In situ reduction and reoxidation of a solid oxide fuel cell anode in an environmental TEM

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Solid oxide fuel cells (SOFC) are efficient devices for the electrochemical conversion of a large variety of fuels into electricity. The standard design is supported by the anode, which is composed of yttria stabilized zirconia (YSZ) and nickel oxide (NiO). NiO is reduced into metallic nickel during the first operation of the cell. Along with porosity creation, this reaction induces the electrical conductivity and the electrochemical activity of the anode (high Ni activity for H_2 oxidation). The reduction procedure is important as it influences the anode support conductivity and strength.

Oxidation of the nickel phase can occur during SOFC stack operation due to air leakage through the sealing, leakage of fuel, high fuel utilization or a shut down without protection gas. The important expansion during oxidation produces stress in the YSZ backbone and may lead to the formation of cracks in the thin electrolyte, which can be extremely detrimental to the cell's performance. A better understanding of the mechanisms involved in the RedOx process of the anode is therefore essential.

In situ environmental transmission electron microscopy (ETEM) allows combining microstructure characterization in a TEM together with atmosphere and temperature controlled variations. It is therefore a powerful tool to understand the reaction processes occurring during reduction and oxidation in the electro-catalytic field, and in particular in the case of SOFCs. It has been used in the present work to give *in situ* information on micro and nanostructures, as well as local compositions and crystallographic analysis of a standard anode during a RedOx cycle.

The first results reveal that the oxygen transfer to the YSZ phase from the NiO triggers the reduction reaction at the YSZ/NiO interface and then how the creation of a porous structure due to the mass transport accounts for the redox instability of the Ni-based anode.