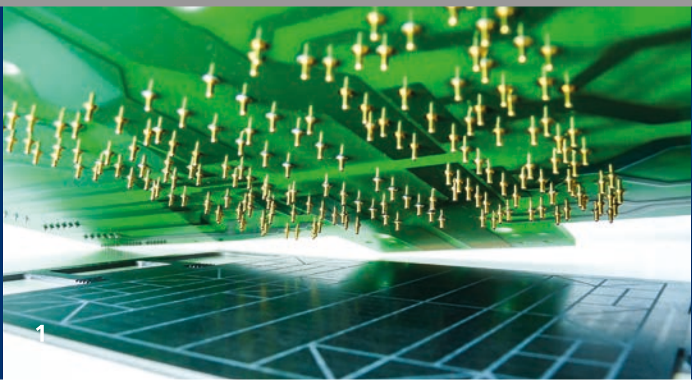
Fraunhofer ISE

FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE



1 Segmented flow field plate and current collector for spatially resolved characterization of an automotive single cell.
2 Characterization of a PEM fuel cell stack under extreme climate conditions with single cell monitoring.

SPATIALLY RESOLVED CHARACTERIZATION OF FUEL CELLS AND STACKS

Fraunhofer Institute for Solar Energy Systems ISE
Heidenhofstr. 2
79110 Freiburg, Germany

Hydrogen Technologies – Fuel Cell Systems
Ulf Groos
Phone +49 761 4588-5202

Single Cell Characterization
Dr. Robert Alink
Phone +49 761 4588-5184

Stack Characterization
Stefan Keller
Phone +49 761 4588-5207

h2fc.systems@ise.fraunhofer.de

www.h2-ise.com
www.ise.fraunhofer.de

A detailed understanding of the coupled electro-chemical and thermo-dynamic processes in a fuel cell is a prerequisite for a cost effective and reliable design. We offer a scientifically based characterization of cell components, single cells, fuel cell stacks and peripheral systems. The results are optimized designs, operation strategies and validated models on both the cell and stack level.

Our Offer

- spatially resolved characterization of customer specific cells up to 790 A
- system-oriented stack characterization up to 20 kW_{el} or 1000 A with an integrated peripheral system also in the climate chamber

Characterization of Fuel Cell Stacks

Especially in the automative industry, fuel cell stacks have large active areas and many cells, therefore making inhomogeneities unavoidable. Aside from investigating the inhomogeneities, we also characterize the performance, efficiency and lifetime of each cell.

We measure our customers' fuel cell stacks in our climate chamber under extreme operating conditions with our 20 kW_{el} / 1000 A test stand. By including units for air supply, anode recirculation and purge valves, we can carry out tests on the system level.

04-530-17

In addition, we can characterize up to 50 individual cells in a stack. At a wide range of operation conditions, we are able to obtain single cell voltages as well as electrochemical impedance spectra (EIS). The EIS allows us to differentiate the frequency dependent processes within the cells and gain an understanding about the stack functionality. For example, we can analyze the gas flow distribution depending on the operation conditions by applying EIS on the individual cells within a stack.

We support our customers in developing their stack design, from the component selection up to the control strategy for their fuel cell system. Particularly, we highlight the stack and system operation in extreme cold, hot and humid or dry environments.

Model-based analysis of experimental results

To extract and analyze properties like gas velocity in channels or cells that are difficult to measure directly, we have developed scientific and thoroughly validated models.

Spatially Resolved Characterization of Single Cells

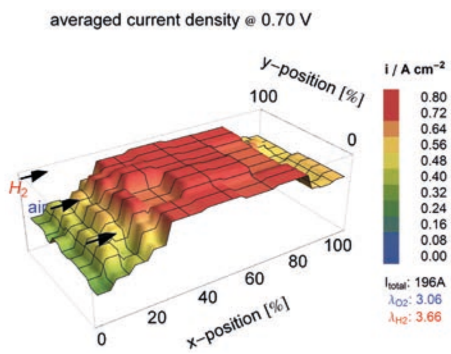
At high current densitites and large cell areas, the reaction gases can significantly deplete, resulting in a local increase of humidity and temperature. The large inhomogeneities within the cell can influence the performance and degradation of the fuel cell. In order to characterize the local operation of the cells, we have a system with 68 independent potentiostats coupled with frequency response analyzers. Hence, customized single cells may be divided into up to 68 segments with their individiual electrical contact. In each segment, the operation can be characterized by simultaneous electrochemical impedance spectroscopy and current mapping. The maximum cell current is 790 A and all segments can be controlled individually.

Using this measurement technique, we evaluate our clients' cell designs, qualify the combination of cell components and investigate control strategies at the cell level. We can analyze the gas flow distribution through the segments depending on the operation conditions by extracting individual characteristic time constants of the impedance spectra.

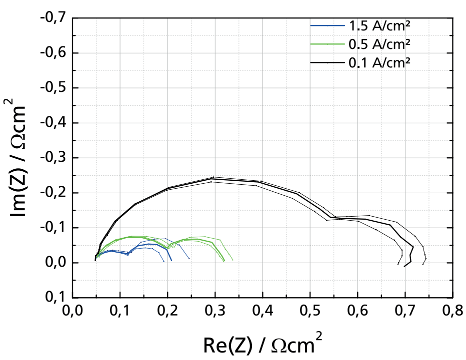
Investigation of along-the-channel effects

While many scientific investigations rely on differential cells, which are used to assure minimized gradients of gas concentrations, humidity, and temperature, the conditions in real cells are different. We offer tests on real cells or stacks. To reduce testing costs due to high power test stations and gas consumption, we have developed an along-the-channel test cell, optimized to study effects from gas inlet to outlet under realistic operation conditions. The cell can be manufactured according to the customers channel geometry with dimensions of the active cell area of 25 x 1 cm². A segmentation, e.g. into 25 electrically isolated segments with 1 cm² each, is one option to investigate the behavior along the length of the channel.

3 *Test stand for spatially resolved characterization of single cells with cell portal for a defined compression (right), a multi-channel system with 68 potentiostats and frequency-response-analyzers (left) as well as gas supply.*



4 *The current density distribution in a segmented automotive single cell illustrating the inhomogeneities on a cell level as a function of materials, construction and operation.*



5 *Average (bold), minimum, and maximum impedance spectra of an automotive short stack at different current densities.*