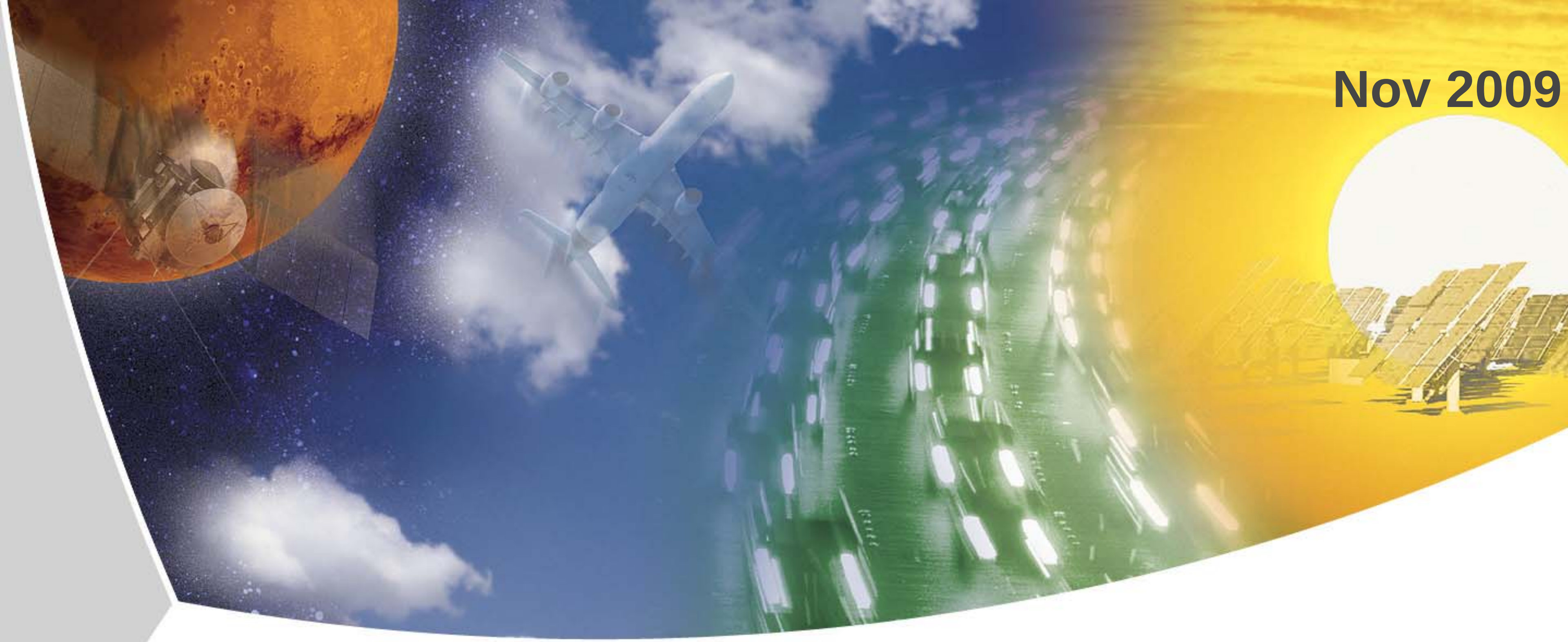

Nov 2009

Application of segmented cell to detect stability & deterioration of PEM fuel cells

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Research Topics

Topic (1)

Design and performance investigation of PEFC and DMFC

-- Advanced manufacturing methods (Dry Spraying for low cost and mass production)

-- Identification of degradation mechanism and of strategies to prevent degradation

-- In-situ and ex-situ studies of fuel cells by means of innovative measurement technology (e.g. spatially resolved measuring technique-Segmented Cell)

-- Modeling of electrochemistry and transport processes in fuel cells

Topic (2)

PEFC system

-- Development of PEFC stacks for operation temperature -30^{o}C to 130^{o}C

-- Integration of fuel cell systems for special application (e.g. for low pressure condition)

Topic (3)

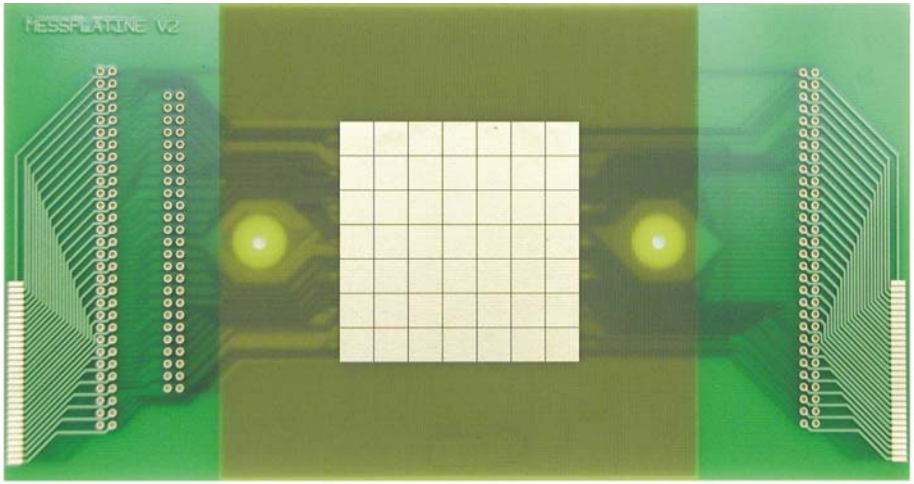
SOFC stack

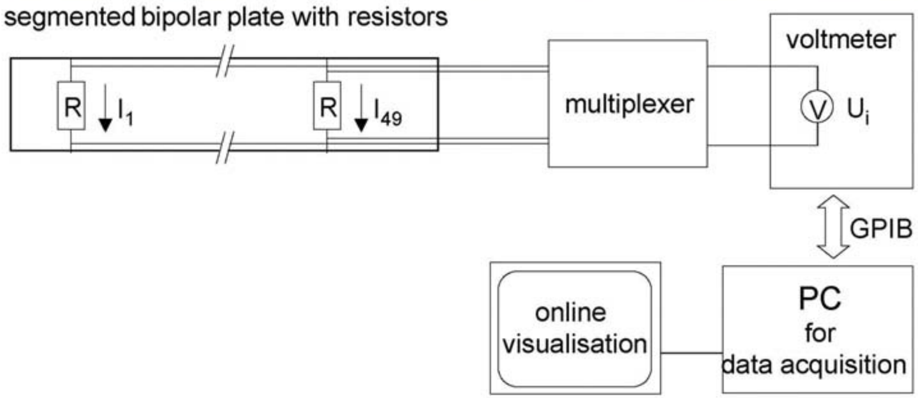
-- Development of planar SOFC stacks with metal supported cells (MSC)

Application of segmented cell to diagnose PEM fuel cell

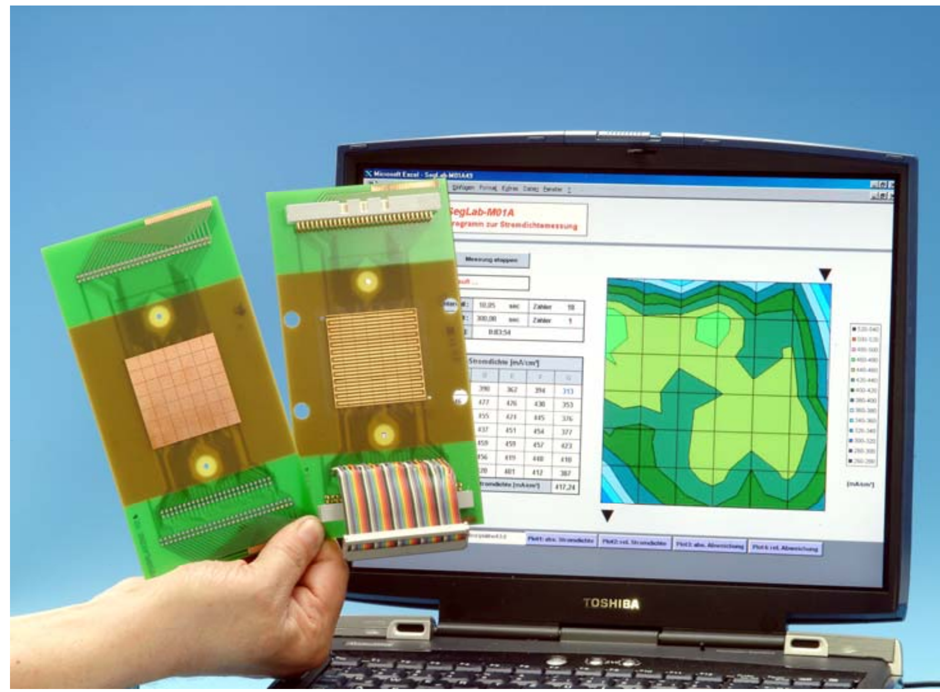
- Water management in PEM fuel cell system
- Error detection of MEA
- Relaxation Investigation of fuel cell system
- Reversibility Investigation of fuel cell system

Segmented current density measuring board



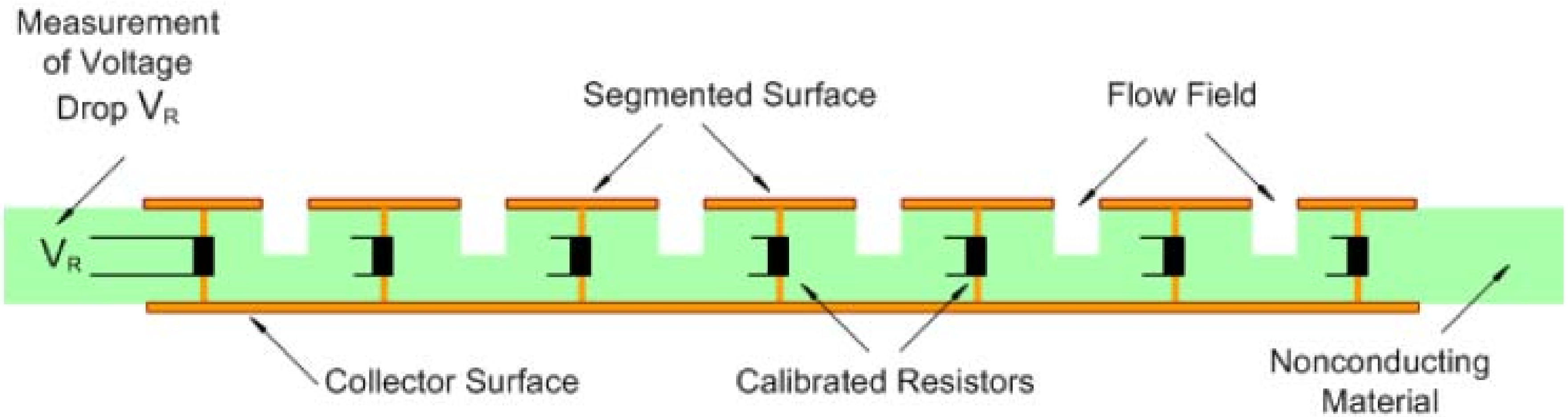


Segmented measuring board with 49 segments for fuel cell



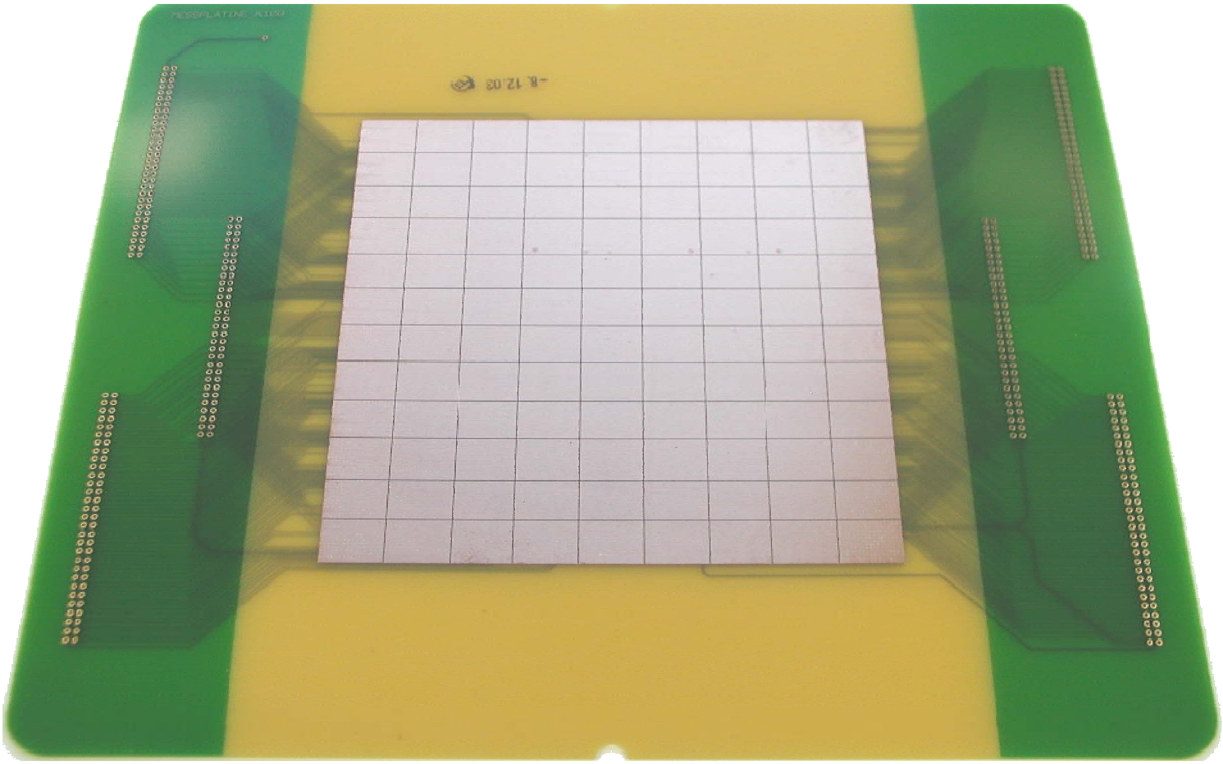
On-line visualization of current distribution measurements

Principle of DLR Segmented Bipolar Plate



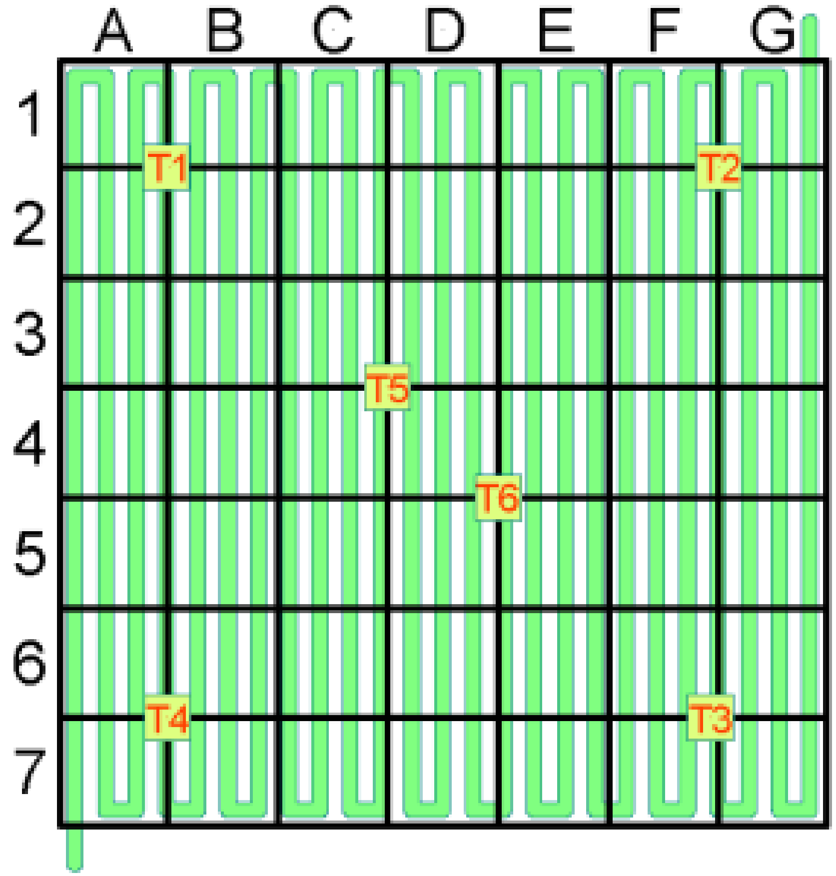
Segmented cell bipolar plate made by non-conducting material except the surface.
Currents goes on discrete one direction pathways.
The current measured by integrating calibrated resistors and the voltage drop.

Segmented current density measuring board



Segmented plate for commersialstack
108 segments, 225 cm² active area
Segment area 2 cm²

Segmented flow field of current density measuring board

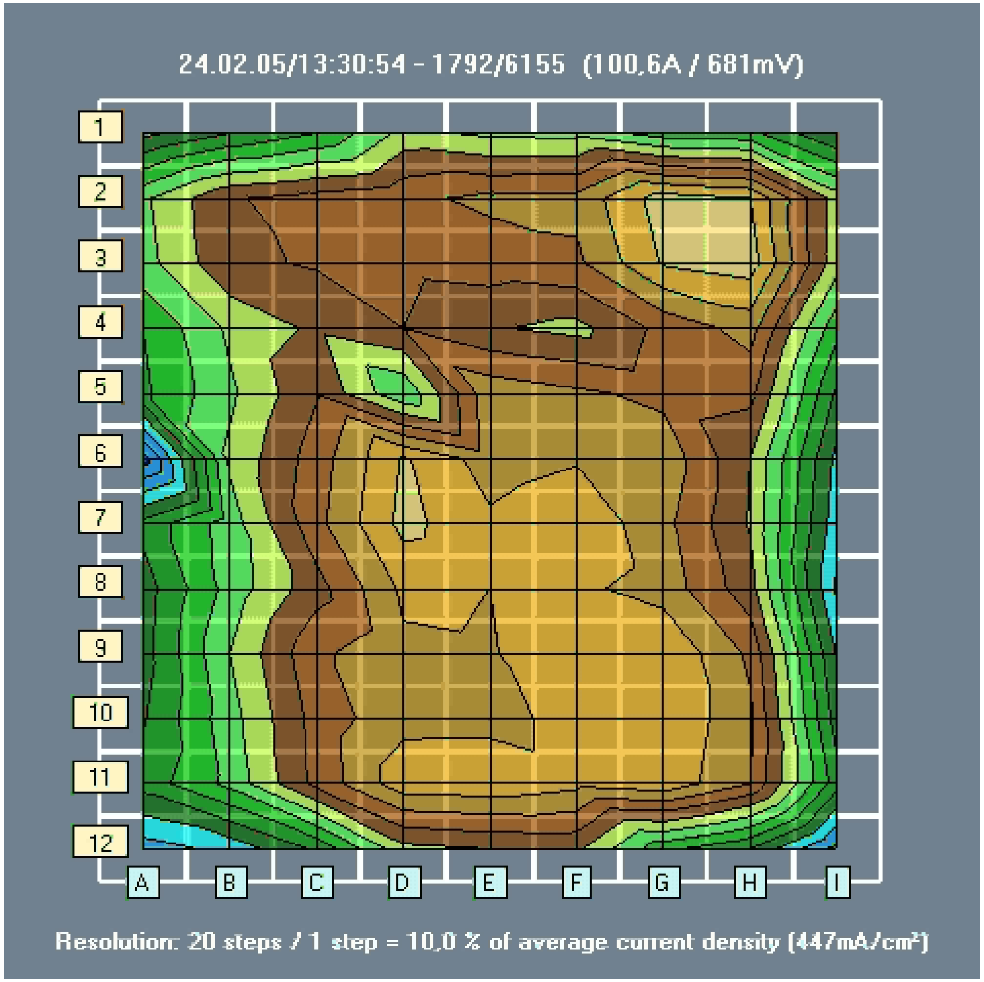


Gas Inlet:
Segment G1

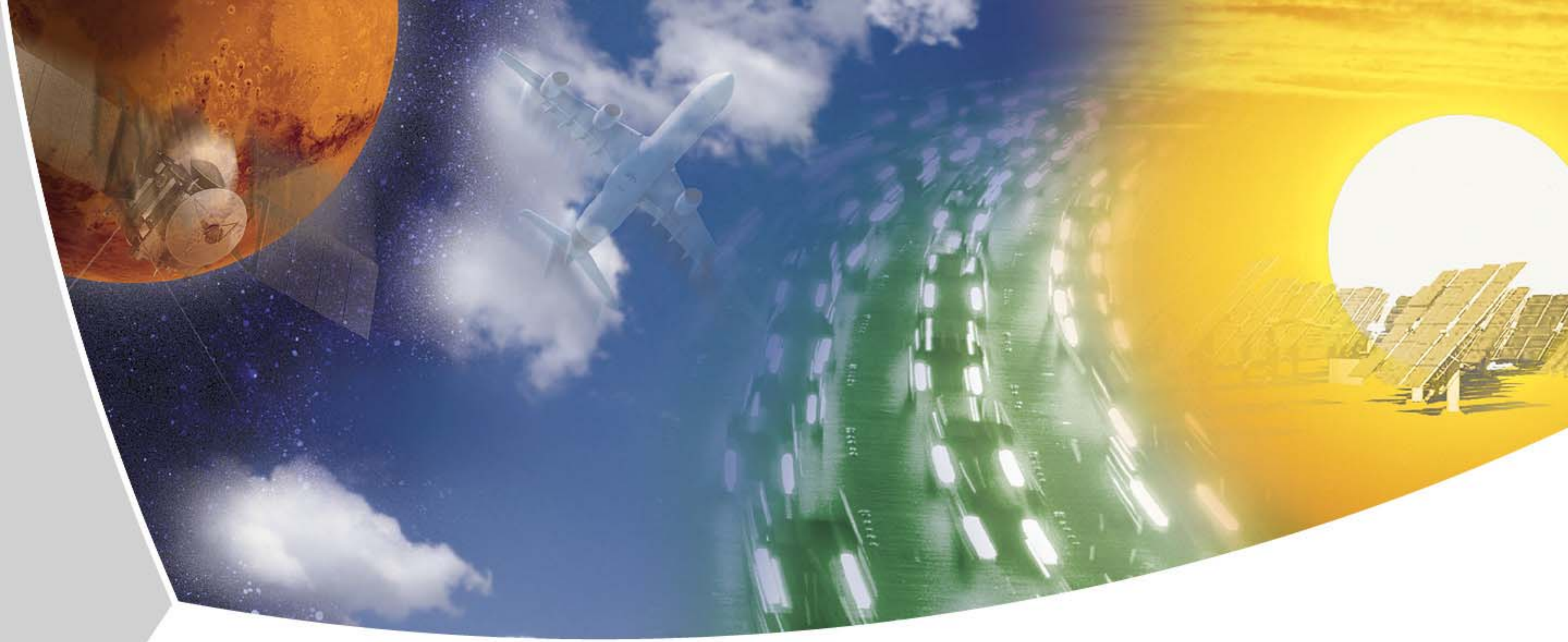
Gas Outlet:
Segment A7

Current density distribution measurements

Demonstration of Segmented Cell



Dynamic change of current density distribution in segmented cell



Water management in PEM fuel cell system

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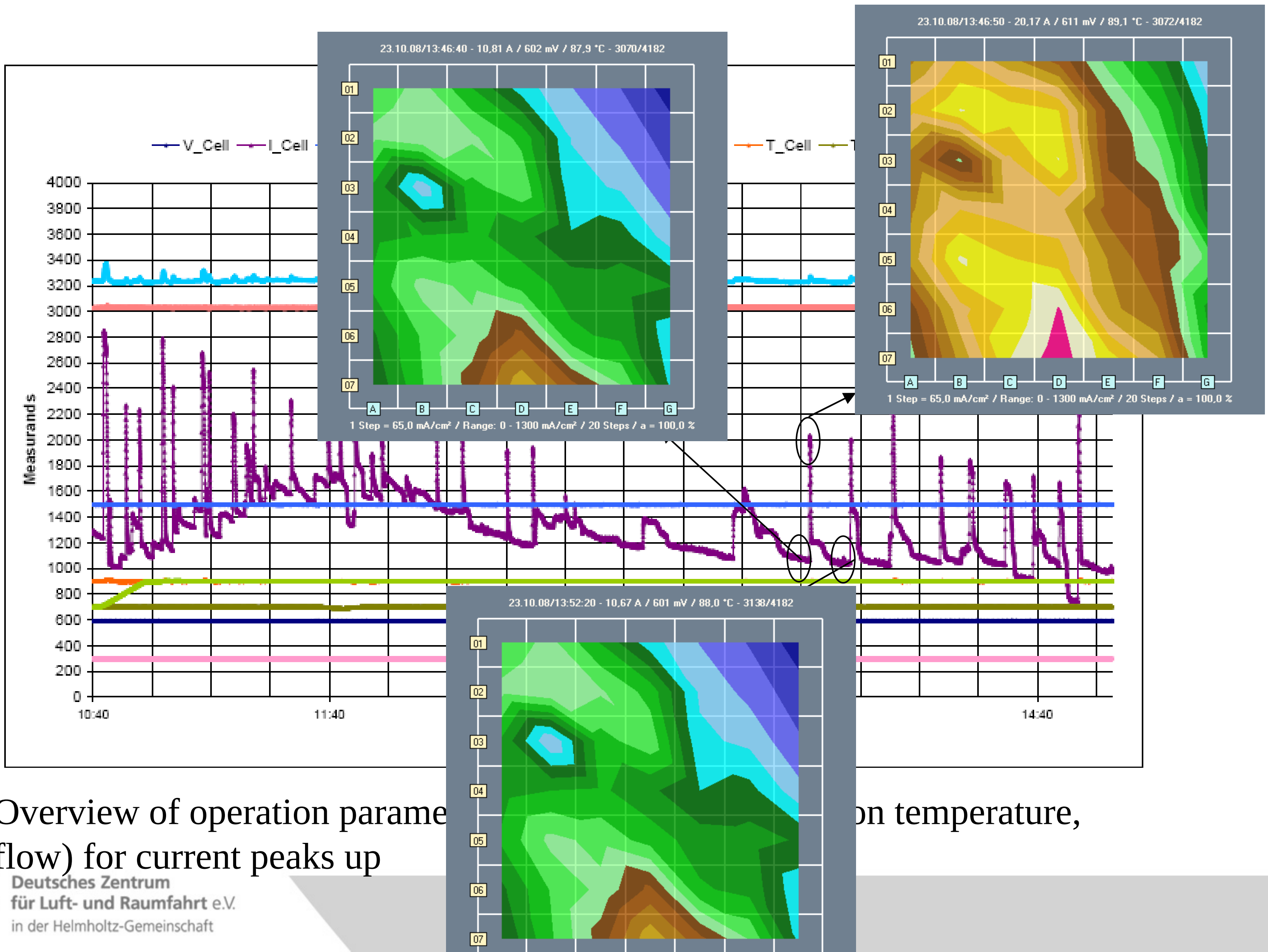
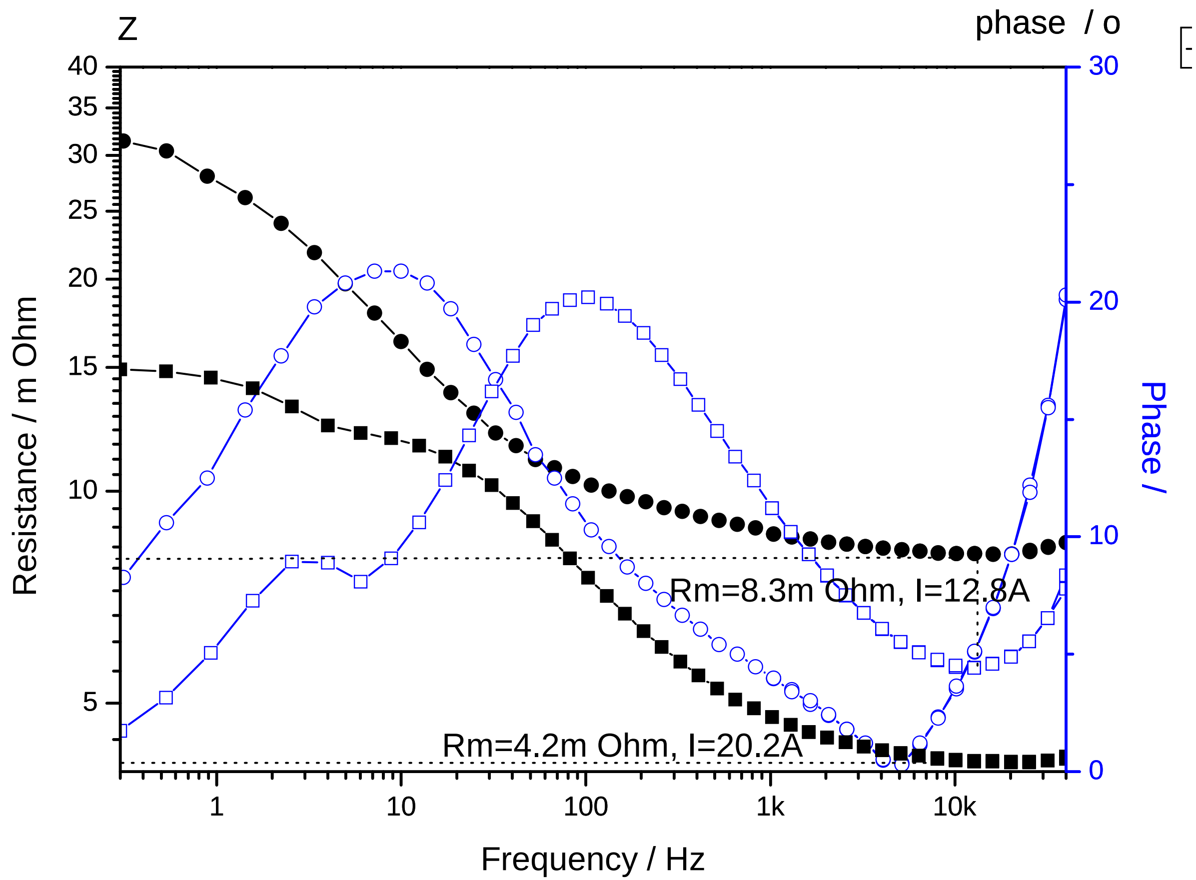
Instability of PEM fuel cell at drying out



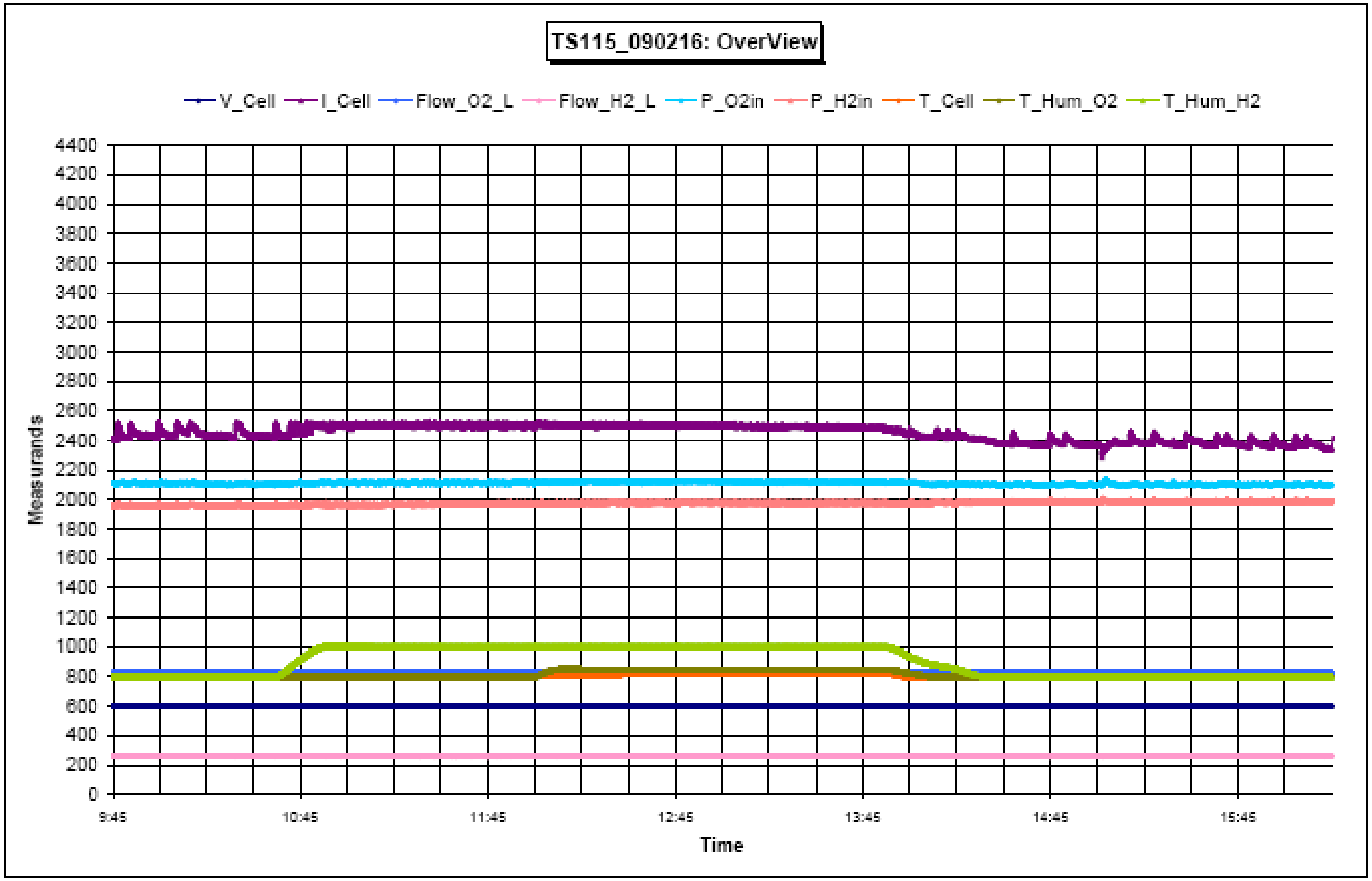
Overview of operation parame… …on temperature, flow) for current peaks up

Investigation of Water Management in PEM Fuel Cells



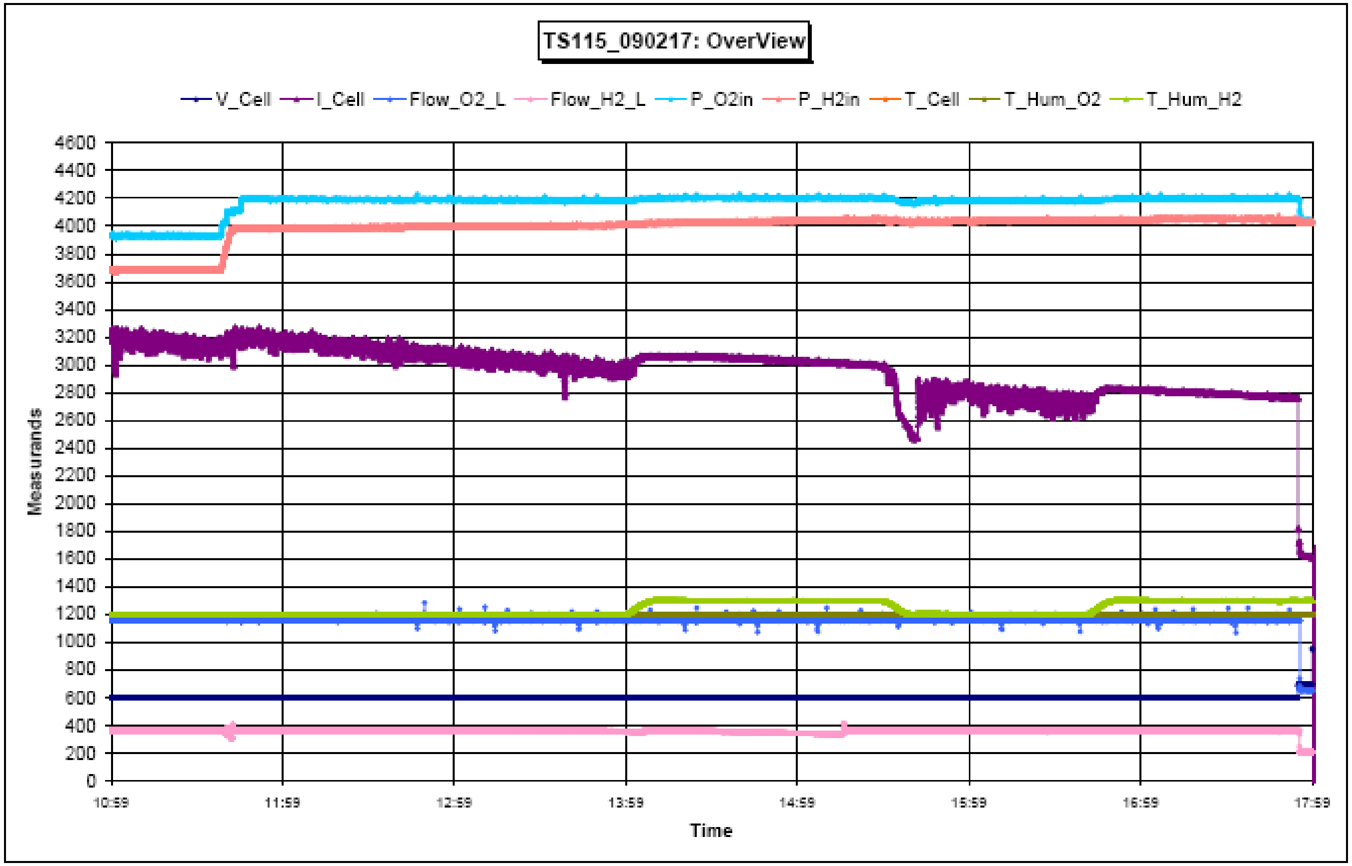
Bode curves: Comparison membrane resistance between peak and baseline

Stability Optimization



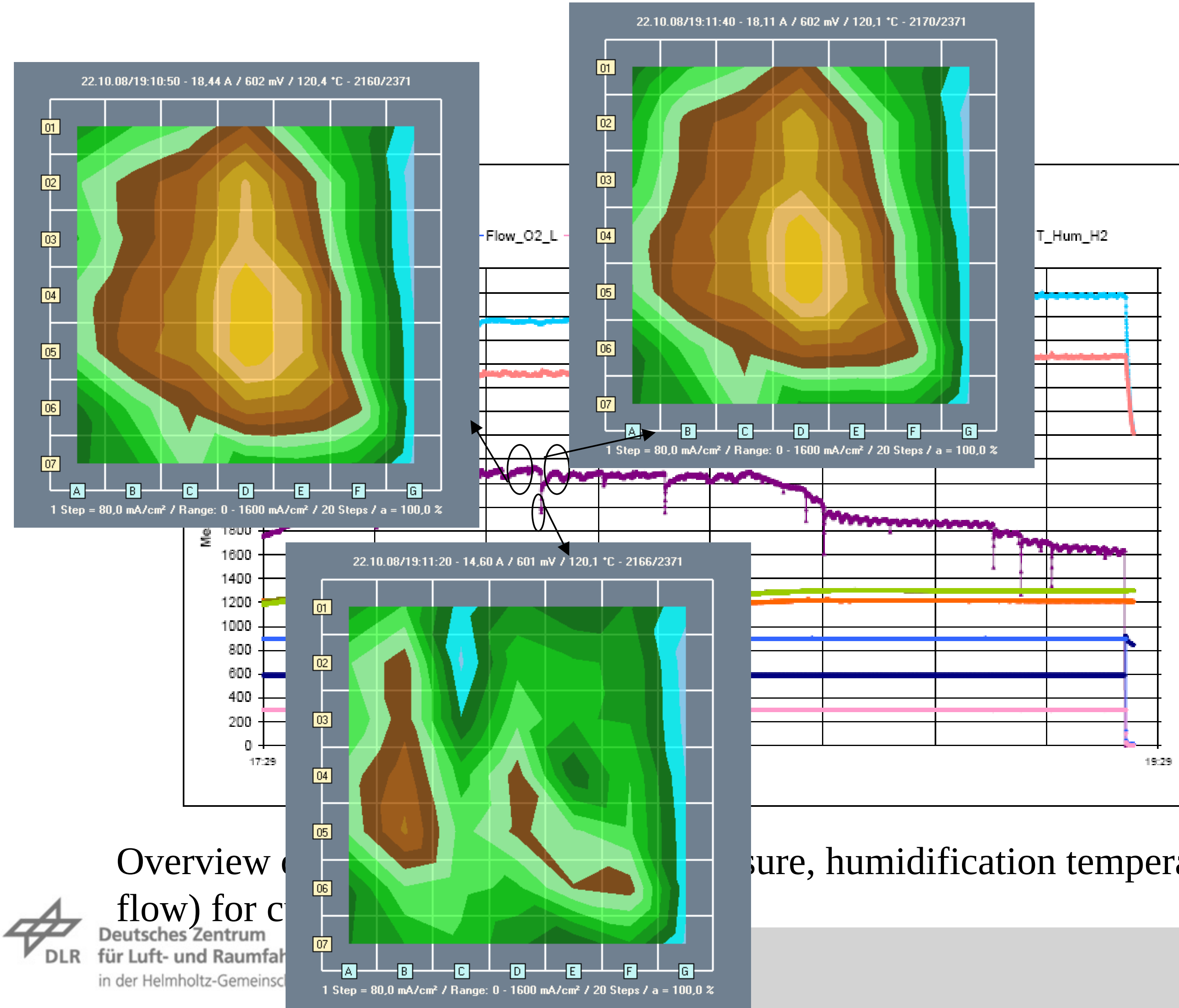
Stability optimization by adjusting feed stream humidification:
Increase of anode humidification at Tcell = 80°C

Stability Optimization

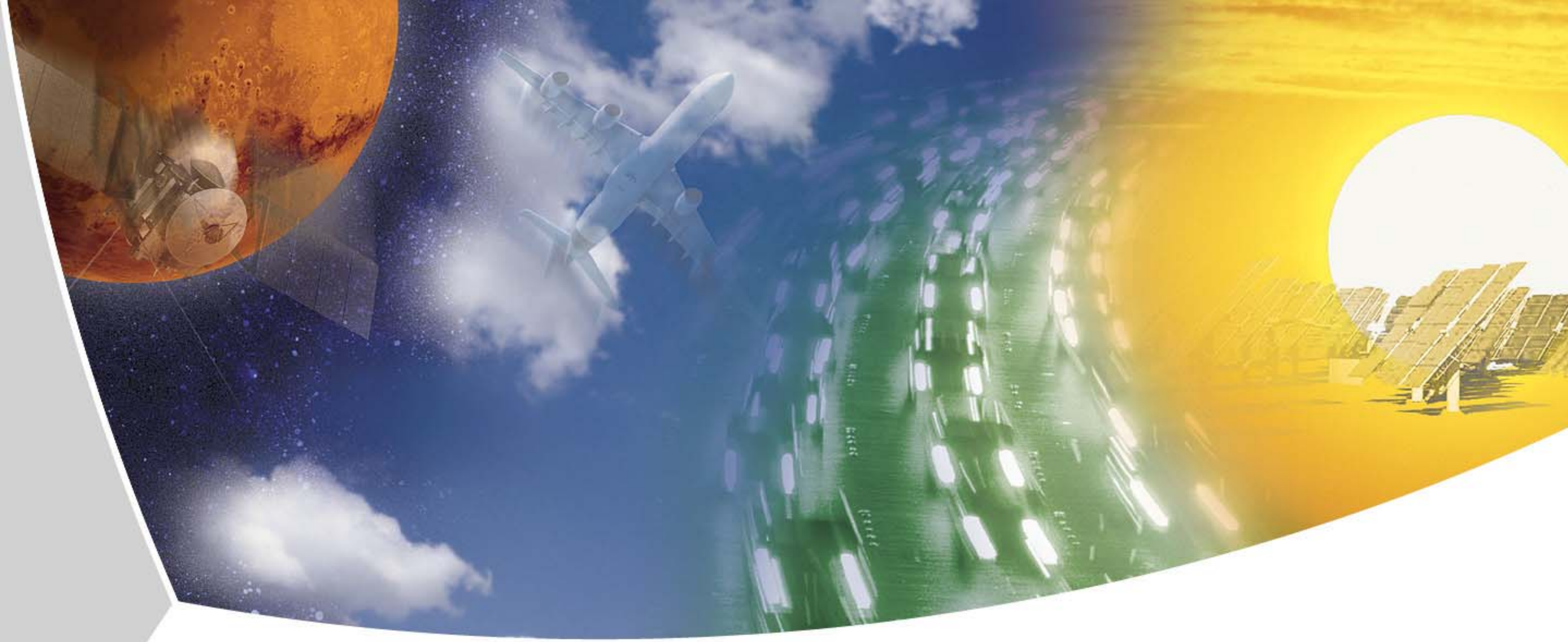


Stability optimization by adjusting feed stream humidification:
Increase of anode humidification at Tcell = 120°C

Instability of PEM fuel cell at flooding

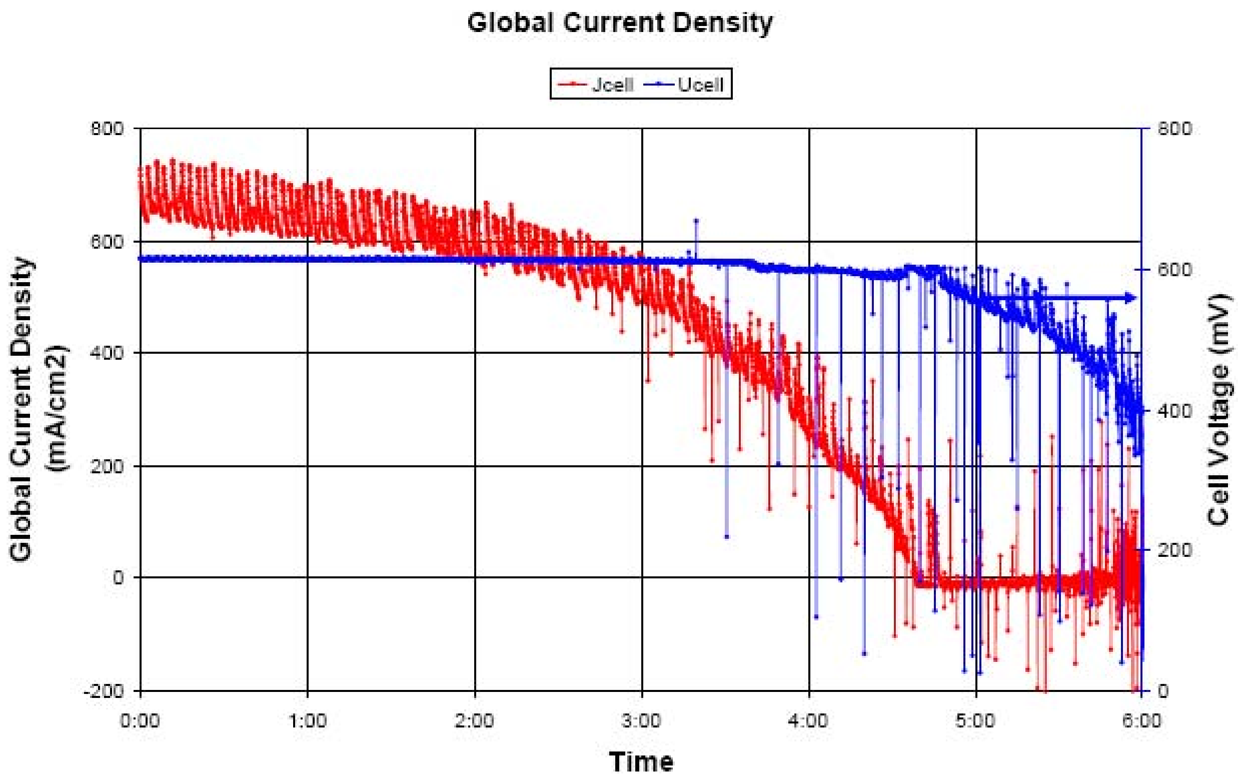


Overview o… …sure, humidification temperature, flow) for c…



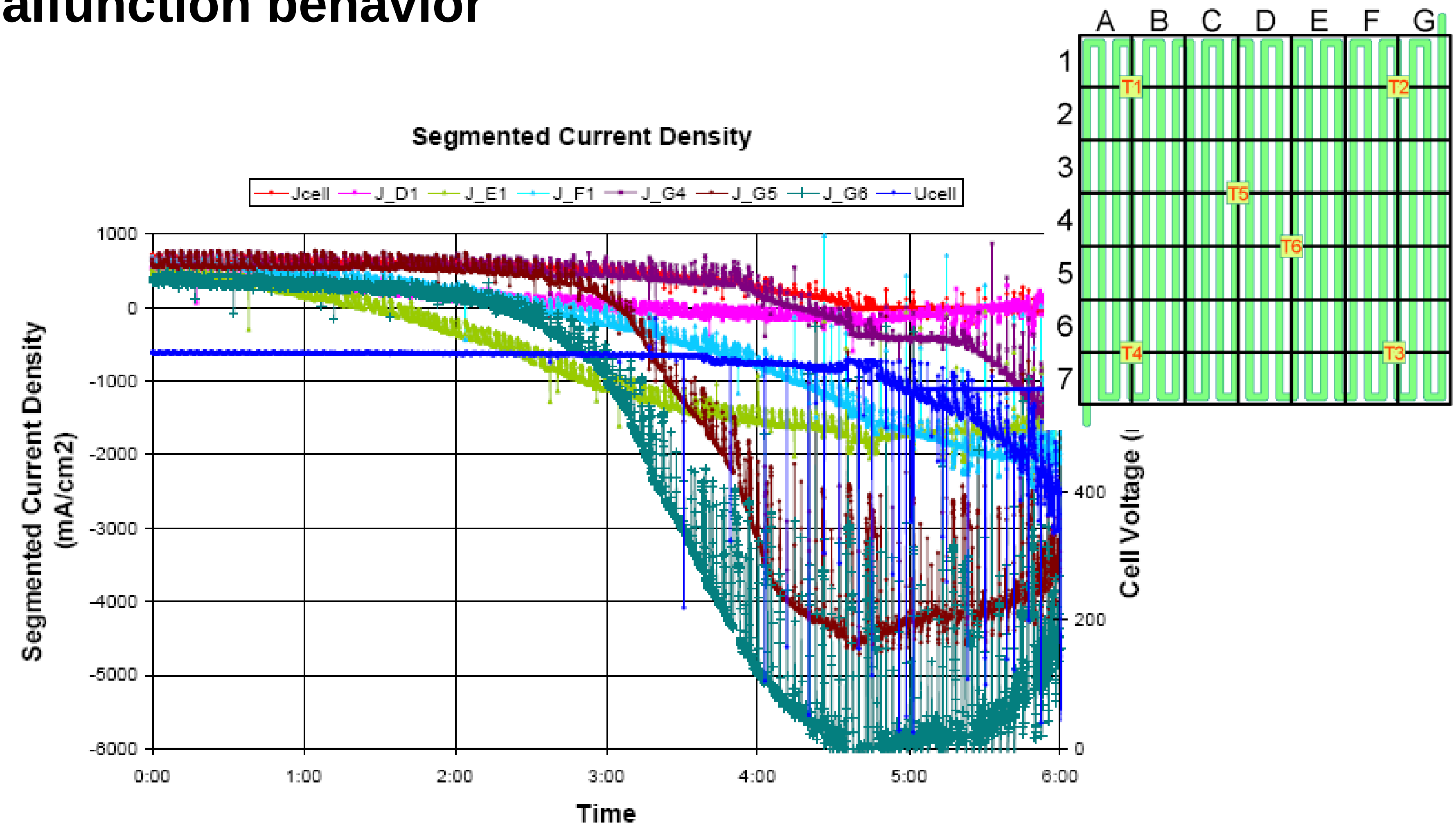
Error detection of MEA

Malfunction behavior



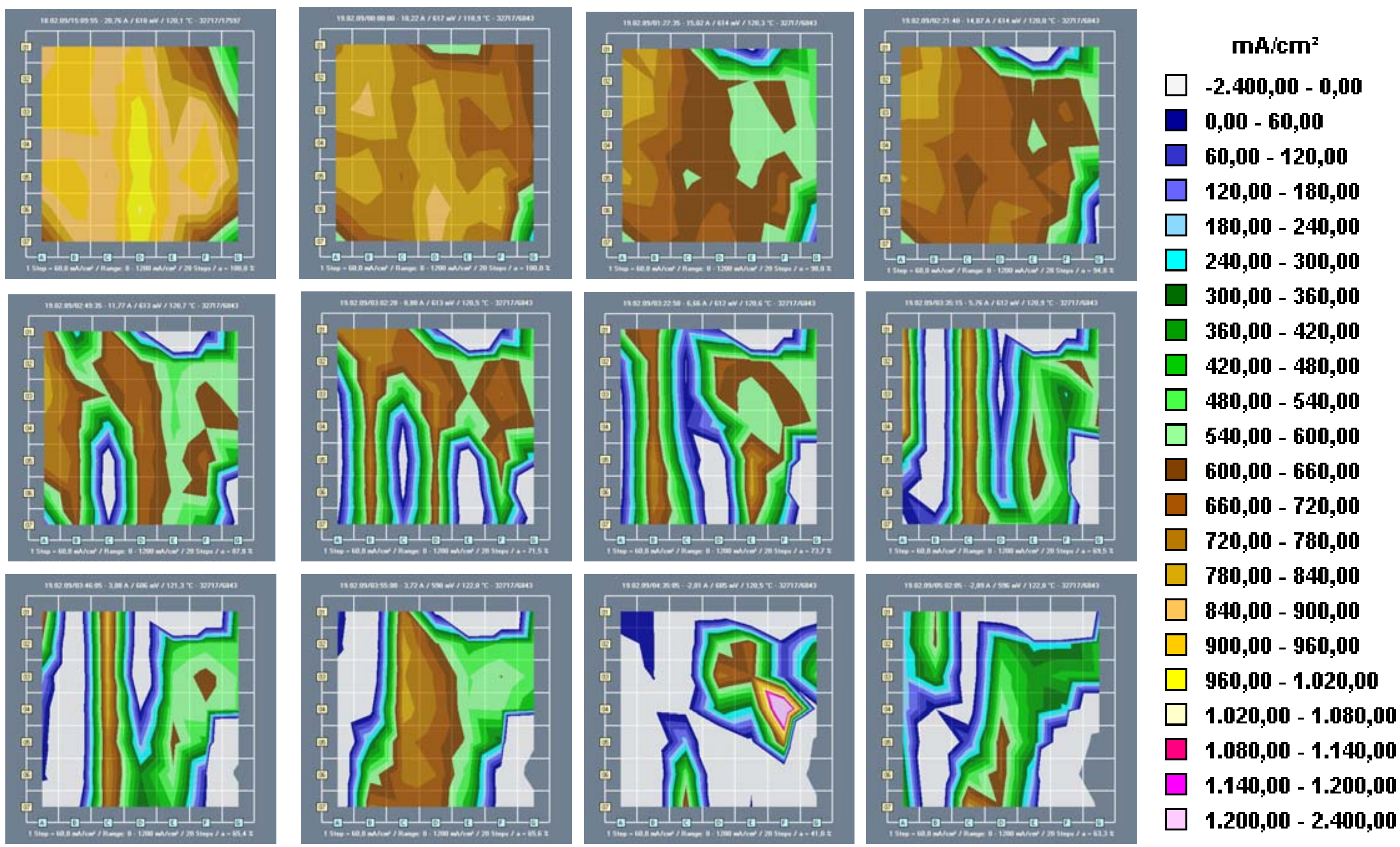
Plots of global current density distribution and cell voltage versus time

Malfunction behavior



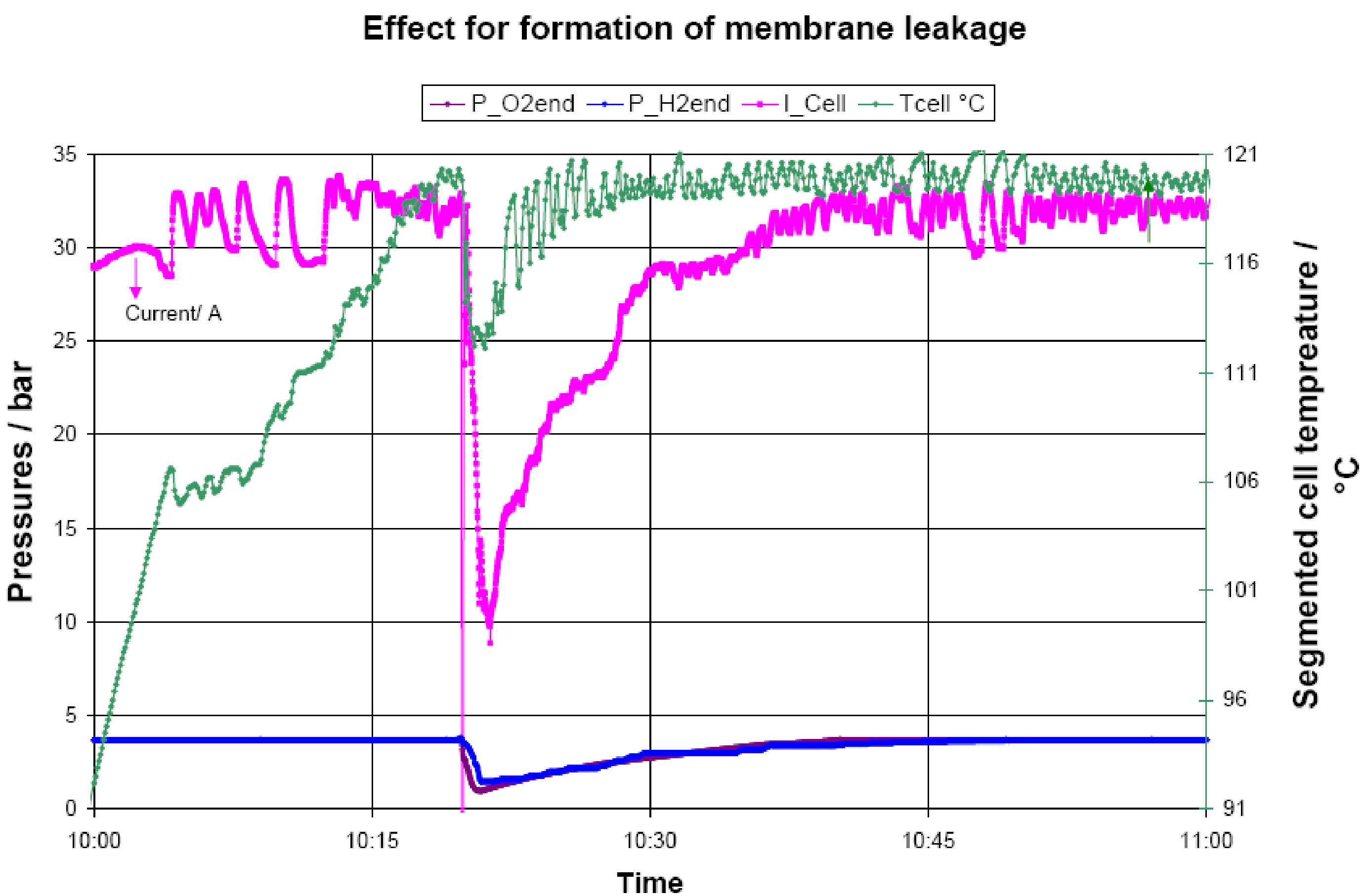
Current density plots of segments E1, G6, F1, D1, G5 and G4.

Mapping of current density distributions during evolution of leakage

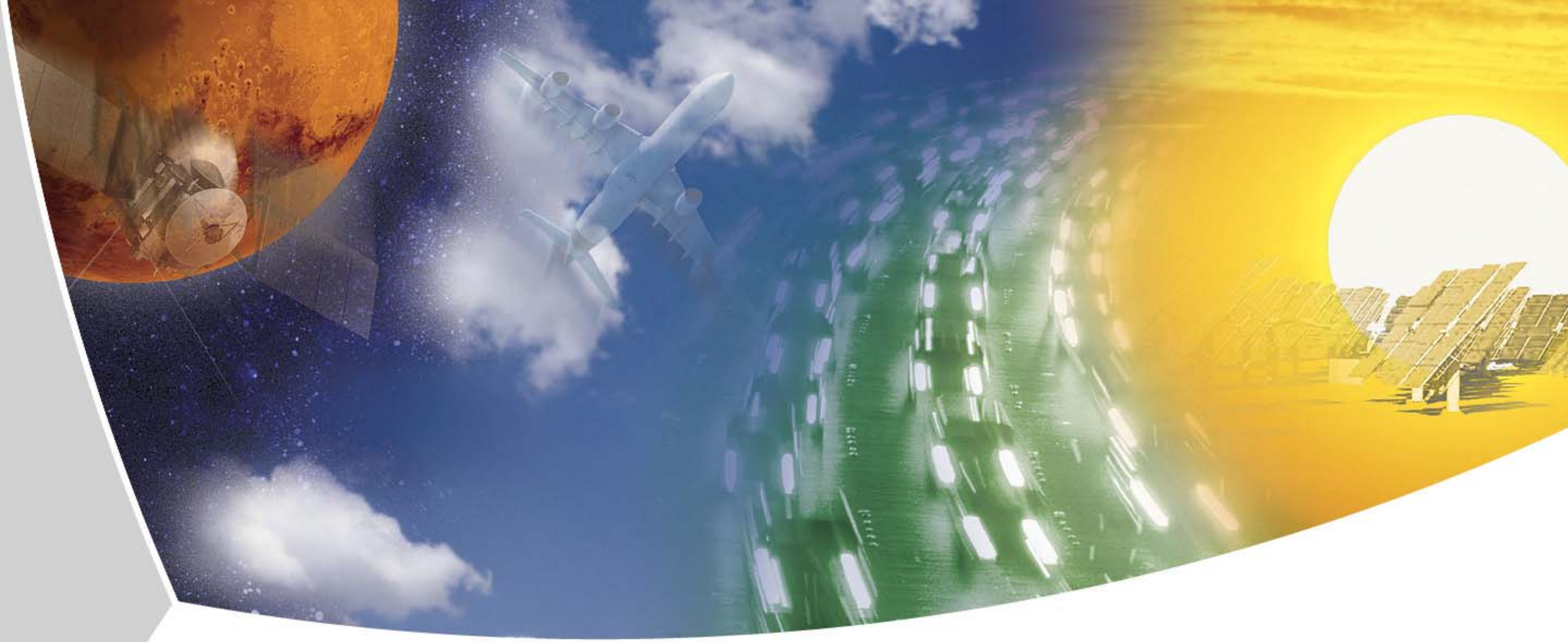


Absolute values of current density plotted (E1, G6, F1, D1, G5 and G4)

Evolution of pressure, current and temperature of the segmented cell



Two days before the membrane leakage started



Relaxation Investigation of fuel cell system

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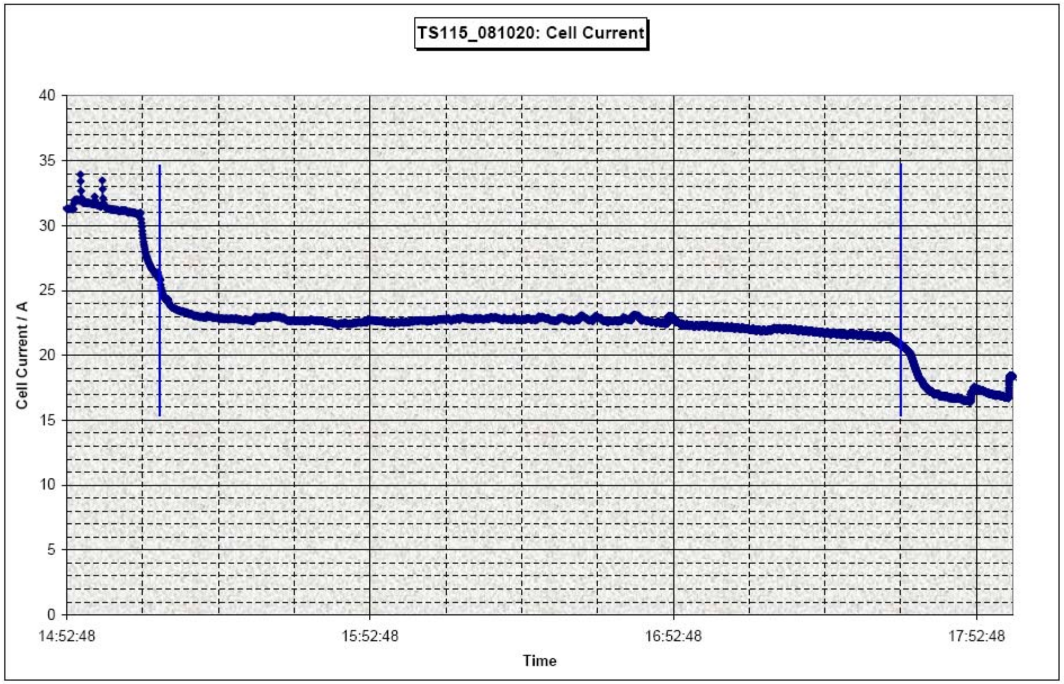
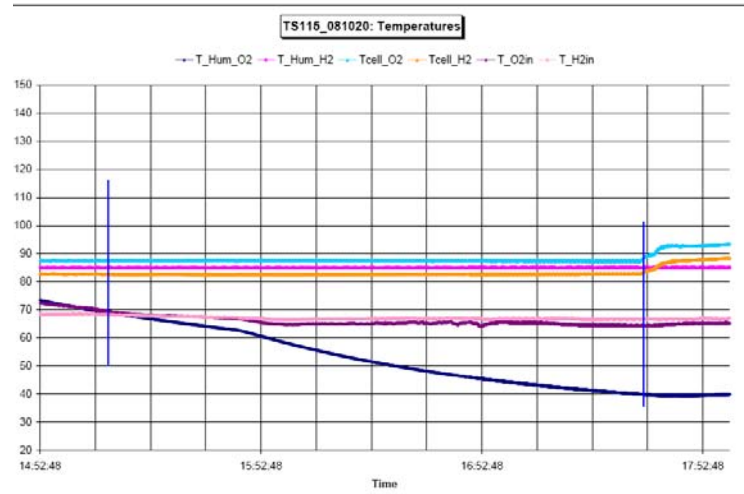
Constant current output while decreasing cathode humidification at 600 mV





T cell= T humid Anode = 85°C; T humid Cathode = 68-40°C, F air=900ml/min; F H_2=300ml/min.

Effect of humidification on the performance of cell

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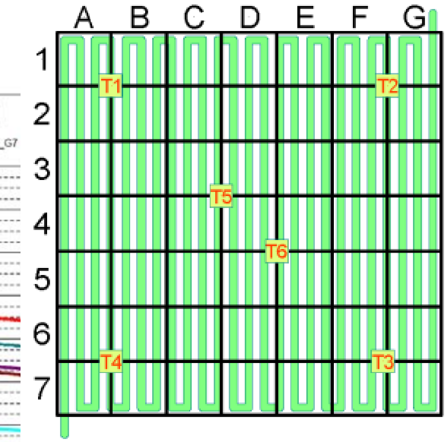
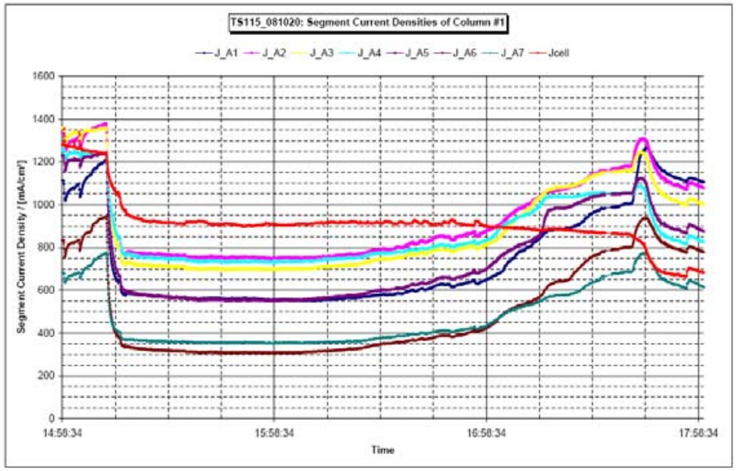
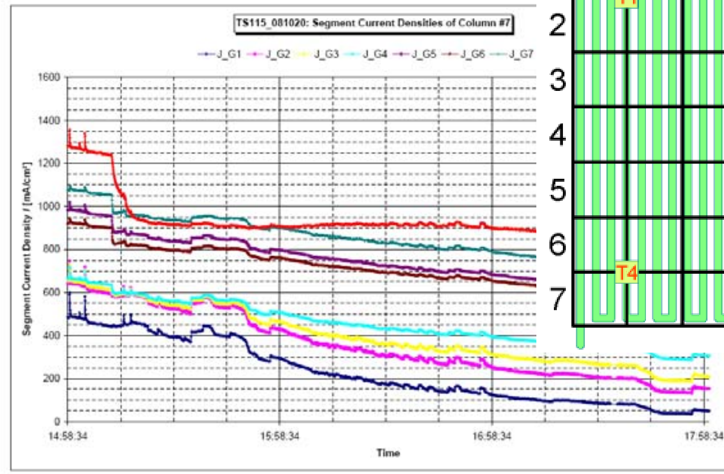
Current density distribution

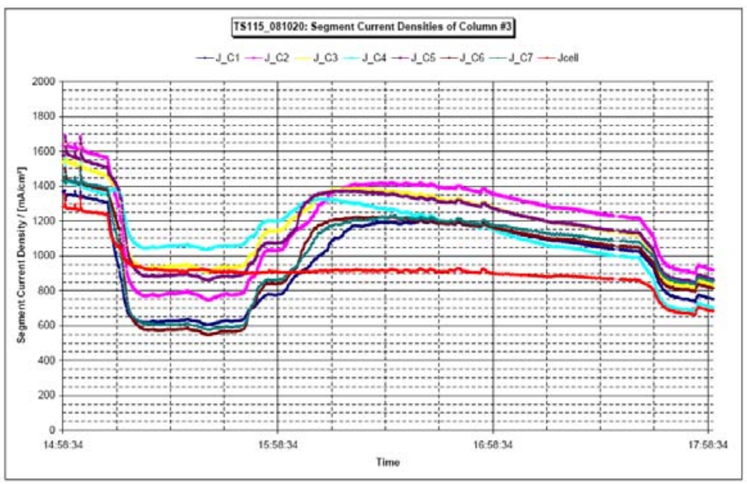


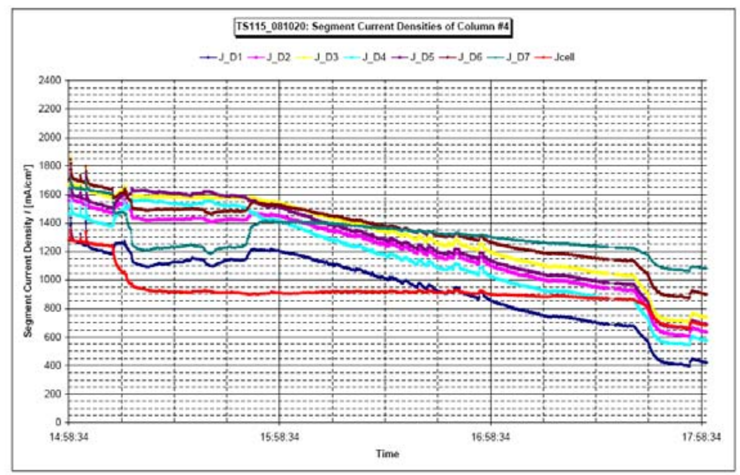
Outlet Region



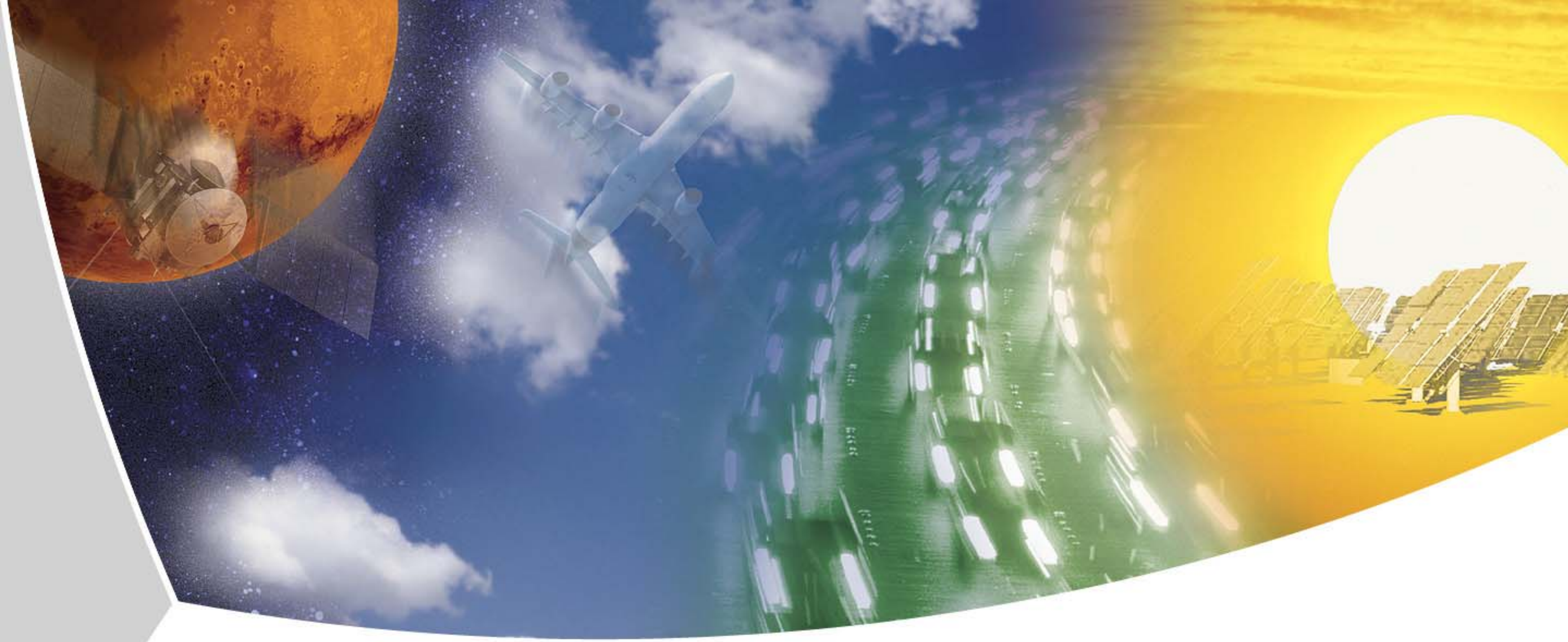


Inlet Region





An internal change of inhomogeneous current distribution occurred while global cell current did not change.



Reversibility Investigation of fuel cell system

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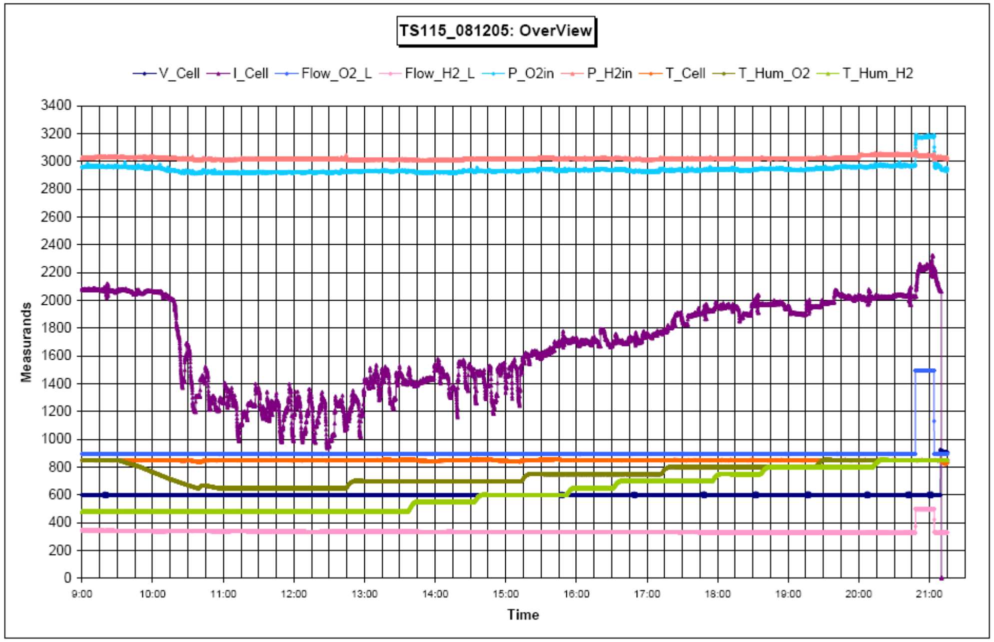
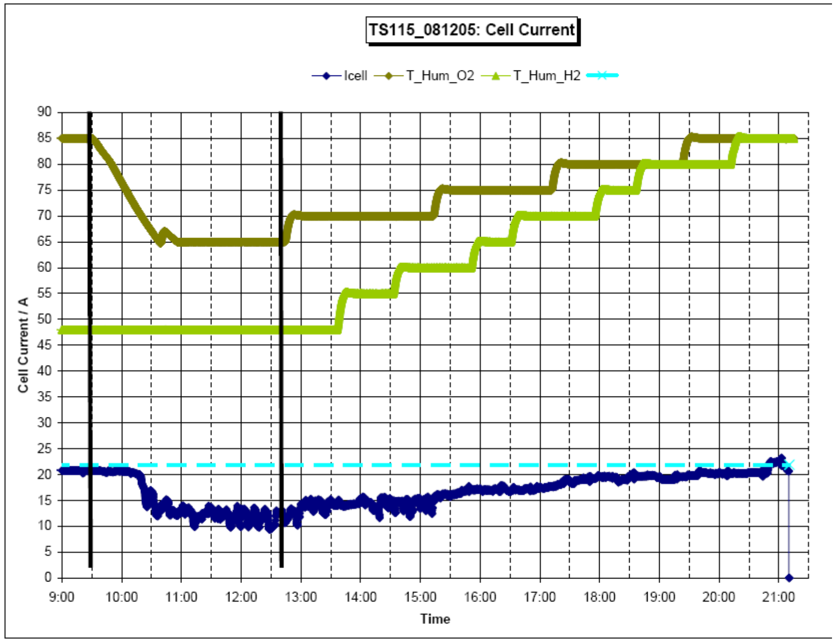
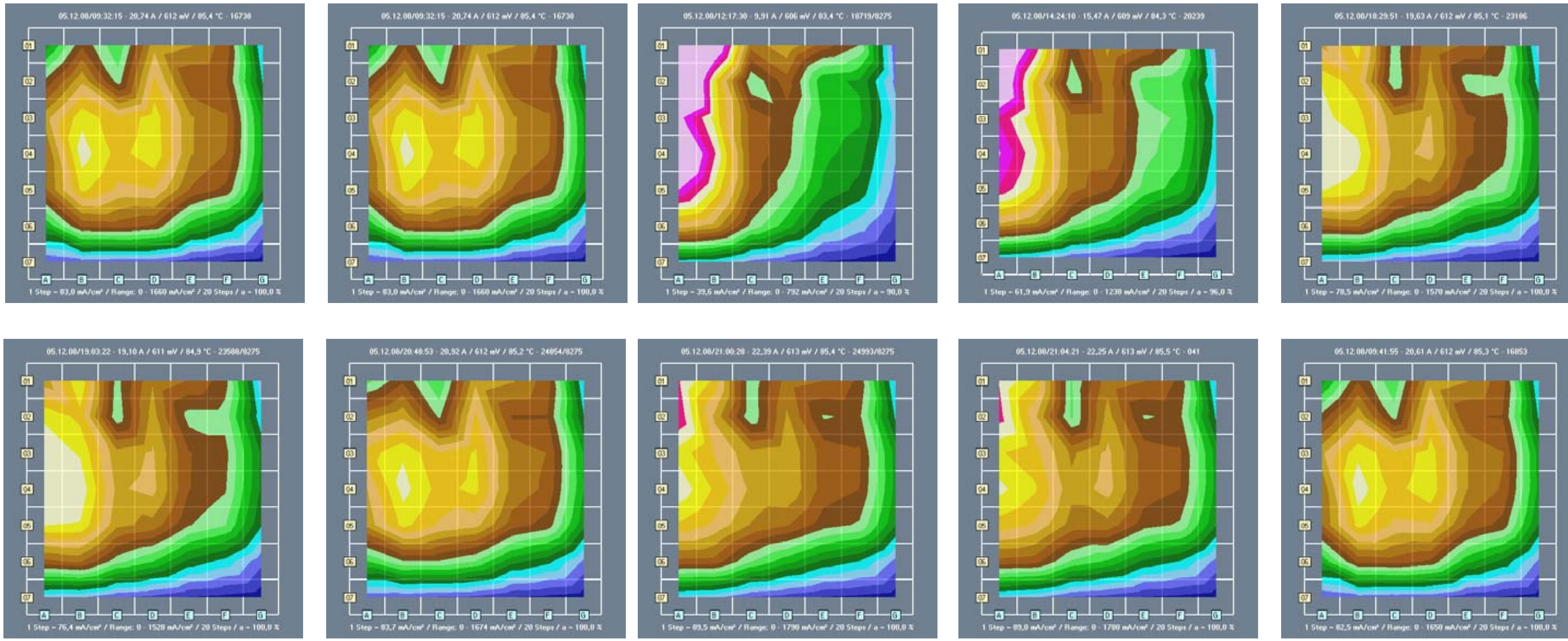
Reversibility of current density distributions after a cyclic process





Mapping of current density distribution changes during a cyclic process



Mapping of current density distributions of the starting, during and after going back to the starting operating conditions.

Conclusions:

- **Detect and assess phenomena which may occur in PEM fuel cell systems:**

  instable operations, degradation & deterioration, flooding & drying, relaxation

  processes (i.e. retardation of equivalent system output to change of system input), etc.

- **Identify methods and system signals to diagnose and to avoid malfunctions with a minimum amount of sensors.**

- **Contribute to the development of a closed-loop control for fuel cell systems to enhance their lifetime and efficiency**

Thanks for your attention!