, does not provide and cannot predict the surface chemistry in operating systems.
The ELETTRA SPEM has been used to study the surface chemistry in operating SOFC electrodes. Model cells with macro-/micro-patterned $(Sr,La)MO_3$ (M=Mn, Fe or Co) electrodes and YSZ electrolyte were operated in the SPEM at 650C, 10^{-6} mbar oxygen and various cell currents Steady state and time resolved relaxation phenomena were investigated by spatially resolved spectroscopy and elemental mapping, while the electrochemical cell performance was monitored at the same time.

Our SPEM studies of the operating cathodes demonstrated that the high temperature surface chemistry of the oxide catalysts and electrolyte differ from that observed ex-situ at room temperature and in addition changes with the cell operation conditions. Results on the steady state surface chemistry of various cathodes will be presented illustrating changes in oxidation state, surface segregation and oxygen surface species. Several examples of the time-resolved response to changes in cell operation parameters will illustrate long-range surface transport and its impact on the electrochemical cell performance.

Even though model cells were studied in the SPEM at SOFC operation temperature, the oxygen pressure of 10^{-6}mbar in the SPEM does not match realistic operation. Questions have to be asked about the impact of oxygen pressure on surface chemistry and cell performance. Electrochemical testing of the SPEM model cells on a test stand as function of oxygen pressure showed that the cell performance in the SPEM matches the results on the test stand; however, high pressure cells are needed to gain information on the surface chemistry and particularly on the quantity and nature of oxygen species being present at high oxygen pressure.