Institute of Technical Thermodynamics

Characterization and Long-Term Testing of Solid Oxide Electrolyzer Cells

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Motivation

Germany and EU has seen an unprecedented growth of renewable power generation which is intermittent by large. SOEC technology has come to focus as a very efficient electrolysis process for production of large amounts of hydrogen for large scale energy storage. Although solid oxide steam electrolysis shows very promising behavior concerning fuel versatility, power density and efficiency, it is still in a developmental stage and hardly used commercially. This is largely due to problems with the long-term stability of the cells.

In order to improve longevity a fundamental understanding of the underlying processes is necessary. Consequently these investigations are focusing on the influence of the major system parameters temperature, fuel gas humidity (AH) and current density on cell degradation.

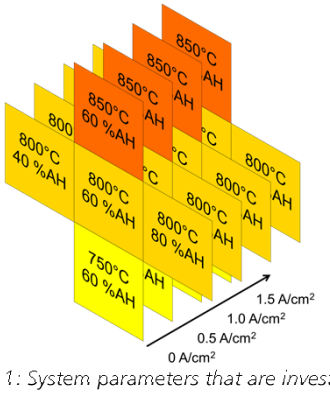


Figure 1: System parameters that are investigated during long-term degradation experiments

Measuring setup

The measurements were conducted using a newly developed cell holder which allows the measurement of ASCs as well as ESCs of any thickness using solely gold as sealing material. The test bench is able to measure up to 4 cells simultaneously. While gas supply and furnace temperature are identical for all cells the current loading can be varied individually for each cell.

Results of cell characterization

In order to properly interpret changes in cell performance it is crucial to have an extensive knowledge of the tested cells in their initial state. To that end cells were electrochemically characterized under all system conditions which are planned to be investigated (see Fig. 1).

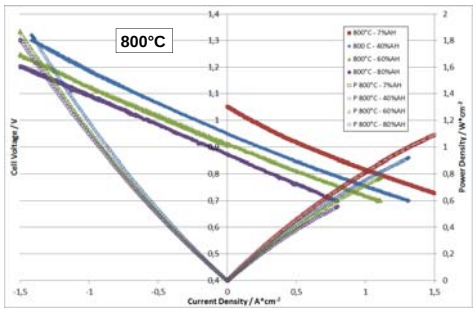
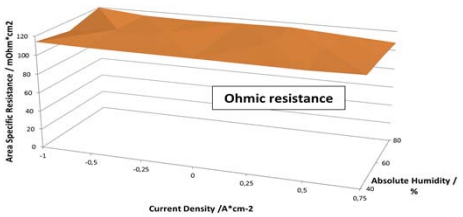
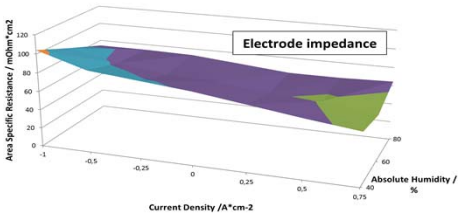


Figure 2: Polarization curves of a typical cell at 800°C and different humidities in the fuel gas.





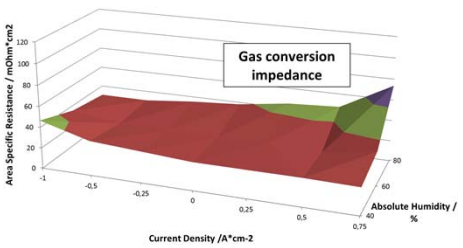


Figure 3: Cell characterization by impedance analysis at different current densities in fuel cell as well as electrolyzer mode and at different fuel gas humidities, exemplarily at 800°C.

Influence of system parameters on cell degradation

The advantage of measuring 4 cells simultaneously not only increases data generation speed but also ensures that the measured cells are exposed to identical conditions including system glitches. The effect of current density on long-term degradation can thereby be investigated with a high reliability. These experiments are conducted for the 5 sets of temperature and humidity shown in Figure 1, each with a duration of approximately 1000 h.

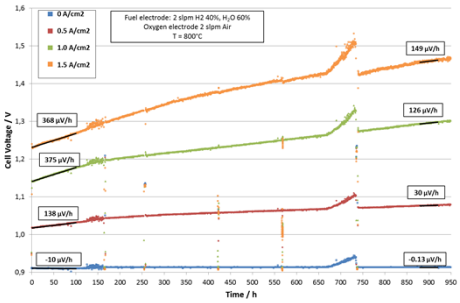


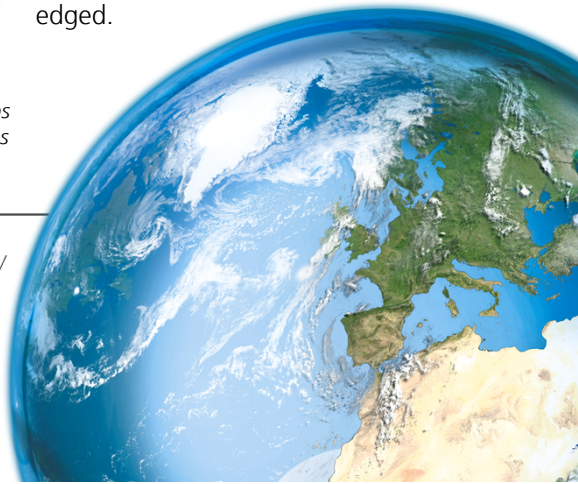
Figure 4: Long-term degradation experiment over 1000 h at 800°C and 60% humidity in fuel gas.

Discussion

An interesting behavior observed during cell characterization is that at low humidities there is a strong dependence of current on the electrode impedance resulting in an impedance twice as high in electrolysis compared to fuel cell mode. At high humidities, however, there is hardly any correlation.
The gathered information will be used for the development of new cells specialized for electrolyzer application.

Acknowledgment

Financial support from the Helmholtz Energy Alliance is gratefully acknowledged.



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