

FCH TEST CENTER

Test Center for Fuel Cell and Hydrogen Technologies

TESTING OF SOLID OXIDE FUEL CELLS AND ELECTROLYSIS CELLS



UNDERSTANDING YOUR SOLID OXIDE CELLS

The combination of electrochemical and microstructural characterization makes it possible to achieve the unique understanding of the fuel cell required for further product optimization



The testing and characterization of Solid Oxide Fuel Cells and Solid Oxide Electrolysis Cells, both single cells and stacks, are the key competences of the FCH Test Center at DTU Energy Conversion. Based on the DTU Risø Campus, the department has been involved in fuel cell activities since 1987.

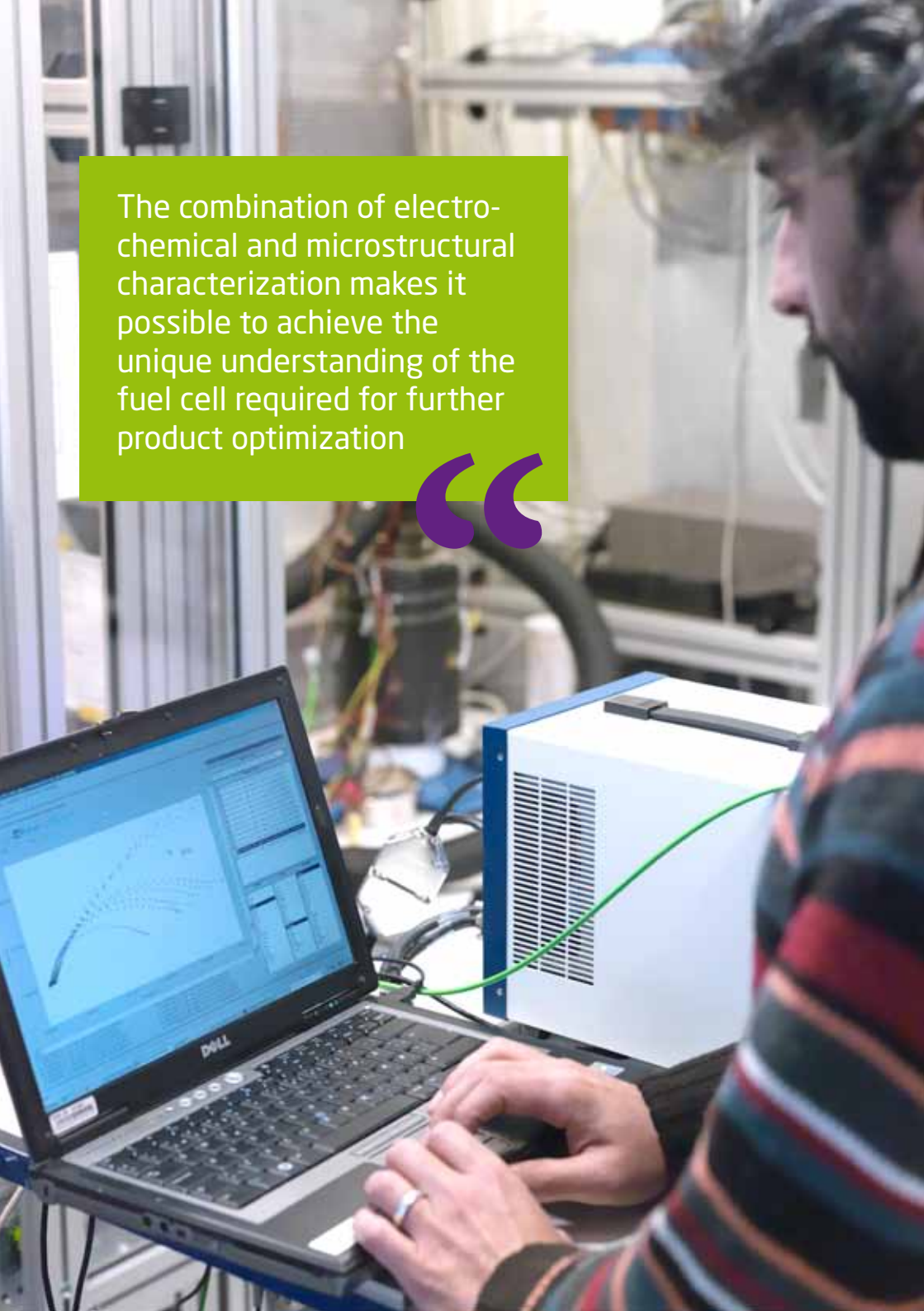
The research group is internationally acknowledged for its unique expertise in testing, characterization and interpretation of results. In particular, the combination of electrochemical characterization and microstructure analysis makes it possible to achieve a detailed understanding of cell and stack performance.

Our testing and characterization have been offered to industry commercially through FCH Test Center since 2010. We use standardized test procedures and respect the confidentiality requirements of the customers.

We are dedicated to finding the right solution for your company.

Please contact us for further information!

Eva Ravn Nielsen
Center Manager
FCH Test Center



SINGLE CELL SOFC/SOEC TESTING

When electrochemical testing of cells in fuel cell mode or electrolysis mode is combined with analyses and microscopy, it can show:

- The general performance level of the cell
- The degradation behaviour
- The durability of the cell - an impartial demonstration of its lifetime
- The part of the cell that has the greatest internal loss (e.g. anode, cathode or electrolyte)
- The part of the cell that causes the greatest degradation
- The integrity of the cell - identification of its weakest point

We can use a patented gas cleaning system that makes it possible to distinguish between degradation caused by impurities in the gas and other degradation mechanisms.

PERFORMANCE TESTING - ELECTROCHEMICAL TESTING

Almost the same test programmes are used for both SOFCs and SOECs. And it is possible to test both modes on the same cell.

A "finger print" will reveal the performance of individual parts of the cell. The finger print combines testing at a number of temperatures with several gas compositions and is performed at the beginning and the end of a test.

- General performance and degradation behaviour
- Long-term testing
- Accelerated cycling (load, redox, temperature)
- Electrochemical impedance spectroscopy (EIS) and iV-curves
- SOEC: steam electrolysis, CO₂ electrolysis or co-electrolysis of steam and CO₂

The sensitivity to sulphur content and other impurities in gases can also be examined.

MICROSTRUCTURE ANALYSIS

Samples can be characterized using high-resolution electron microscopes, which can help to explain the cause of degradation, and examine the structural integrity of the cells (delamination, cracks, etc.).

Advanced techniques for SEM and TEM microscopy can show:

- Changes in microstructure (grain boundaries, delamination, grain growth, pore structure)
- Poisoning of grain boundaries
- Connectivity of Ni particles in Ni-YSZ electrode and much more

Combined with other materials characterization (mechanical testing, electrical conductivity and resistance measurement of interconnect), the results can provide crucial input for designing and dimensioning, quality control, trouble-shooting and further development.



FACTS ABOUT THE PERFORMANCE-TESTING OF CELLS:

- Gas options: H₂, O₂, air, CO, CO₂, CH₄, N₂, Ar, H₂S, other upon request
- Electrolysis of steam, CO₂, or co-electrolysis of steam and CO₂
- Electrical loads of up to 40 A (SOFC) and power supplies of up to 40 A (SOEC)
- Potentiostatic or galvanostatic testing
- Impedance spectroscopy under current load: 100 kHz → 0.05 Hz
- Gas cleaning: The possibility of removing impurities in the inlet gas stream
- Future option: Testing under high pressure

A patented gas cleaning system makes it possible to distinguish between degradation caused by impurities in the gas and other degradation mechanisms



SOFC/SOEC STACK TESTING

When electrochemical testing of stacks in fuel cell mode or electrolysis mode is combined with analyses and microscopy, it can show:

- The general performance level of the stack
- The degradation behaviour
- The durability of the stack - an impartial demonstration of its lifetime

In combination with single cell test, it can also show:

- Any difference between the performance and degradation of single cells and stacks
- The part of the stack that causes the greatest degradation (in combination with interconnect testing)

- Whether any stack performance issues are due to cell performance, contact resistance to interconnect plates, gas flow rates, temperature gradients or other reasons.



FACTS ABOUT THE PERFORMANCE-TESTING OF STACKS:

- Up to 25 cells in one stack. Short-stack testing, e.g. with 5 cells
- Gas options: CH_4 , CO , CO_2 , air, H_2 , N_2 , O_2
- Steam electrolysis or co-electrolysis of steam and CO_2
- Gas cleaning: The possibility of removing impurities in the inlet gas stream
- Electrical loads of up to 1100 W (SOFCs) and power supplies of up to 30 V and 400 A (SOEC)
- Impedance spectroscopy under current load: 20 kHz \rightarrow 0.5 Hz
- Future option: Testing under high pressure



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The FCH Test Center is part of the Department of Energy Conversion and Storage at the Technical University of Denmark (DTU). The department has 250 employees, more than half of whom are working on fuel cells and electrolysis.