FUEL CELL SYSTEMS AT FRAUNHOFER ISE

Assisting industry in fuel cell technology

photo: Joscha Feuerstein

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Fraunhofer ISE

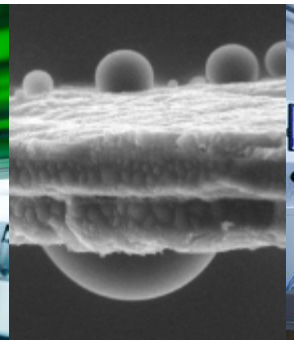
Fuel Cell Systems at Fraunhofer ISE

Providing scientifically sound services to our customers

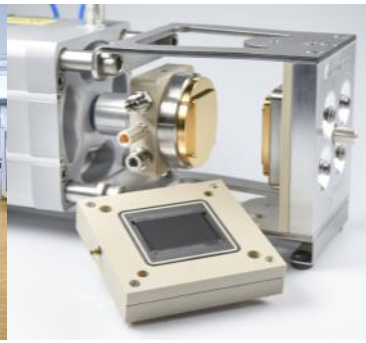
- > 25 years of fuel cell research
- > 20 researchers plus students
- 3.4 Mio € annual budget and 40% direct revenue by industry contract research (2020)
- >500 m² laboratory area with 10 single cell test stations, 4 short stack test stations, 1 system test site, 2 climate chambers (all fully automated for 24/7 operation)
- Focus on transport application (LT PEMFC)


stack testing


analysis of local effects


SEM analysis


MEA laboratory


test cell


environmental test of BoP

Our Offers to our Customers: From Catalyst to System

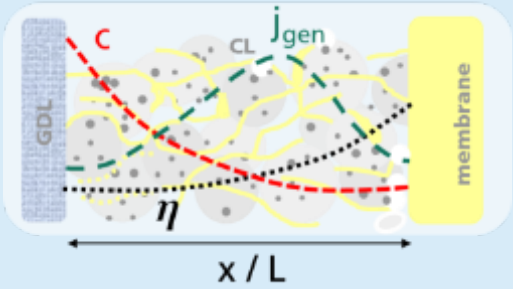
Performance and degradation evaluation of fuel cells

- Modelling, developing and testing of membrane electrode assemblies (and its layers)
- Investigating and developing MEA process technologies
- Developing and analyzing bipolar plate coatings
- Characterizing fuel cell stacks
- Spatially resolved evaluation of cell and stack design, also at extreme climate conditions
- Fuel cell system technology: testing of balance of plant components, developing and testing of operating strategies (e.g. freeze start, hybridization, efficiency), monitoring of field tests

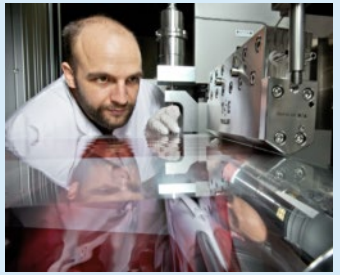

monitoring


degradation


characterization



modelling


process technology

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Value Proposition to our Customers

State of the art fuel cell expertise

- Optimizing materials and components
- Developing production technologies
- Understanding cell and stack designs
- Optimizing operating strategies from cell to system level (depending on environmental conditions and design rules)
- Validating models

Above: degradation modelling and (environmental) stack testing

Middle: CCM / MEA laboratory and test of contamination effects

Down: spatially resolved characterization of cell design and life-time testing of balance-of-plant components

MEA Material Characterization

photo Joscha Feuerstein

Fraunhofer-baltic PEM Fuel Differential Cell Test Cell

High quality material characterization

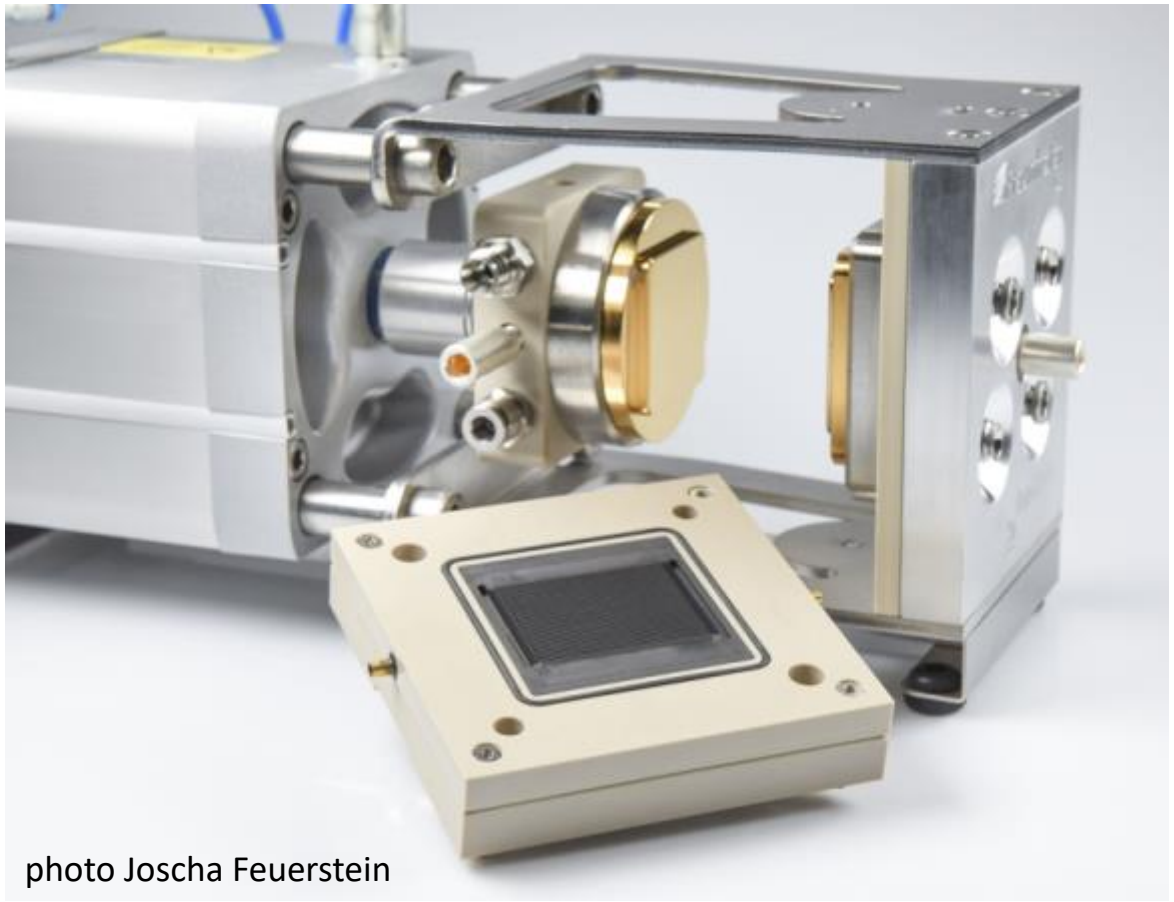


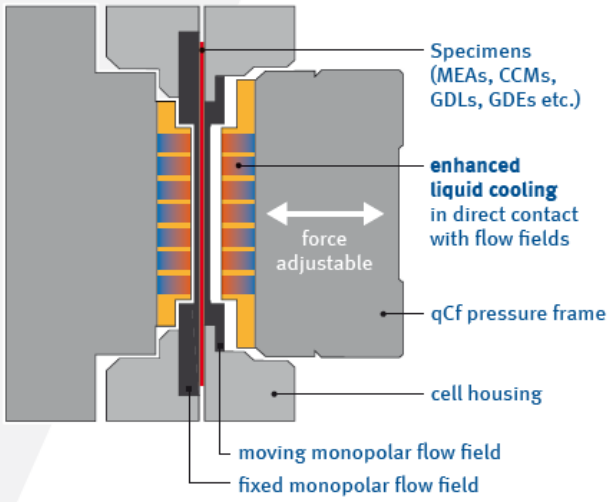
photo Joscha Feuerstein

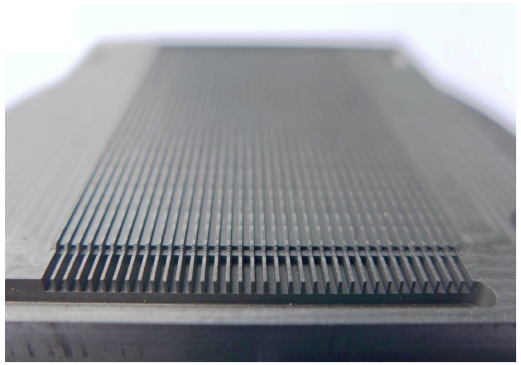
- Differential test cell (zero-gradient) for homogeneous conditions
- Effective liquid cooling
- Controllable (pneumatic) clamping pressure directly on the active area (GDL thickness variable & no gasket compression set-off)
- Easy handling for fast component exchange and low down-time

baltic FuelCells
Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur
Koordiniert durch: NOW GMBH.DE
Projektträger: PtJ
Fraunhofer ISE

Fraunhofer-baltic PEM Fuel Differential Cell Test Cell

High quality material characterization





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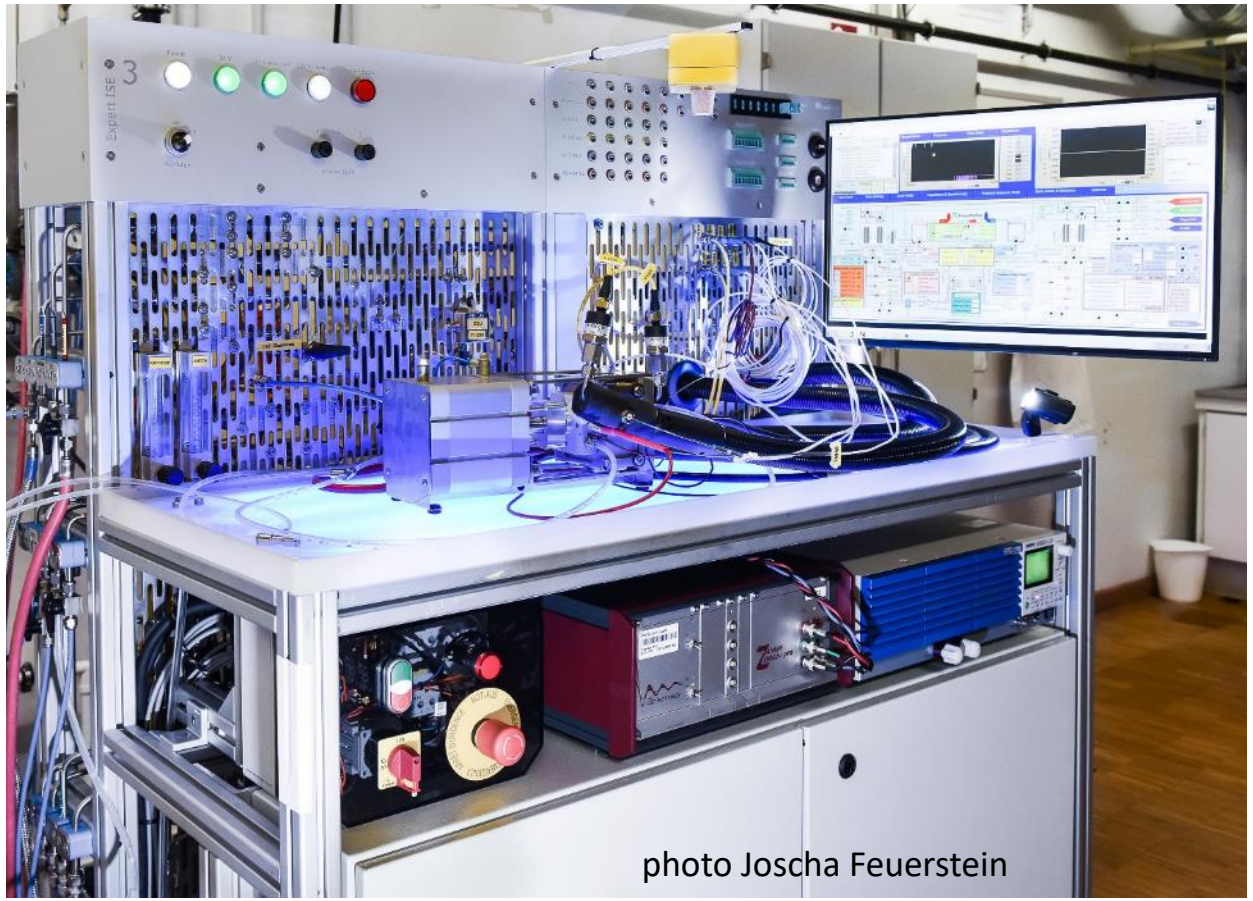
Fraunhofer ISE Single Cell Test Stations

High quality material characterization



- 3rd generation of in-house developed test stations
- Fully automated for 24/7 operation
- Operation with air, oxygen, hydrogen, nitrogen, CO, or contaminants
- Dynamic humidification
- State-of-the-art electro-chemical in-situ characterization for polarization curve, electro-chemical impedance spectroscopy (air/H_2 and N_2/H_2), cyclovoltammetry, linear sweep voltammetry, limiting current measurement, CO stripping and displacement

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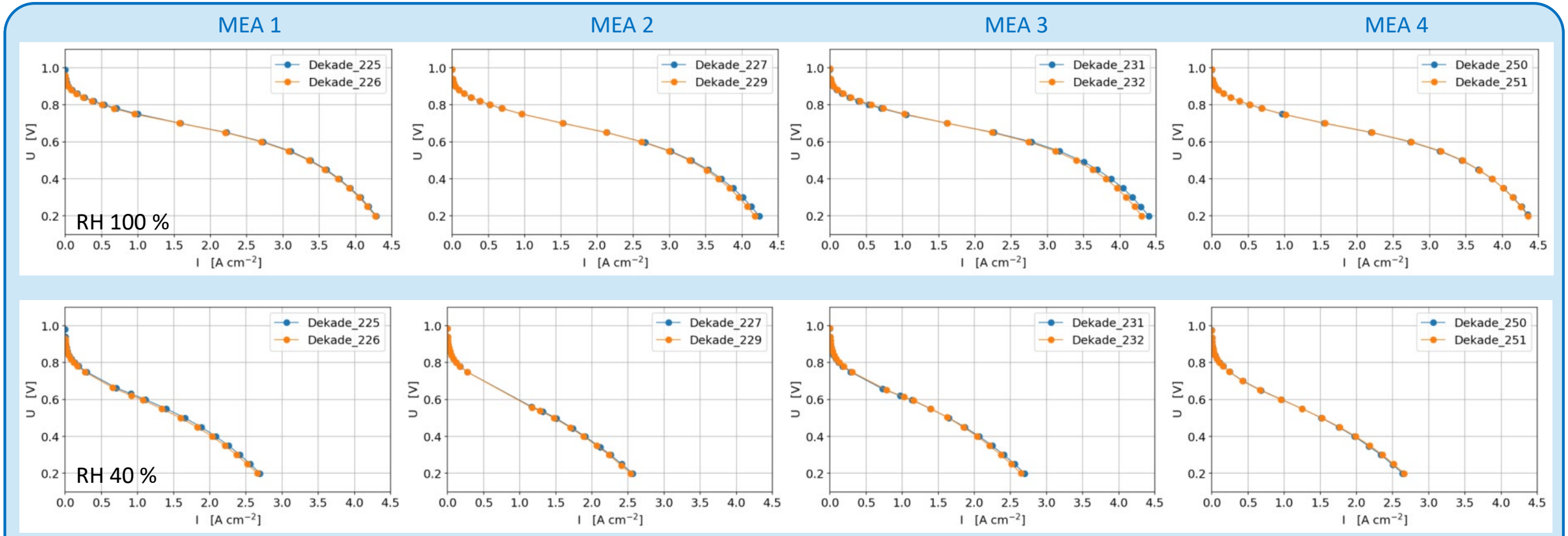
High Reproducibility of Production Process and In-Situ Characterization

Polarization Curves, wet & dry conditions



air/H_2, 0,25 mg_{Pt}/cm^2 (C), 0,05 mg_{Pt}/cm^2 (A), RH 100% A/C, 2 bar_a

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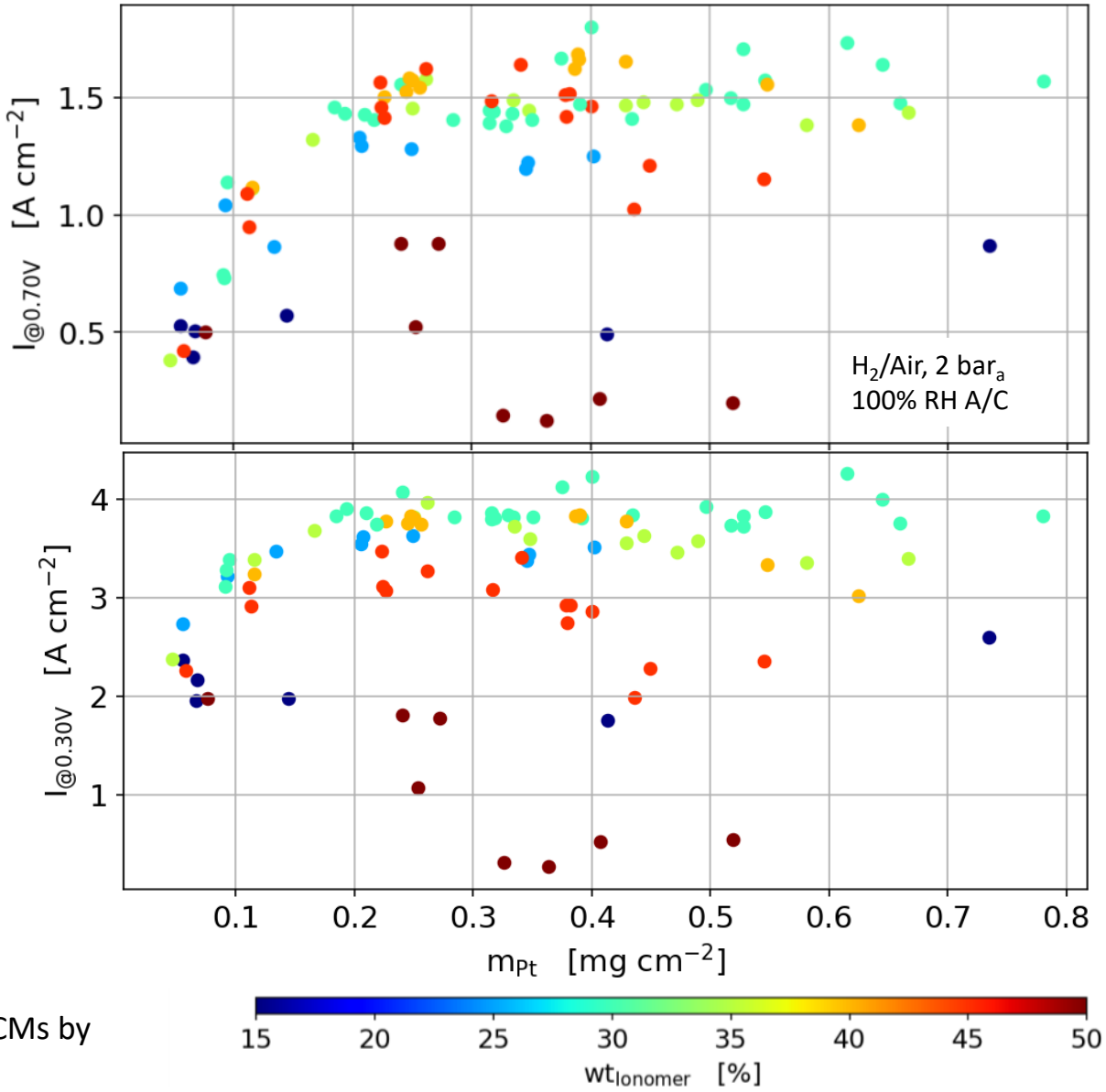
Impact of Catalyst Layer Composition on Fuel Cell Performance

- @ 700 mV: Higher Ionomer contents (35 – 45 wt%) reach highest currents
  - Limited by protonic connection at membrane-catalyst layer interface
- @ 300 mV: Medium Ionomer contents (25 – 30 wt%) reach highest currents
  - Limited by gas diffusion at catalyst layer – gas diffusion layer interface



Performance of CCMs at 700 mV (above) and 300 mV (below) depending on cathode Pt loading (x-axis) and ionomer content (colours). Fraunhofer ISE CCMs by screen printing.

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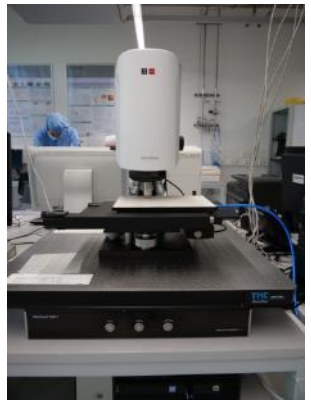
CCM Production Research at ISE

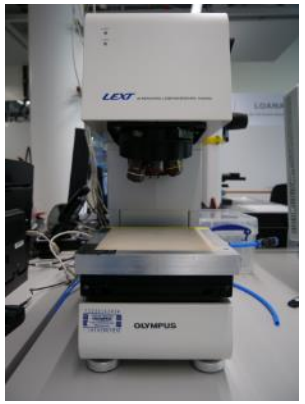
Quality assurance

Laser Diffraction Particle Size Analyzer

TGA



Sensofar



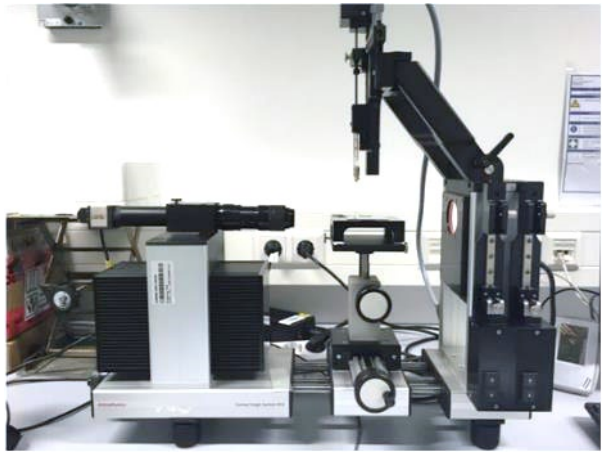
Olympus LEXT

Anton Paar Rheometer

Quadrasorp (Nitrogen-Adsorption)

Ionic conductometry & pH-value

DSC

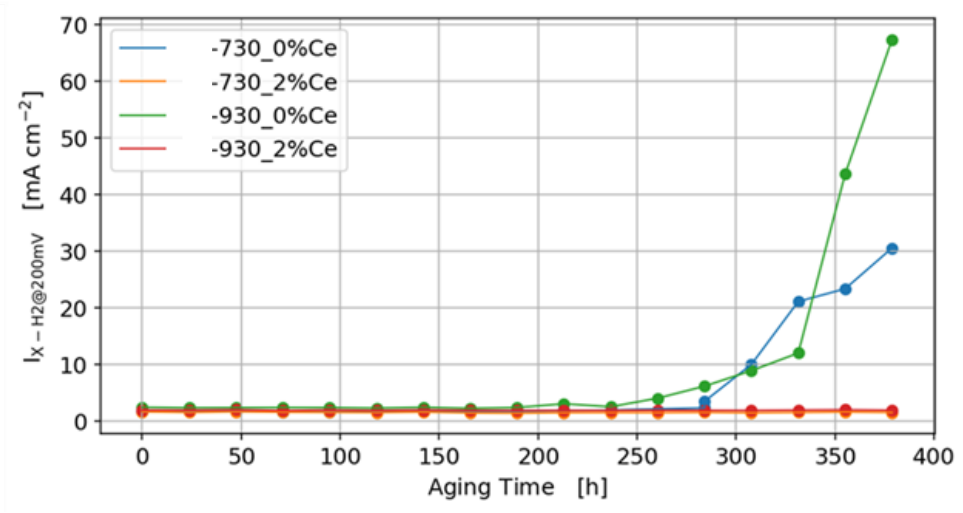


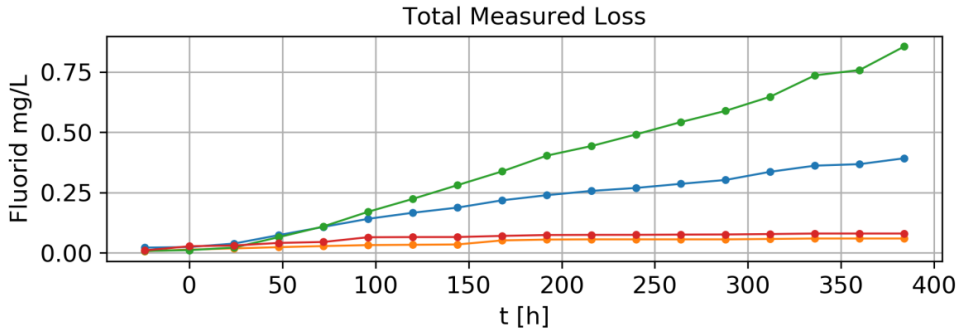
OCA contact angle

Parallelization of up to Four Single Cells

High throughput lifetime testing

- Lifetime testing of up to four samples in parallel
  - Membrane aging
  - Drive-Cycles
- Product water analysis with ICP and others
- Fully automated





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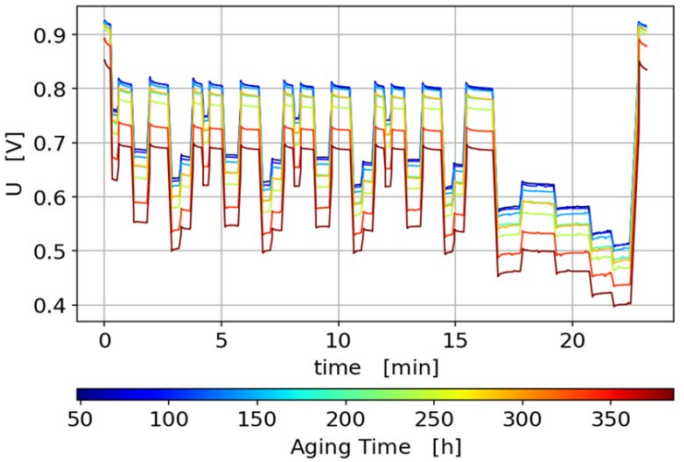

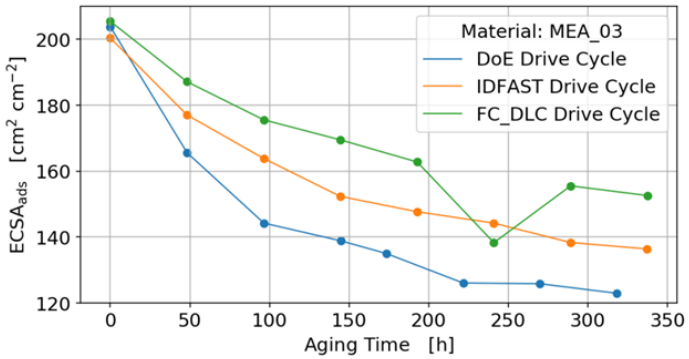

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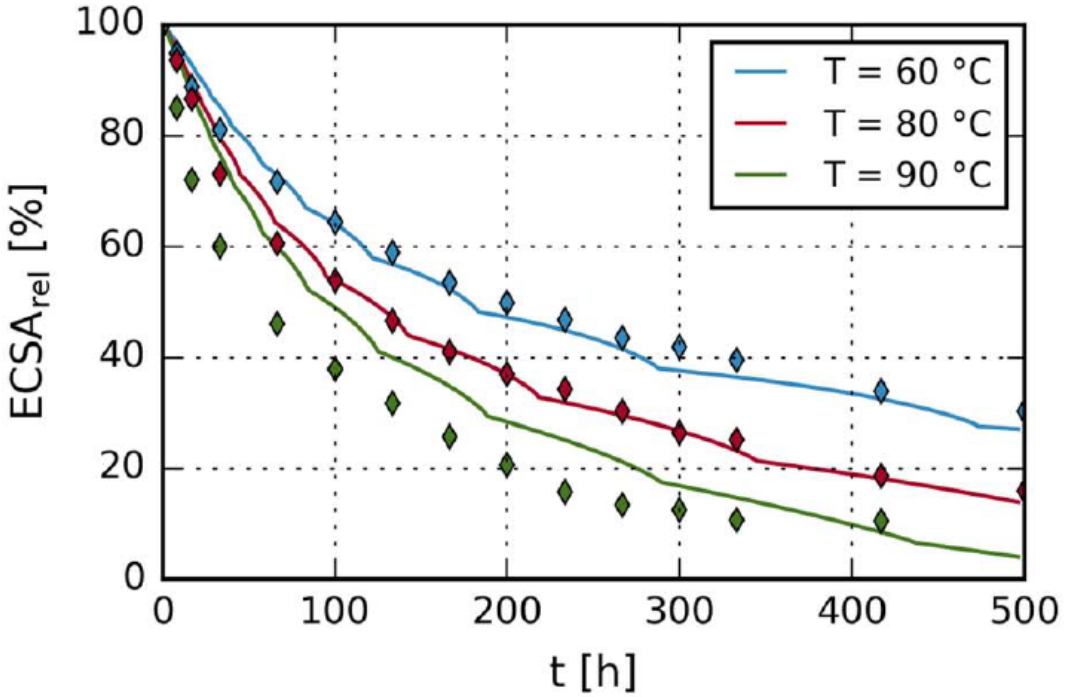
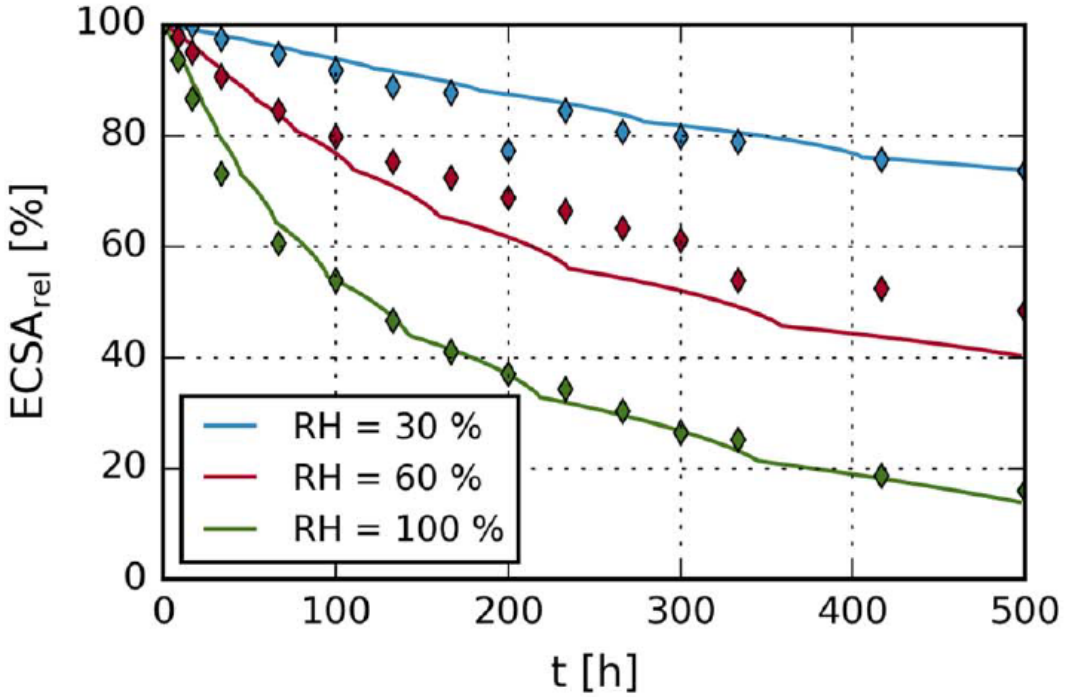
Focus on Fuel Cell Lifetime Analysis

Wide range of Pt degradation ASTs





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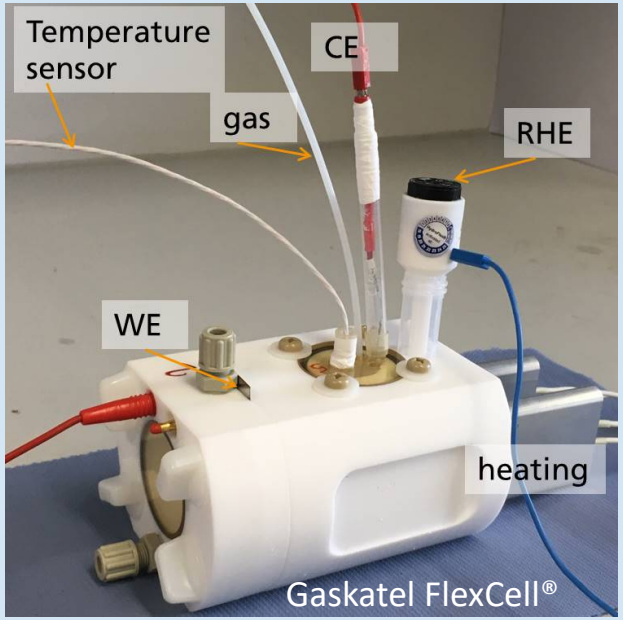
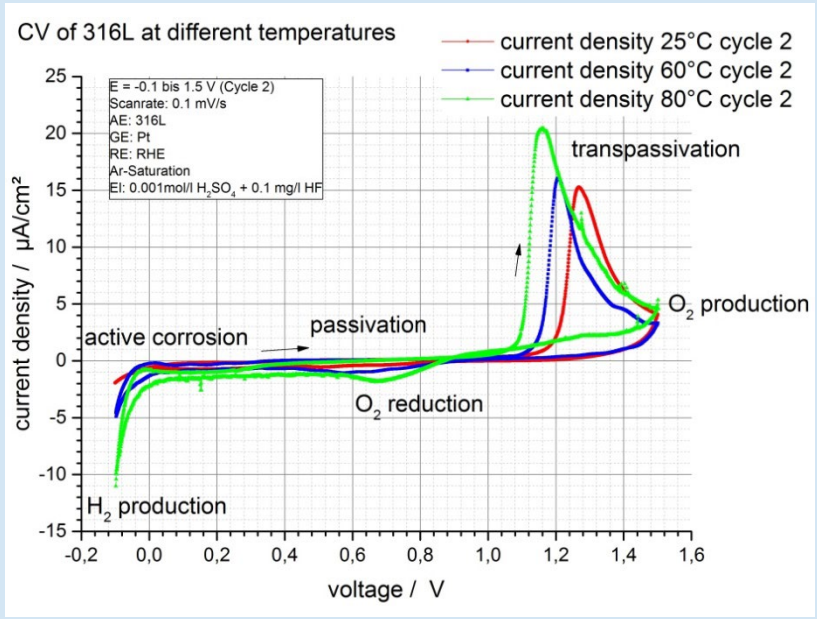
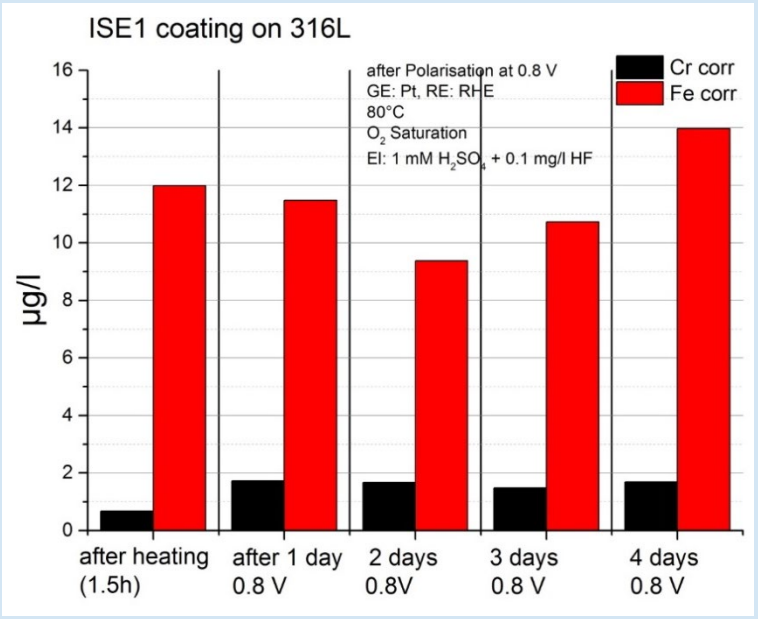
Electrochemical characterization of bipolar plate materials



Test cell made of PTFE, integrated heating, gas (Ar or O_2), working electrode (WE) (sample), reference electrode (RHE), counter electrode (CE).



Cyclic voltammogramm of stainless steel at different temperatures, electrolyte:
0.001 M H_2SO_4+0.1 mg HF



Electrochemical measurements is combined with elemental analysis of the electrolyte with ICP-MS (here during potentiostatic test at 0.8 V for 4 days), SEM/EDX analysis, and contact resistance measurement.

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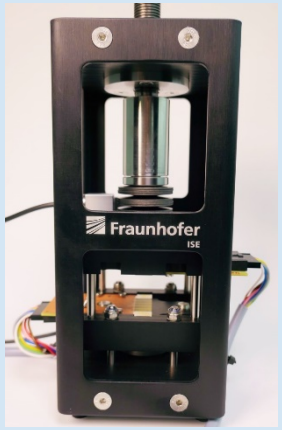
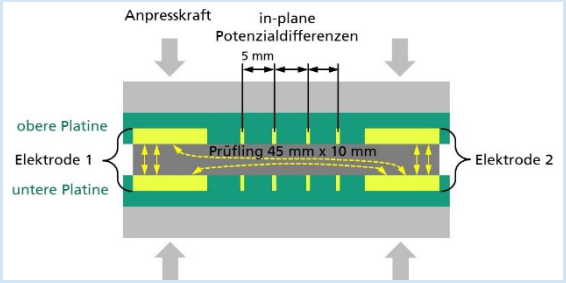
Through-plane resistance and interfacial contact resistance

- Measurement of through-plane resistance of different materials
- Interfacial contact resistance (ICR) between bipolar plate and GDL
- Bulk resistance of GDL
- Thickness measurement

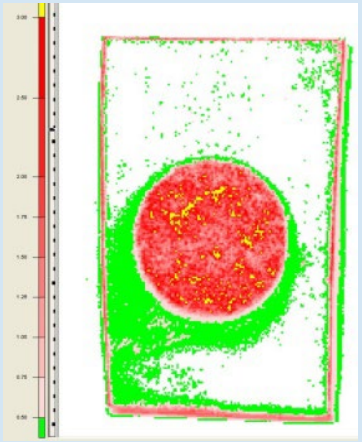
Measurement setup



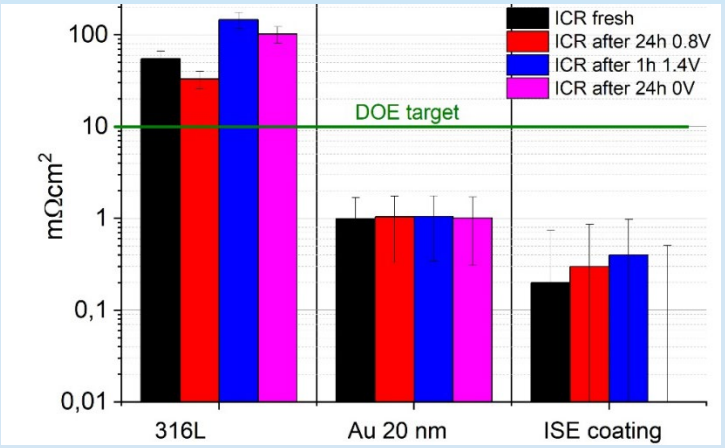
Measurement principle



Homogeneous pressure distribution



ICR of uncoated and coated SS 316 L before & after electrochemical testing



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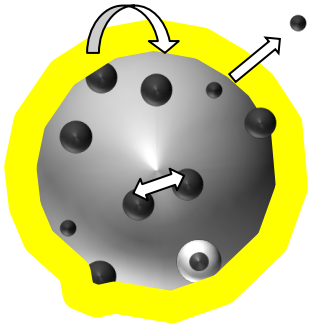
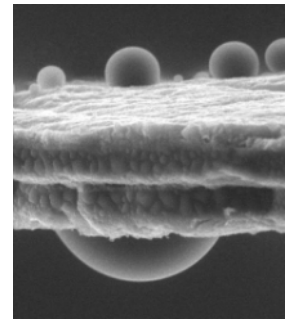
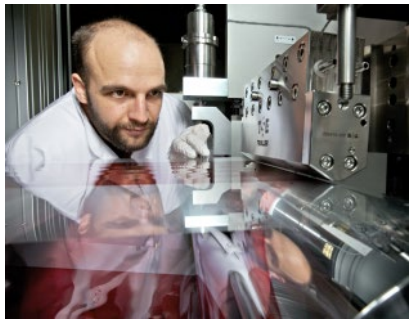
Thank You! Any Questions?



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