Karlsruher Institut für Technologie

Institut für Angewandte Materialien
Elektrochemische Technologien
Adenauerring 20 b
76131 Karlsruhe

Student Research Assistant (HiWi)

Multiphysics 3D-FEM Modeling of MIEC-based SOEC

Research area

- ☐ Batteries
- ☒ Fuel cells and electrolysis
- ☐ Electrocatalysis

Alignment

- ☐ Experimental
- ☐ Electrical Characterization
- ☐ Material analysis
- ☐ Development of measurement technology
- ☒ Modeling
- ☒ Simulation
- ☒ Literature Research

Course of study

- ☒ Electrical engineering and IT
- ☒ Mechanical Engineering
- ☒ Chemical Engineering
- ☒ Physics
- ☒ Techno mathematics
- ☒ Industrial Engineering

Language

- ☒ English
- ☒ German

Starting date

As soon as possible

Contact person

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Motivation

The position is offered in the framework of ongoing joint research project “ElChFest” between IAM-ET and Forschungszentrum Jülich (FZJ) and pertains to green hydrogen technologies for energy sustainability of our future. The student research assistant will contribute in the development of high-temperature solid oxide electrolysis cells for hydrogen production. For their high performance and reliability, the cell design, materials and microstructure of the components are decisive. In this regard, SOECs based on mixed ionic and electronic conductors (MIEC), such as ceria and its doped derivatives, in combination with particular cell design exhibited encouraging results. For instance, the recently developed FZJ’s cathode-supported cells (CSC) with solid gadolinium-doped ceria (GDC) electrolyte layer and porous Ni-GDC cathode showed an outstanding performance in terms of hydrogen production during high-temperature steam electrolysis. However, the formation of cracks in the electrolyte and substantial drop of cell performance were noticed after the operation in electrolysis mode. Presumably, these result from mechanical stresses that develop in the cell components or at their interfaces due to electrochemically induced expansion / contraction of GDC lattice upon operation under strong (and uneven) gradients of oxygen chemical potentials between the cell electrodes. This assumption is to be testified in the ElChFest project, which would be relevant for the optimization of technology of new types of GDC-based SOECs. The goal is to create a three-dimensional finite element (FEM) electro-chemo-mechanical model of GDC-based CSCs that would shed light on the relationships between the microstructure, the operating parameters, mechanical stability and the cracking in the electrolyte. The cornerstone is the simulation of spatial distribution of oxygen chemical potential in the microstructure of the cell accounting for all relevant electrochemical processes involved in the SOEC operation and its further experimental verification. The student research assistant will participate in setting up and validation of an initial yet sufficiently comprehensive FEM model of oxygen potential distribution in Ni-GDC-cathode supported SOECs using the simplified artificial 3D microstructure of the cell. This validated and working model of oxygen spatial distribution will then be tested on the reconstructed (by FIB-SEM) real microstructure of the actual FZJ’s state-of-the-art GDC-based electrolyzer cell and, finally, will be used for simulation of mechanical stresses in the SOEC microstrcuture by the ElChFest partners.

We seek for a support of a highly motivated student (bachelor or master) to engage in the development of an above-described 3D FEM model. The model is to be developed using the commercial software COMSOL Multiphysics®. The candidate’s experience with this or other FEM-oriented packages, knowledge of scientific software (MATLAB, Origin, etc.) are an asset. The minimum employment is 20 h per month and may be adjusted upon request.

Areas of responsibility:

- Development and testing of simplified 3D FEM Model
- Participation in writing of scientific papers

Application

We offer lively atmosphere and the opportunity to work in an interdisciplinary team on an innovative topic. Interested candidates are asked to send a brief motivation letter, curriculum vitae and grades to the email address mentioned. Please contact Dr. Kogut for more detailed information.

PD Dr.-Ing. André Weber