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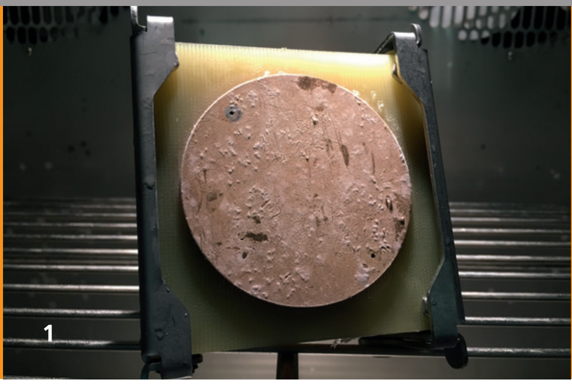

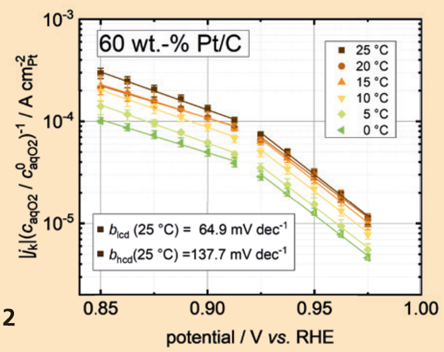

1 *Cell holder for measurements of MEAs at low temperatures.*
2 *Tafel plots of Pt/C catalyst at different temperatures.*

CHARACTERIZATION OF COMPONENTS FOR PEM-FC AT LOW TEMPERATURES

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Introduction

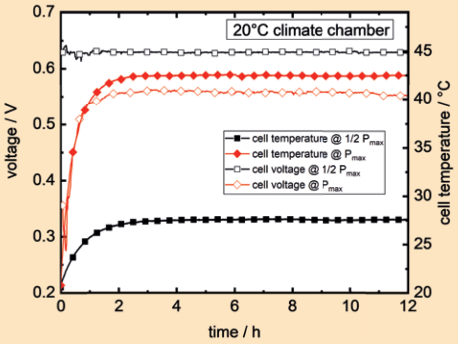
Proton exchange membrane fuel cells (PEM-FCs) are a promising alternative for future mobility applications. They oxidize hydrogen and reduce oxygen from air electrochemically to generate electricity. During this process only water is generated as the final product.

Challenge: low temperatures

The behavior of PEM-FCs in low ambient temperatures (e.g. during winter) and under cold-start conditions is the key to their application in the transport sector. Typically PEM-FCs are operated at 60 to 80 °C.Cold ambient temperatures are therefore detrimental to operation, but the fuel cell must function despite this. Both the activity and the degradation of individual components under these conditions must be studied, especially if ice crystal formation occurs.

Solution: cold tests

In order to evaluate components like catalysts, gas diffusion layers or membranes with respect to their suitability for use at low temperatures, different characterization tests are conducted at Fraunhofer ICT at low temperatures (-5 to 25 °C, depending on the technique). Our research focuses on the electrochemical parameters of the materials, as well as determination of degradation mechanisms. Our expertise also covers the manufacturing of these components and samples for the different studies, e.g. catalyst synthesis or fabrication of membrane-electrode assemblies.



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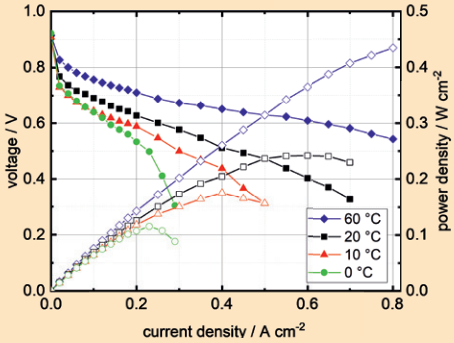

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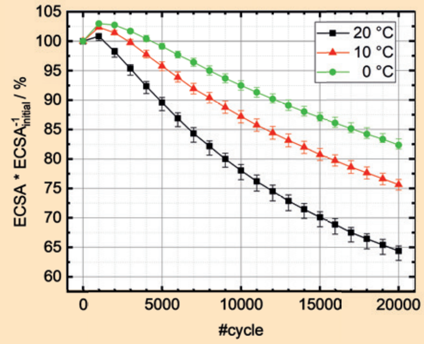

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Rotating ring-disc electrode

At Fraunhofer ICT rotating (ring-)disc electrodes (RRDE) are available for the evaluation of catalysts. Using this technique, information on the kinetic current, activation energy, catalyst degradation or reaction mechanism can be gathered. Our measurement cell allows cooling to -5 °C (depending on the electrolyte). Figure 2 shows Tafel slopes for the oxygen reduction reaction at a Pt/C catalyst at different temperatures.

Single-cell tests

In order to characterize and optimize catalysts and other components in an application-oriented environment, membrane-electrode assemblies (MEAs) are tested at Fraunhofer ICT in single-cell setups. We also have the possibility to manufacture MEAs using material from research partners or industrial customers. Thus, we can also vary fabrication parameters like binder content, catalyst loading or pre-treatment and study their effects. Other cell components like GDLs, membranes or bipolar plates can also be characterized in single-cell setups. Single-cells are in an operating environment that corresponds to an industrially relevant stack with just a single cell. By this means system-relevant results can be obtained with a low material expense. Operation in our climate chamber allows regulation of ambient temperatures between -70 and 180 °C, as well as control of ambient and media feed humidity for both electrodes.

Using temperature sensors, the heat generation during the reactions and the temperature development in the cell can be traced (3). Typical measurements include current-potential curves (4), impedance spectroscopy and long-term measurements at constant current or voltage. Moreover, accelerated stress tests (ASTs), as well as experiments on cold-start and start-stop conditions can be executed in the climate chamber.

Degradation

A strong expertise at Fraunhofer ICT is degradation, and we are able to couple various characterization techniques to make assessments of component degradation or poisoning by harmful gases. For this purpose techniques such as differential electrochemical mass spectrometry (DEMS) are applied.

One of our results for instance shows a significantly reduced Pt/C degradation at low temperatures (5).

Our expertise

Based on our measurements, we are not only able to produce results on performance and degradation, but are also able to derive recommendations on operating points and strategies.

Our competence covers:

- Catalysts und supports
- Porous transport layers and gas diffusion layers
- Membrane-electrode assemblies
- RDE and RRDE measurements of catalysts down to -5 °C (depending on electrolyte)
- Single-cell measurements in climate chamber (-70 to +180 °C)
- Long-term and degradation studies
- Accelerated stress tests
- Studies on different media gas compositions and harmful gases

Potential end-users

Producers of:

- Catalysts and catalyst supports
- Proton exchange membranes and binders
- Gas diffusion layers
- Bipolar plates
- MEAs

End-users and interest groups for:

- Fuel cells and hydrogen technology
- Renewable energy

3 *Temperature development in a single cell at 20 °C and 200 mA cm^{-2} and 600 mA cm^{-2}.*

4 *Current-potential curve of MEA with 0.4 mg cm^{-2} Pt/C at 0-60 °C*

5 *Current-potential curve of MEA with 0.4 mg cm^{-2} Pt/C at 0-60 °C*