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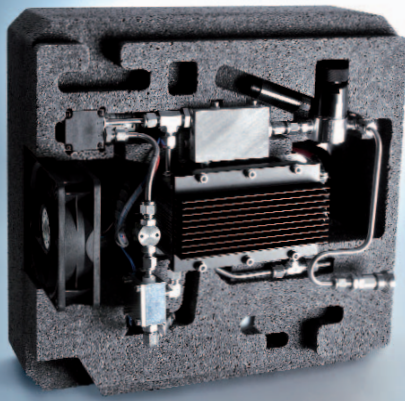
FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE

**TESTLAB FUEL CELLS.
MEASURED VALUE. MARKET VALUE.
ADDED VALUE.**



SCIENCE FOR THE PRACTICE

Qualified measurement data serve as the basis for good product development, and objective test results as the basis for successful marketing. The »TestLab Fuel Cells« at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg supports clients by offering scientifically sound analyses in conjunction with application-oriented, as well as standardized, tests for PEM fuel cells, stacks and systems.



From the technological point of view, fuel cells are highly complex electrochemical systems. In converting chemical energy into electrical energy, material flow, material phase change, various reactions, charge carrier transport and heat transport are some of the processes involved. In order to develop reliable fuel cells, it is necessary that these processes as well as the behavior of the singular components are understood down to the last detail.

The expertise available at the »Test Lab Fuel Cells« at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg ISE has developed over decades of research. We support customers worldwide and offer them a comprehensive range of services for an efficient, evidence-based product development. Base the marketing of your product on valuable experience, founded information and an internationally recognized name. We are happy to offer you our range of services!

For a given application, what combination of materials ensures an optimal behavior? What factors lead to the highest efficiency values? What control strategy is most suitable? How can the lifetime of fuel cell stacks be increased? Whether you request a full system analysis or rather just a closer look at singular components, we offer you fast, precise and reliable results.

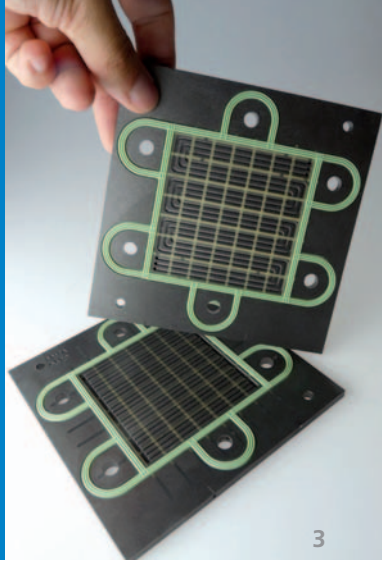
Our Services

- Characterization of single cells, fuel cell stacks and systems with electrical power ranging from 100 mW to 5 kW
- Lifetime investigations on single cells and short stacks
- Investigation of the start-up, operating and shut-down behavior for stacks and systems under defined climate conditions
- Standardized tests of stacks and systems
- Characterization of cell components
- Feasibility tests of peripheral components

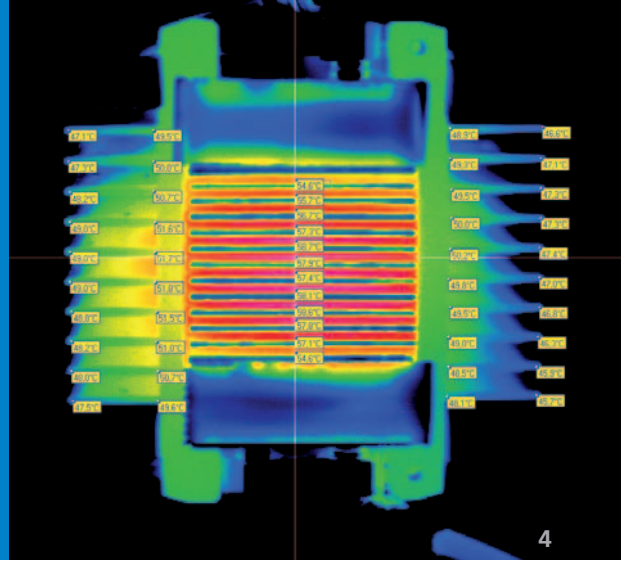
Title photo *Climate chamber for characterizing fuel cell stacks and systems up to 5 kW_e.*

1 *Portable fuel cell system for a temperature range from -15 °C to +50 °C.*

2 *50-channel measurement system for the spatially resolved characterization of segmented single cells with respect to electrochemical impedance (Photos: Rammelberg).*



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CHARACTERIZATION OF SINGLE CELLS

As fuel cell developer, would you like to optimize the component characteristics, the cooling and control strategy? We analyse the product properties and evaluate the results for you.

- Analysis of local inhomogenities based on test cells with up to 50 segments as designed by the customer
- Time-resolved transient measurements to record transport properties specific to the material
- Electrochemical impedance spectroscopy for analysing the water management as well as component characterization
- Cyclic voltammetry for determining the reactive surface
- Current-voltage characteristics to measure performance

LIFETIME INVESTIGATIONS ON SINGLE CELLS

Would you like to determine the durability and performance efficiency of single cells, verified with concrete data? We qualify your products using long-time measurements, cyclic and material tests.

- Long-time measurements from cyclic stress tests with defined humidification of the anode and cathode as well as cell heating and cooling
- Parallel investigations of maximum 30 cells with different cell components and variable loads in autonomous outdoor test stands
- Cyclic voltammetry and electrochemical impedance spectroscopy

CHARACTERIZATION OF FUEL CELL STACKS

Do you require information about fuel cell operation under extreme conditions and about aging? We analyse the operating performance and advise you about product development.

- Analyze local inhomogenities by characterizing up to 50 single cells within a cell stack
- Electrochemical impedance spectroscopy for analysing the water management as well as for characterizing the components
- Thermography measurements for visualizing the temperature distribution
- Current-voltage characteristics to measure performance

STANDARDIZED TESTS FOR FUEL CELL STACKS AND SYSTEMS

As fuel cell manufacturer, you depend on the legal certainty of certified products and quality assurance. We provide market-based consultancy services and carry out standardized safety and performance tests.

- IEC 62282-2 for fuel cell modules
- IEC 62282-5-1 for portable fuel cells
- IEC 62282-6-100 and -200 for micro fuel cells

3 Test cell with 50 segments for single cell characterization.

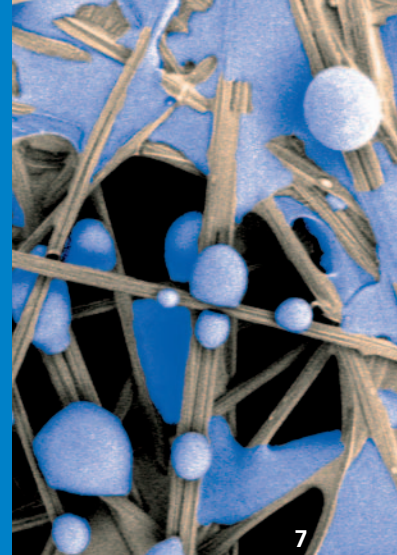
4 Temperature profile of a LT-PEM fuel cell stack during a start-up phase.



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CYCLIC STRESS TESTS UNDER EXTREME CLIMATIC CONDITIONS

Would you like the characteristics of your fuel cell tested under extreme outdoor conditions? We measure the performance under full and partial load tests as well as during the start-up and shut-down phases.

- Climatic tests for fuel cells stacks and systems with electrical power range from 100 mW to 5 kW.
- Performance tests in the temperature range from -20 °C to +60 °C
- Performance tests between 10 % and 95 % relative humidity at temperatures above 5 °C

In a walk-in climate chamber, conditioned air with a large flow rate of up to 2000 m³ per hour guarantees comprehensive test results for air-cooled stacks and systems up to 5 kW. For system design improvements, the combination of both stack characterization and climate chamber tests is highly recommended.

5 Outdoor autonomous test stand with 30 test cells operating in parallel undergoing investigations for degradation effects due to air pollutants (Photo: Rammelberg).

6 Test stands for evaluating single cells and life time investigations (Photo: Rammelberg).

7 Water droplets in a gas diffusion layer (Environmental Scanning Electron Microscopy, ESEM).

CHARACTERIZATION OF MICRO FUEL CELLS

Do you work on the development of micro fuel cells and systems? We characterize active and passive micro fuel cells from above 100 mW, even under extreme climate conditions.

- Electrochemical impedance spectroscopy for analysing the water management as well as component characterization
- Cyclic voltammetry for testing different electrode processes
- Characterizations at low temperatures pressures in a vacuum chamber
- Current-voltage characteristics to measure performance

INVESTIGATION OF COMPONENTS

Would you like to confirm or even improve the quality and reliability of the peripheral components? We investigate materials and components with respect to long-term stability and degradation effects.

- Electrical conductivity measurements and contact resistance analysis of gas diffusion layers and bipolar plates
- Environmental Scanning Electron Microscope (ESEM) investigations to analyze surfaces and wetting characteristics
- Energy Dispersive X-ray spectroscopy (EDX) to determine the element composition in the surface of the material, e.g. by catalyst migration
- Mass spectrometer with Inductively Coupled Plasma (ICP-MS) to analyze the product water as well as to determine the chemical stability from system components



»Reliable measurement results, characterization and standardized testing are the basis for technical and economic success. Take advantage of our available test stands and our long-standing expertise.«

Dipl.-Ing. Ulf Groos, Department Head Fuel Cell Systems

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