TU Clausthal
Clausthal University of Technology

MM 27.14

Investigations on degradation effects in SOFC fuel cells

Hanna-Friederike Poggemann[1,2], René Gustus[2], Georgia Sourkouni[2], Christos Argirusis[2,3], Wolfgang Maus-Friedrichs[1,2]

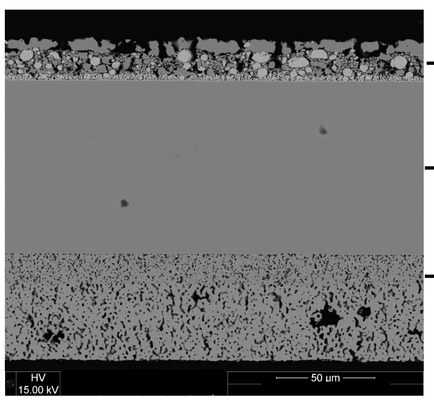
[1] *Institute of Energy Research and Physical Technologies, Clausthal University of Technology, Leibnizstraße 4, 38678 Clausthal-Zellerfeld, Germany*
[2] *Clausthal Center of Material Science, Clausthal University of Technology, Leibnizstraße 4, 38678 Clausthal-Zellerfeld, Germany*
[3] *School of Chemical Engineering, National Technical University of Athens, 9 Heroon Polytechniou St. Zographos Athens, Greece*

Introduction

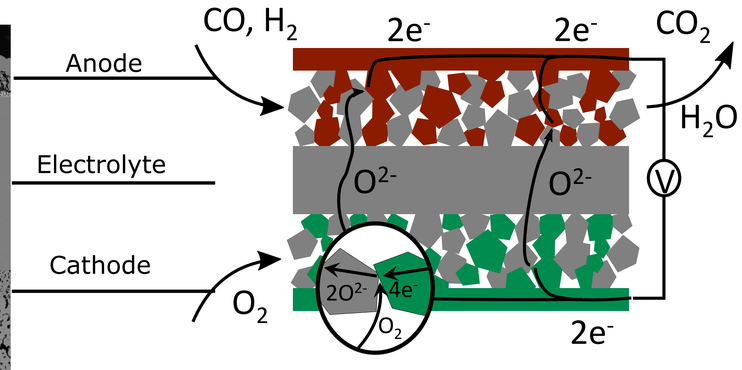
Fuel cells are an important alternative to conventional processes of power generation. A fuel cell produces electrical power and heat directly from chemical energy. This avoids losses that can occur in conventional thermal and mechanical conversion processes during power generation. Nevertheless, the application of SOFCs for power generation is strongly limited by the life span and the robustness of the cells. In this regard, we investigated the degradation of SOFC fuel cells as a function of runtime and temperature under thermal and current drawing conditions in order to distinguish degradation stemming from each mechanism.

Experimental

We used microscopic and spectroscopic methods like Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray analysis (EDX) to investigate the microstructure and chemical composition of the anode and the cathode to get insight into changes in the elemental distribution and porosity of the fuel cells. In this context, we also examined the grain growth in the anode of the SOFC.

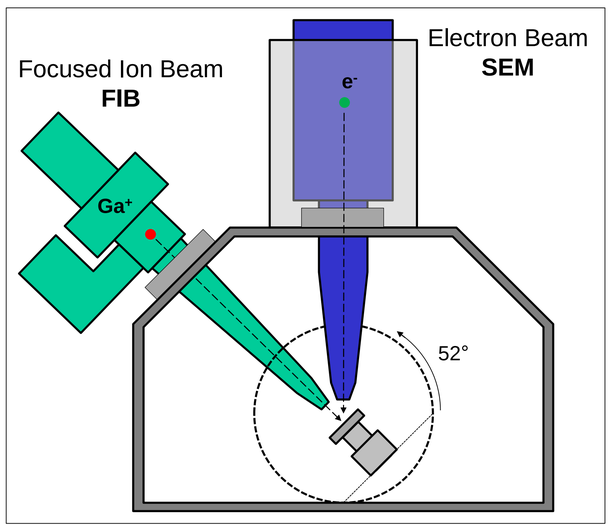


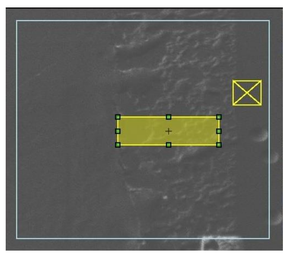
SEM image of a cross section of a SOFC fuel cell

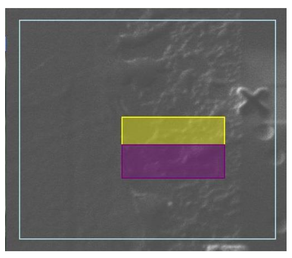


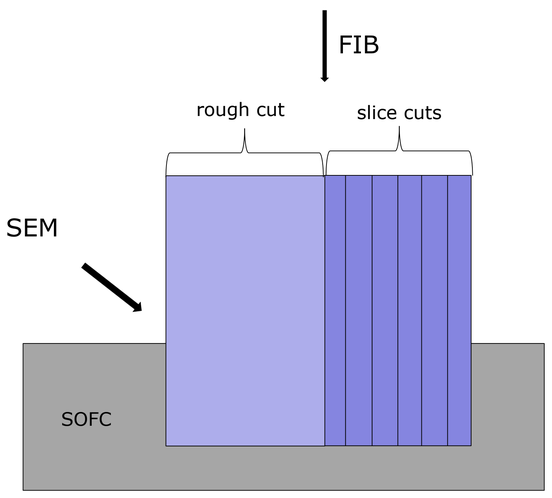
Scheme of a SOFC fuel cell

FIB-Tomography









To gain further inside into the cell Focused Ion Beam (FIB) Tomography is used.

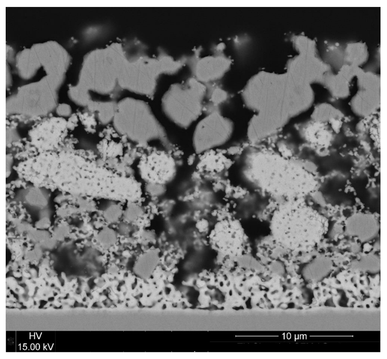
Therefore:

- FIB is used to prepare several slice cuts (50) of a few hundred nanometers each
- SEM pictures are taken after each slice cut
- Afterwards the slices are used to reconstruct the 3D structure of the investigated volume

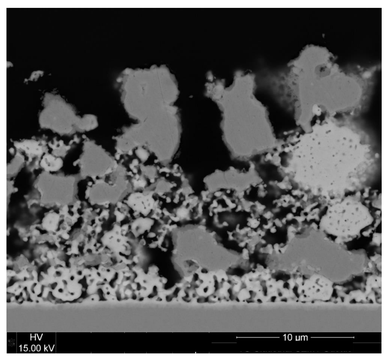
Summary

- In SOFC fuel cells the three phase boundaries, where the fuel, the electrons and the ions are supplied, are of great importance
- The decrease of the phase boundaries and the increase of porosity due to temperature and operation time is one important degradation mechanism
- SEM investigations reveal a change in microstructure as a function of thermal and electrochemical load
- FIB-Tomography is a potential method to gain more information about the microstructure due to the possibility to get real 3D information

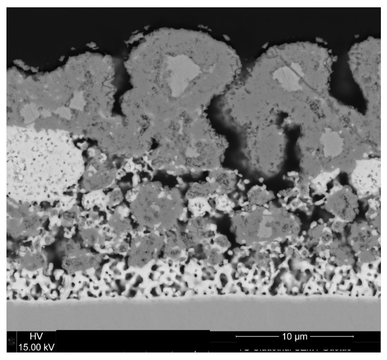
Investigation of Anode degradation



SEM-Image of **Cell A**
- Cell preparation: reduced for 4h at 850°C
- Reference cell



SEM-Image of **Cell B**
- Cell preparation: in operation for 1000 h at 850°C
- No electrochemical load

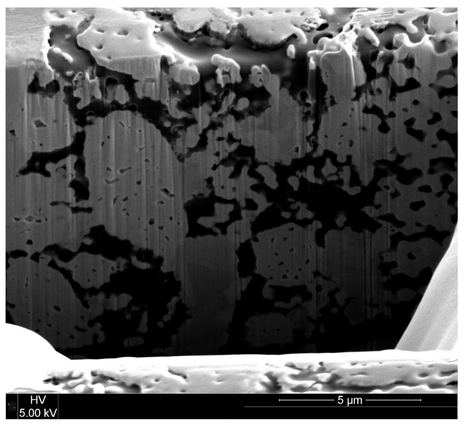


SEM-Image of **Cell C**
- Cell preparation: in operation for 1000 h at 850°C
- Electrochemical load: 230mA/cm²

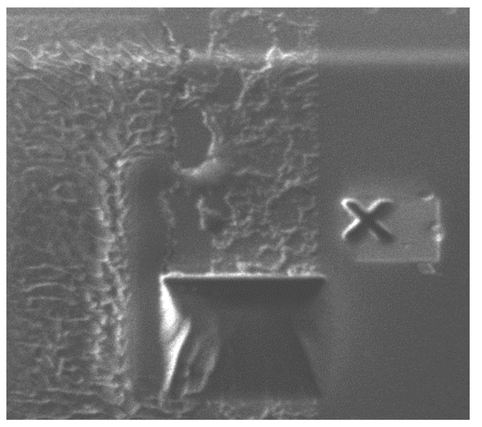
Cell	porosity [%]
A	35.58
B	33.67
C	26.96

- The porosity was determined with the help of the software ImageJ.

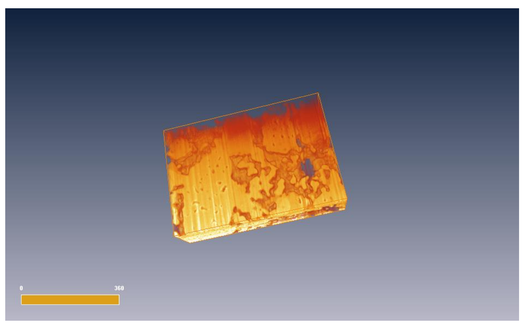
FIB-Tomography of Cell B

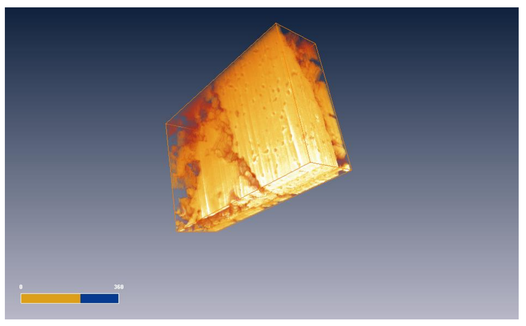


SEM image of a slice cut



FIB image of the cut region





- Reconstructed 3D model of the investigated volume
- For reconstruction the software Amira was used

Clausthaler Zentrum für Materialtechnik