Karlsruher Institut für Technologie

Institut für Angewandte Materialien
Elektrochemische Technologien
Adenauerring 20 b
76131 Karlsruhe

Master thesis

Development of perovskite-based fuel electrode with high electrochemical activity for high-temperature steam electrolysis

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
☒ Chemistry
☒ Physics
☒ Material Science
☐ Techno mathematics
☐ Industrial Engineering

Language

☒ English
☐ German

Starting date

As soon as possible

Contact person

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Motivation

Our modern society faces a crisis of energy and environmental issues resulting from the rapid depletion of fossil fuels and global warming. The development of sustainable energy storage and conversion devices is urgently necessary to overcome these complications. Regarding energy conversion, solid oxide electrolyzer cells (SOECs) are the most efficient and environmentally friendly technology for producing green hydrogen. In today's SOECs, nickel/yttrium stabilized zirconia ceramic-metal compounds (Ni/YSZ-cermets) with excellent electrochemical performance are widely used as fuel electrodes. However, the performance of such electrodes degrades due to Ni agglomeration and migration, limiting the lifetime of the SOEC. This problem promotes the development of materials exhibiting higher stability as fuel electrodes in SOECs.

All ceramic fuel electrodes based on mixed ionic-electronic conductors (MIECs) can effectively improve the stability of the SOEC. The challenge is to find a composition that combines a sufficient electrochemical performance (conductivity and electrocatalytic activity) with high structural stability. In the previous master's project, the powder synthesis, structural analysis, and initial electrochemical performance were conducted for the $Sr_{0.6}Pr_{0.4-x}Ce_xMnO_3$ (SPCM) (x = 0.1, 0.2, and 0.3) fuel electrode. The results showed improvement of phase stability with substitution Pr by Ce in x = 0.1 and 0.2. In addition, the $(Pr,Ce)O_2$ catalyst phase was identified in the XRD pattern with heat treatment at similar operation conditions. However, the practicality of formed catalyst particles to enhance the electrode performance is an open question that requires more analysis. Accordingly, the current master's project aims to perform further electrochemical testing for steam electrolysis applications in thermoneutral conditions. Then, compare the electrode performance with Ni-infiltrated SPM perovskites, in which an additional processing step forms the Ni catalysis.

The following tasks are included in this project

- Literature study on perovskite-type fuel electrodes
- Synthesis of SPCM and SPM perovskite via sol-gel combustion method
- Processing of the cells (paste preparation, screen printing, sintering)
- Electrode material and cell characterization (Conductivity measurement and microscopy study)
- Electrochemical testing and stability evaluation of prepared electrodes

About us

We offer a lively atmosphere and the opportunity to work in an interdisciplinary team on an innovative topic. The IAM-ET offers a constantly growing team with expertise in battery, fuel cell, and electrocatalysis research at the South Campus of KIT. Independent work and the motivation to work on current research topics are required. For further information please get in touch with Yousef Alizad Farzin. Interested candidates are asked to send a brief motivation letter, curriculum vitae, and grades to yousef.farzin@kit.edu.

The supervisors

Dr. Yousef Alizad Farzin and Dr.-Ing. André Weber