IN SITU TRANSMISSION ELECTRON MICROSCPY ON OPERATING ELECTROCHEMICAL CELLS

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Abstract

Solid oxide fuel/electrolysis cells (SOFC/SOEC) will play an important role in future efficient energy systems and so will environmentally friendly energy systems if a better long term performance of the cells can be achieved. Conventional SEM and TEM are often used for characterization of the SOFCs/SOECs ex situ, and until recently it was not possible to characterize the nanostructures in an operating SOFC/SOEC in situ. This was mainly due to limitation in complexity of TEM holder designs which until recently did not allow for analysis during exposure to the sample of gas flow, elevated temperatures and electrical biasing in combination.

The present contribution benefits from recent developments in chip based TEM holders at DTU allowing for an electrical potential across the sample at an elevated temperature. The in situ TEM characterisation is conducted by using a 80-300kV Titan ETEM (FEI Company) equipped with an image corrector and a differential pumping system. In this microscope the samples can be analysed in a reactive gas environment at a pressure of a few millibars.

The goal of the project is to describe the nano-scaled dynamical changes near the interfaces between the electrolyte and electrodes for an SOFC/SOEC in a few millibars of reactive gas and at temperature up to 800°C. In addition to the structural and compositional analysis, electrochemical analysis is to be conducted by using impedance spectroscopy on the cells.

To perform the in situ TEM analysis, it is necessary to develop model SOFCs/SOECs since we found that industrial cells cannot be modified sufficiently to allow for the in situ TEM analysis. The model cells consist of typical ceramic materials used for industrial SOFCs/SOECs (e.g. NiO-yttria-stabilized zirconia as a fuel electrode, yttria-stabilized zirconia as electrolyte and Lanthanum strontium manganite as oxygen electrode) and are prepared e.g. by pulsed laser deposition (PLD) or by a combination of tape casting and screen-printing. A focussed ion beam is used for thinning the sample before the TEM characterization.

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