Utilizing of TOF-SIMS method for SOFC and SOEC development

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In order to achieve a significant decrease of CO_2 emissions there is indisputable demand for carbon-neutral power generation technologies. Fuel cells and electrolyzers are regarded as one of the most promising energy conversation and storage devices for sustainable and green energy development. Among various types of fuel cells, wide commercialization of high temperature solid oxide devices (SOD) consisting of solid oxide fuel cell (SOFC) and solid oxide electrolysis cell (SOEC) as well reversible solid oxide cells (RSOC) is highly expected because of their high energy conversion efficiency and flexibility of various fuel utilization.

Major challenges connected with SOFC/SOEC technology include the high operation temperature-related issues, stack durability, and thermal cyclability. It has been demonstrated that the changes in the electrode/electrolyte interface, such as element segregation, contamination with impurities, microstructural changes, and interfacial reactions leads to the ageing and decrease of performance of a SOFC/SOEC devices. Time of flight secondary ion mass spectrometry (TOF-SIMS) is perfect tool to identify and analyze chemical and structural changes caused by aforementioned phenomena.

Probably the most well-known SOFC/SOEC technology challenge where TOF-SIMS method can be extremely beneficial is so called unwanted element movement at high manufacturing and operation temperatures. The best example here is strontium migration and formation of $SrZrO_3$ during solid oxide cell manufacturing.[1,2,3] The presence of $SrZrO_3$ causes the decrease of ionic conductivity in the electrolyte and it can create mechanical stresses inside electrolyte layers.

As a second example the surface oxygen exchange activity mapping utilizing the ^{18}O exchange method together with the TOF-SIMS gives us a great tool to analyze electrode activities at different regions.[4] This kind of analysis method gives valuable information to design better gas distribution and temperature exchange systems during the design of SOFC/SOEC stacks.

TOF-SIMS is also a very helpful tool to analyze contamination of cells with impurities [5], to analyze the loading of electrolyte scaffold with electrode material [6] and for mapping the surface chemistry at gas environments [7]. Different examples from mentioned techniques will be presented and discussed.

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