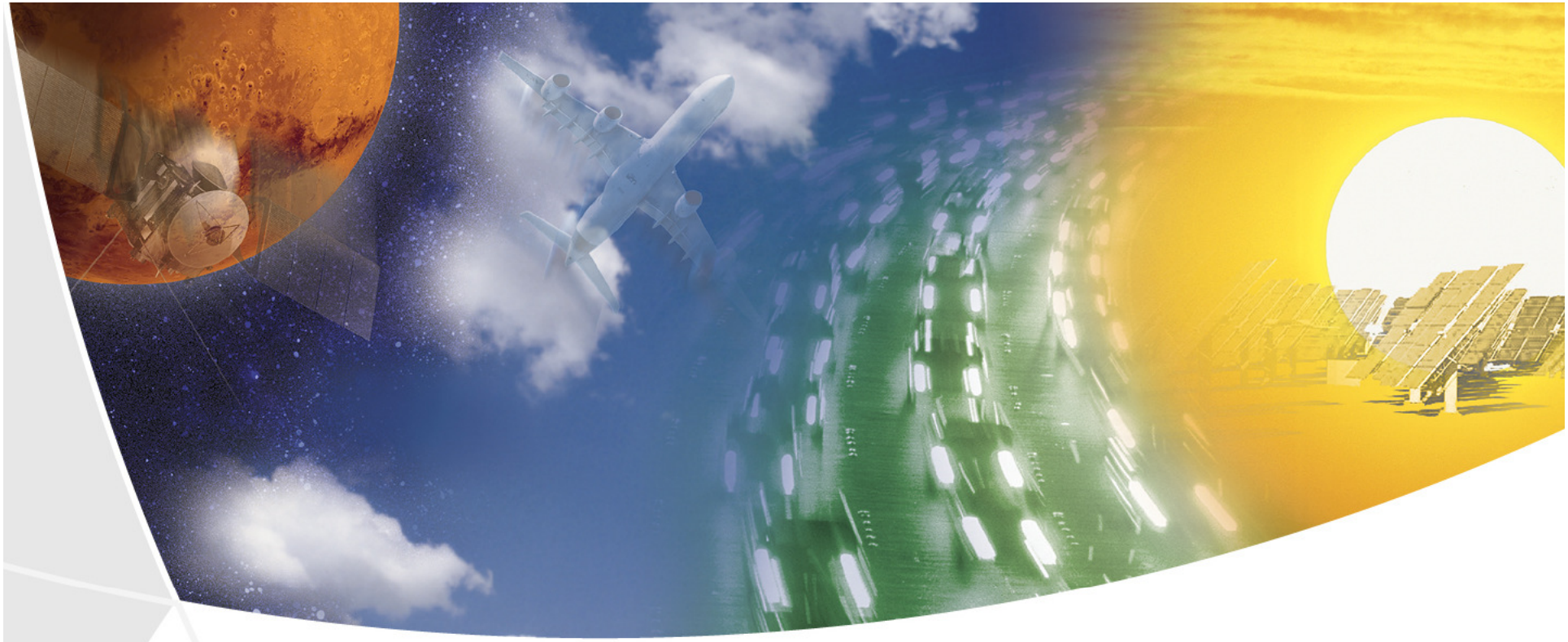

PEFC-Stack Development with up to 130 °C Operation Temperature

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Why 130 °C Operation Temperature?

- Larger operation temperature range
- Cooling system with much more efficiency
- simplified operation strategy

But:

- No increasing of humidification (no additional water)
- No increasing of pressure
- No increasing of stoichiometry

- Control of the first realized stacks with local resolved measurements like current density distribution / temperature distribution / locally resolved EIS

Polymer electrolyte fuel cells with extended operating temperature range of –30 °C to 120 °C

Performance and application of PEM fuel cell systems are limited by cooling requirements due to the low operating temperature (≤ 80 °C) of standard PEM fuel cells.

However, the present PSA membranes (e.g. Nafion®) exhibit high performance and the capability to ***start up from – 30 °C***. The goal for the next-generation cells is a higher average operating temperature and a transient operation ***up to 120 °C for about 45 minutes***.

DLR will take advantage of novel membrane materials to develop a concept for an extended-temperature fuel cell operation involving adapted electrode structures, gas diffusion electrodes, stack design and system operation to ascertain reliability and durability.

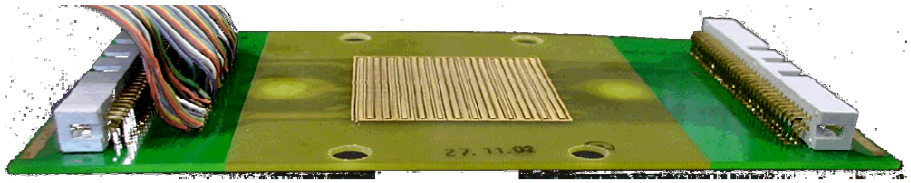
Polymer electrolyte fuel cells with extended operating temperature range of –30 °C to 120 °C

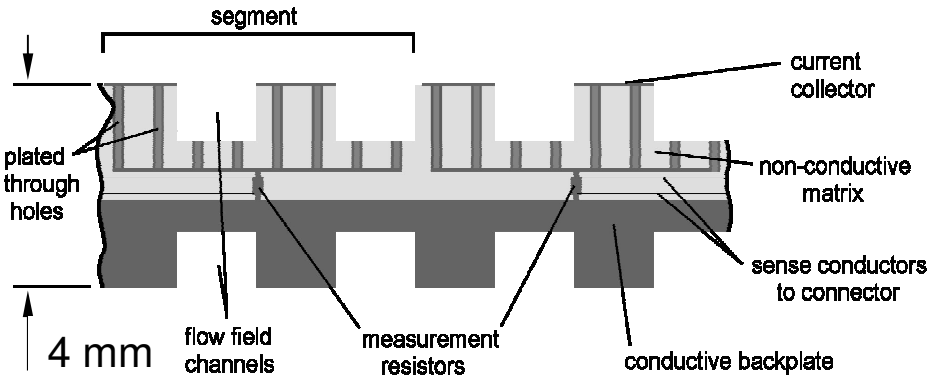
Development of system architecture to optimize performance, durability and reliability of the stack.

Operational strategies with sensor technology and ***specific control systems*** will be developed and investigated to ascertain a stable and durable application.

Important considerations are electrical efficiency, fuel utilization, circulation strategies (including nitrogen management), thermal management at different ambient conditions (temperature, pressure, humidity) and control systems.

New generation of locally resolved measuring device





- Increasing of **operation temperature up to 200 °C**

  usable for diagnostic and investigation tasks at 130 °C Stacks and additional HT-PEFC

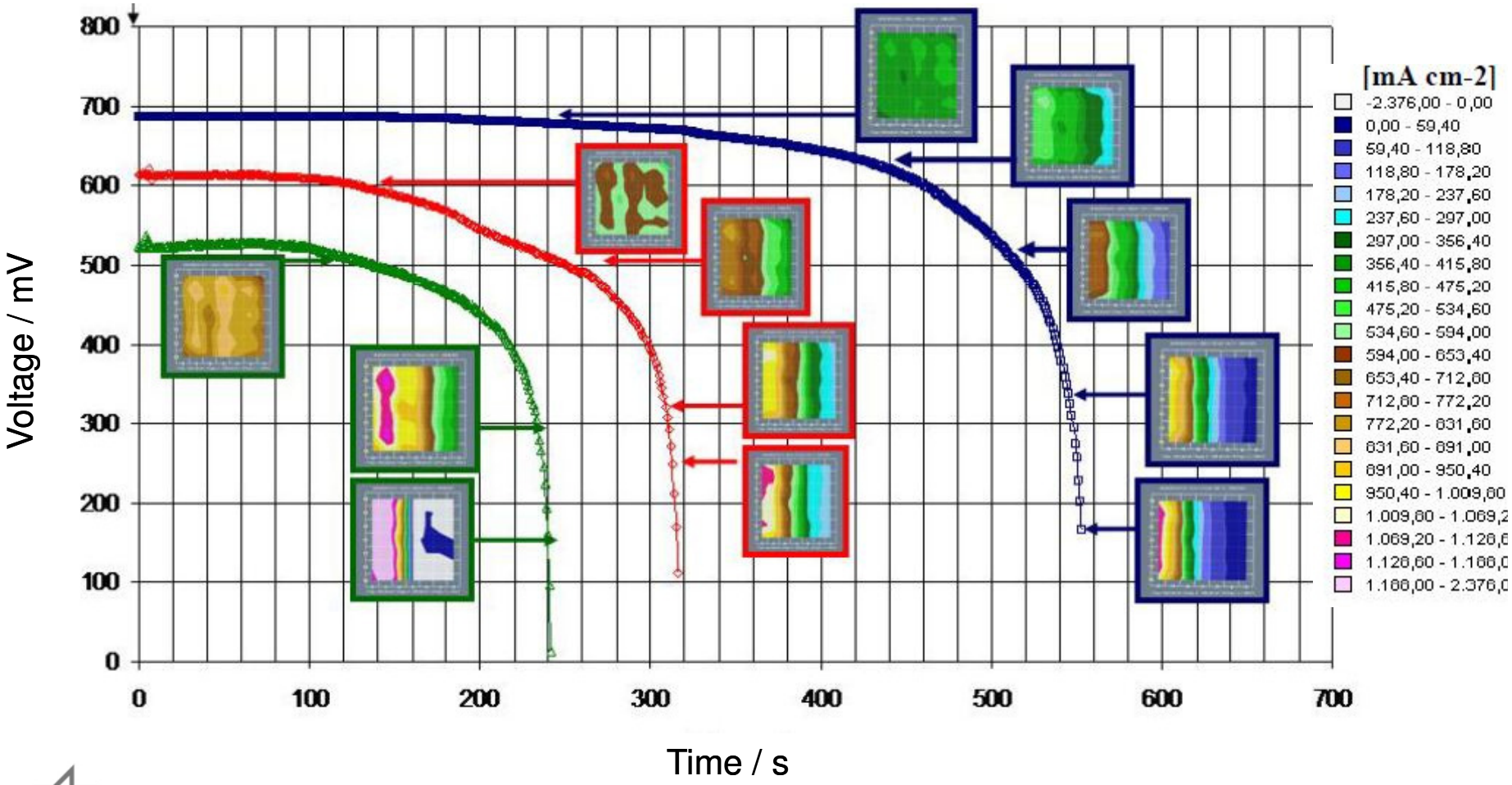
- Two **side measuring plate** – no external backside necessary

- Low Cost **amplifier**

Time depending cell voltage at 0% r.H.

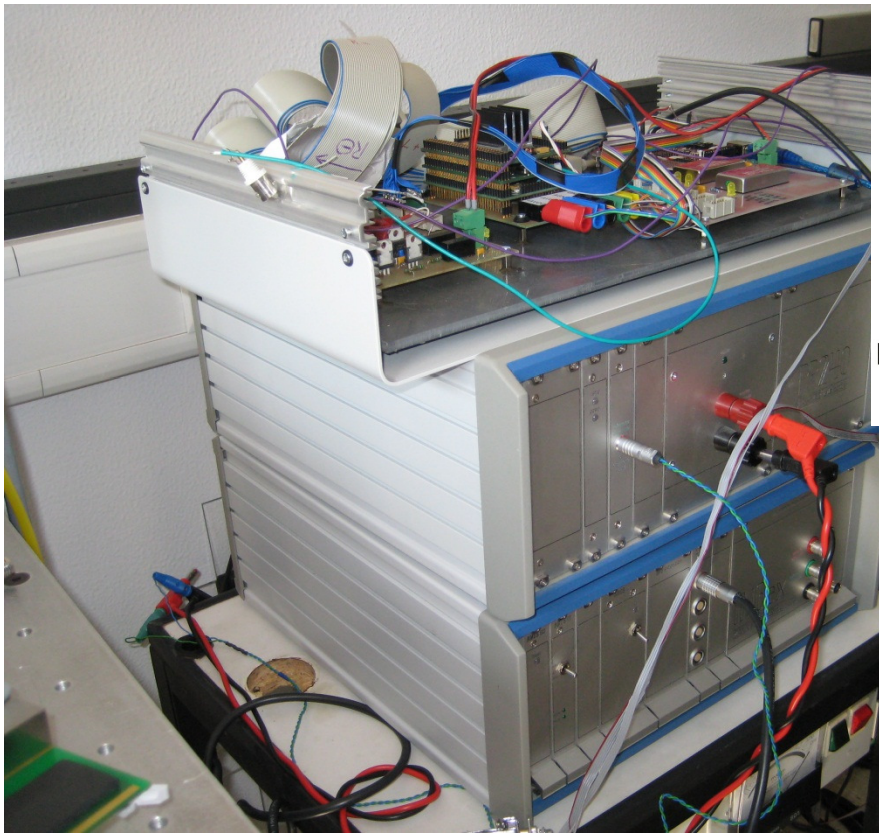
Galvanostatic: 20 A green; 15 A red; 10 A blue

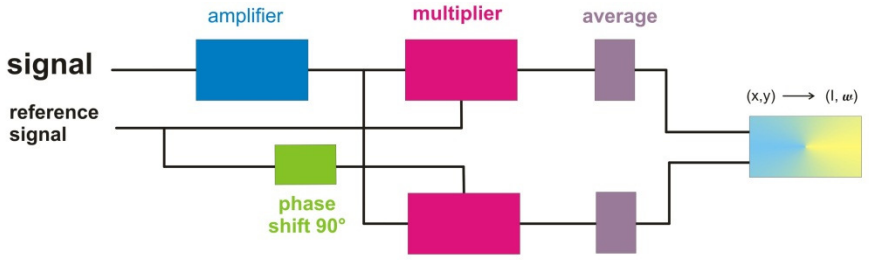
H2-flow: 209 ml/min; Air: 665 ml/min; Tcell: 80 °C; Humidifier : 80 °C; Pressure: 1,5 bar



Animation of Investigations with segmented Cell

Locally Electrochemical Impedance Spektroscopy

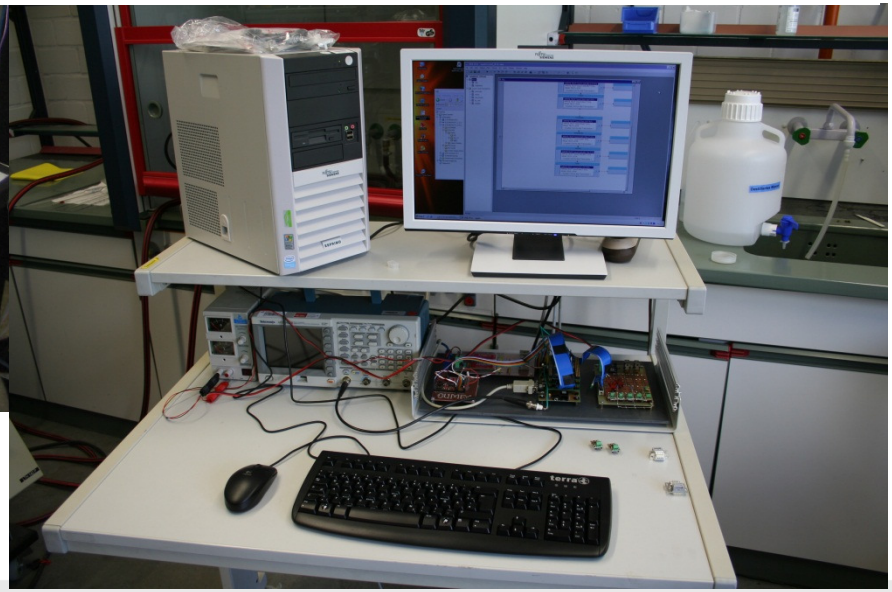




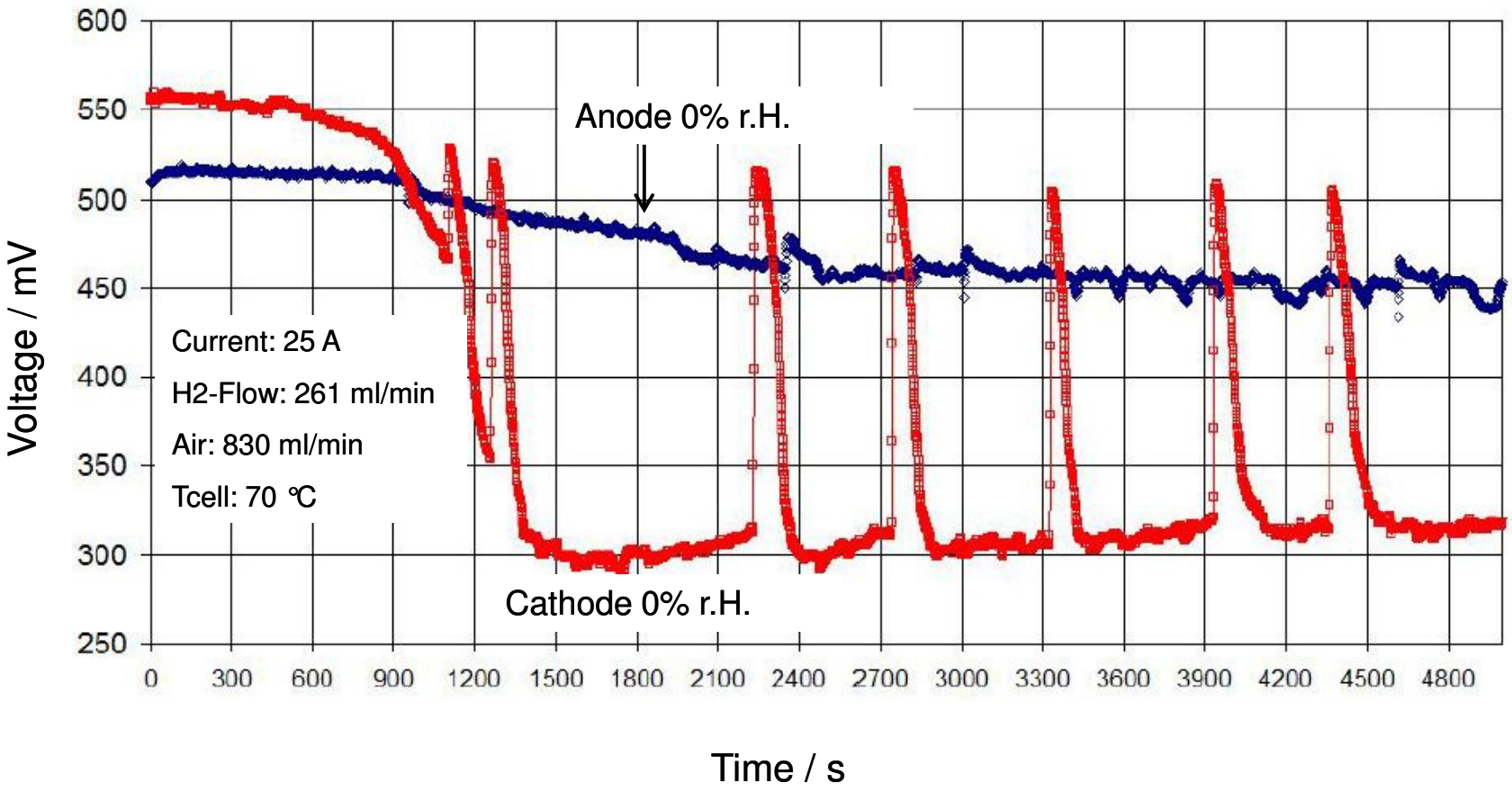
signal as Fourier series

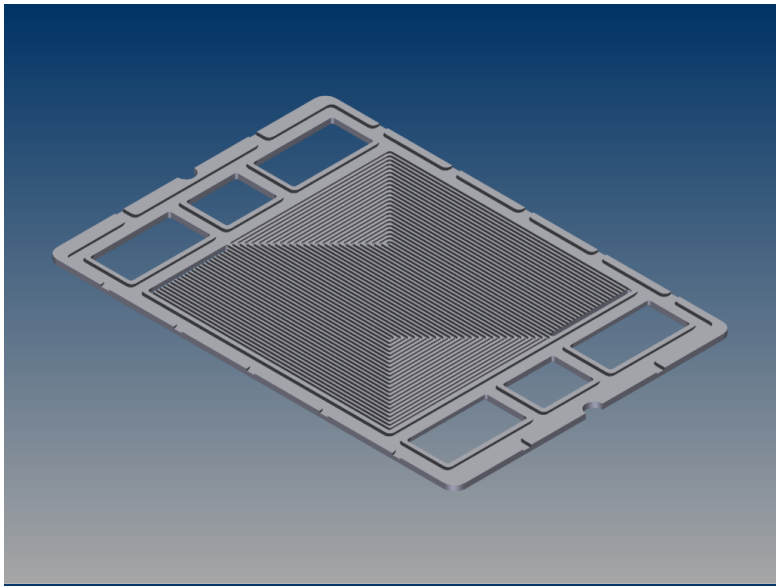
orthogonality of sinus functions, only one Fourier component

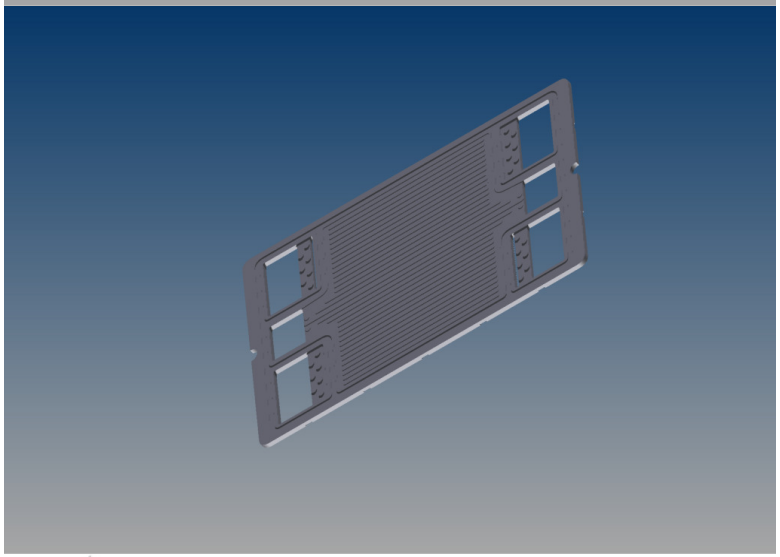
amplitude and phase shift



Comparison of asymetric humidification Anode/Cathode
(0% r.H. Anode und 0% r.H. Cathode)

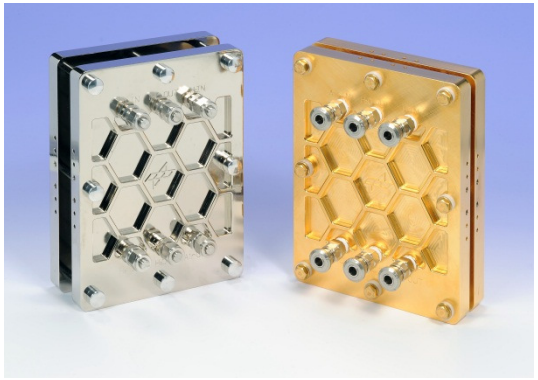




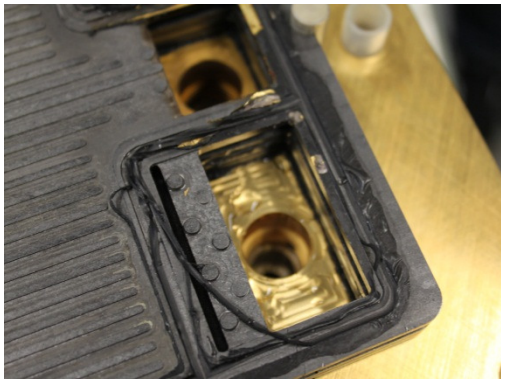


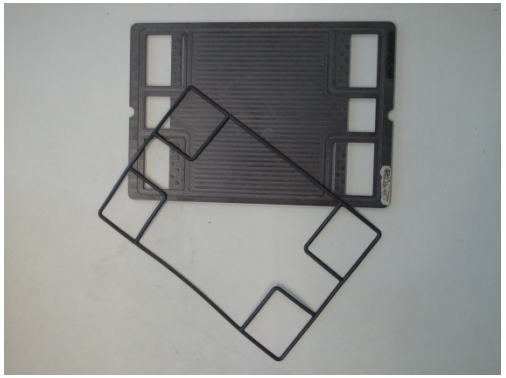
Design 130°C Stacks

- Design Bipolar Plate
- Bipolar Plate Material
- Sealing (Design / Material)
- Membrane
- Electrode coating
- End Plate



Development Steps





Development of sealing (2nd generation):

Failed sealing (Flow fields and cooling plate) with leakages:

⇒ New design and new sealing material

2nd Generation:

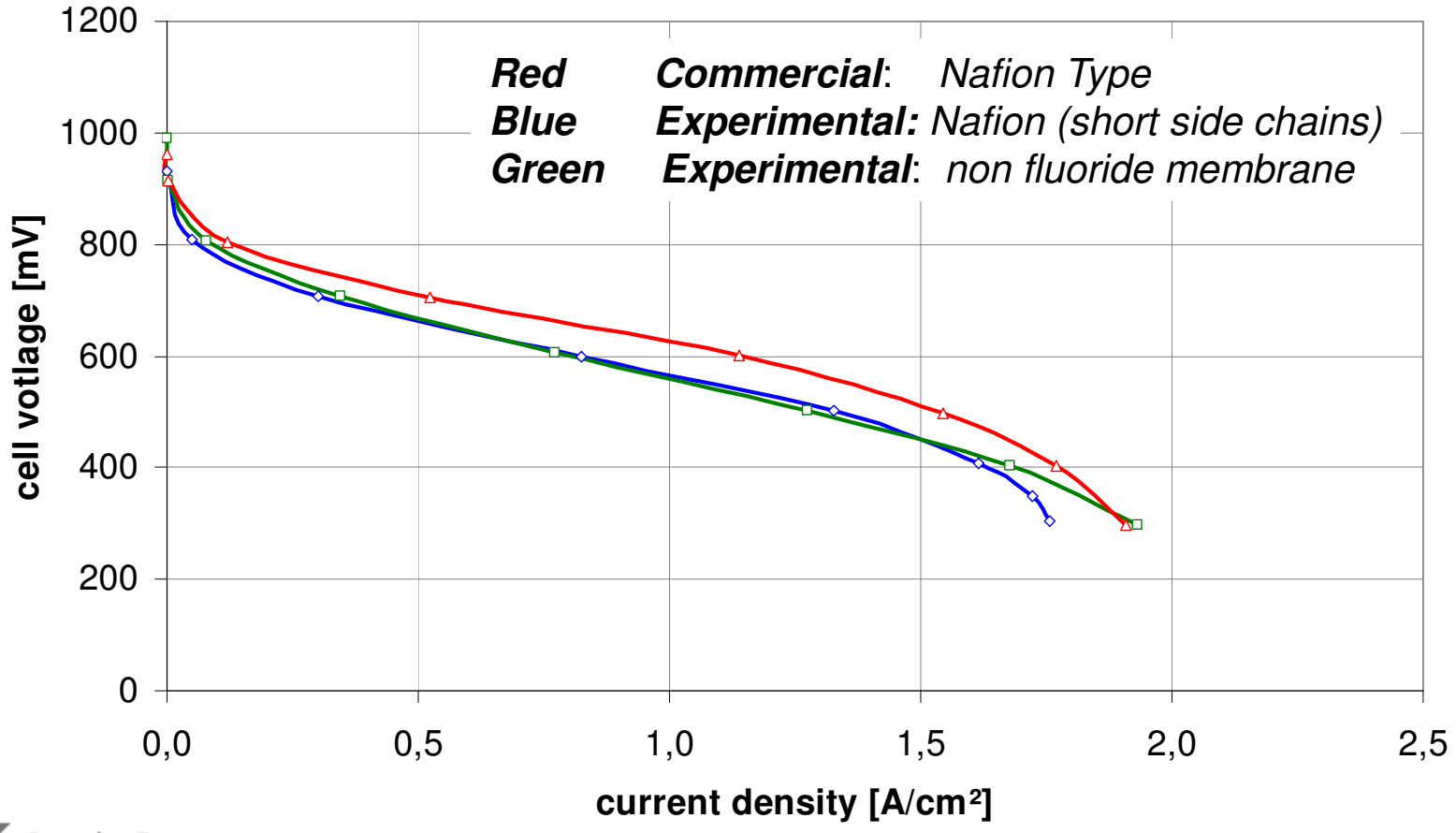
The sealing fulfill technical requirements up to the temperatures of 130 °C

- **Leakage:**
  - ⇒ Anode: 5,3 mbar/min
  - ⇒ Cathode: 4,8 mbar/min
  - ⇒ Cooling: 7,3 mbar/min

Comparison of Membrane Materials

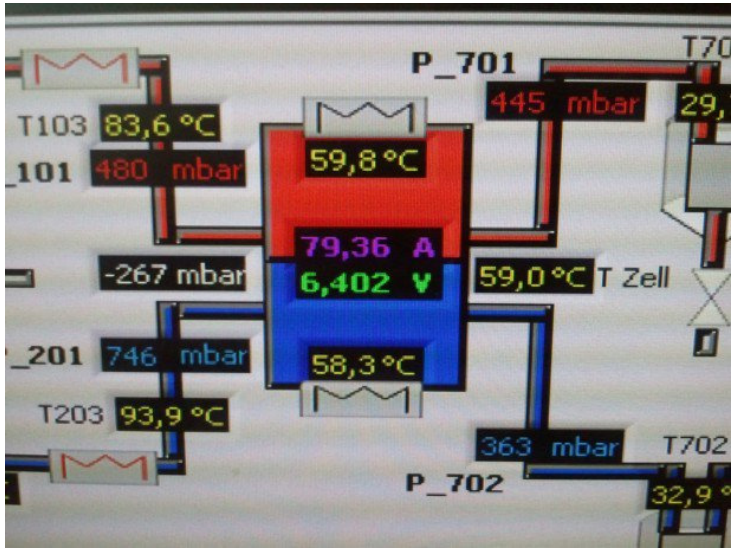
E-i curves

(@ 85°C, r.H. = 100%; 23 cm²; 0.5 mg Pt/cm²)

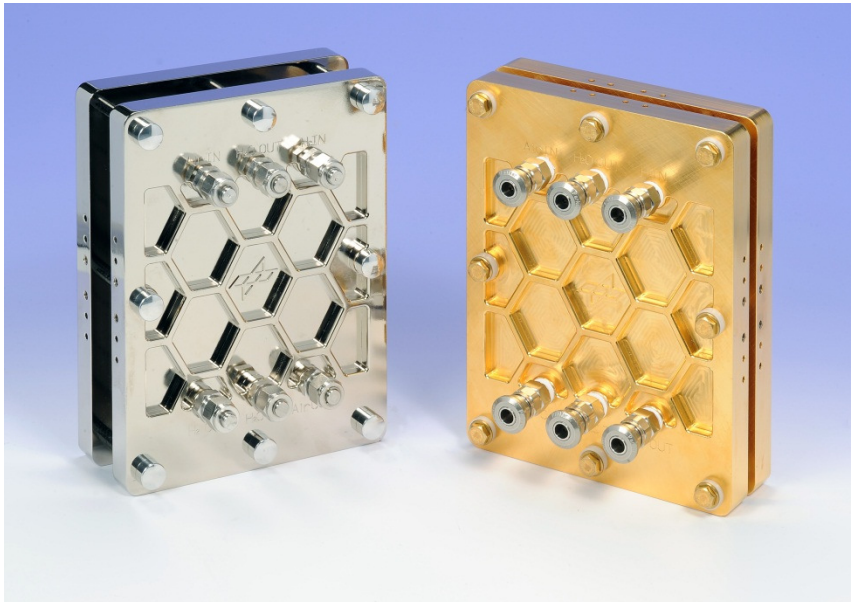


Investigation with commercial membrane

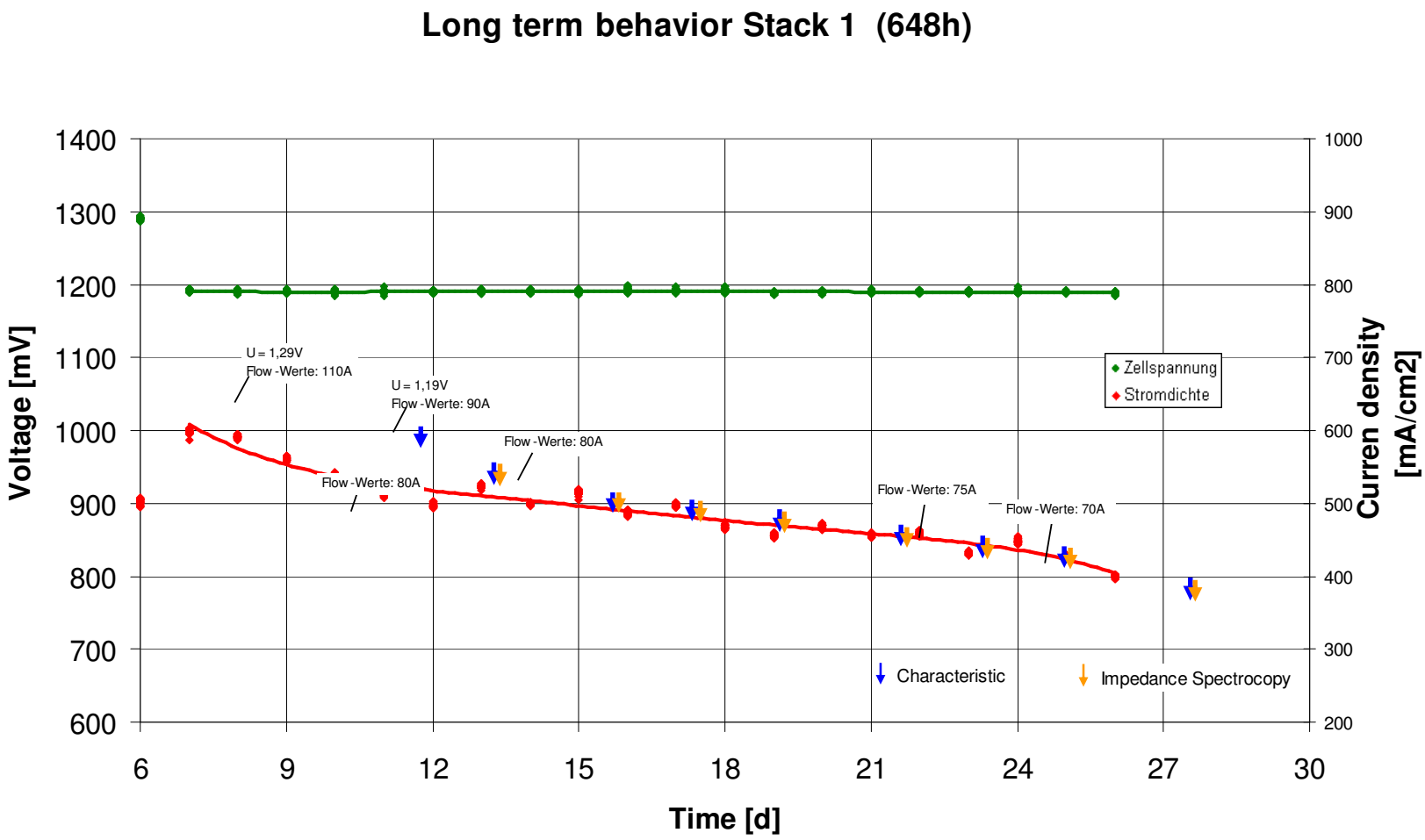
Realization of short Stack with 10 cells an 500 W power:



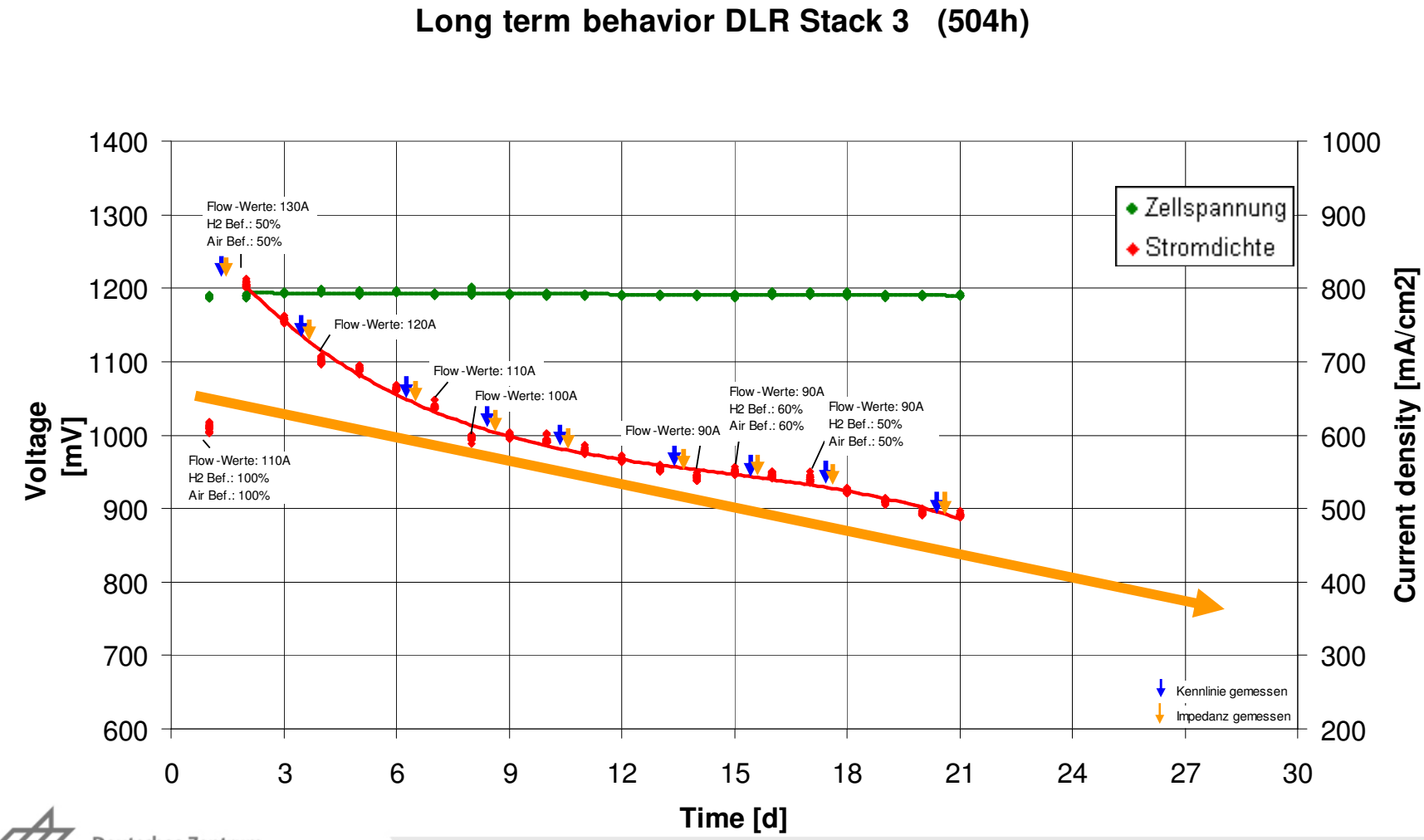
- **More than 500W (up to 595W)**



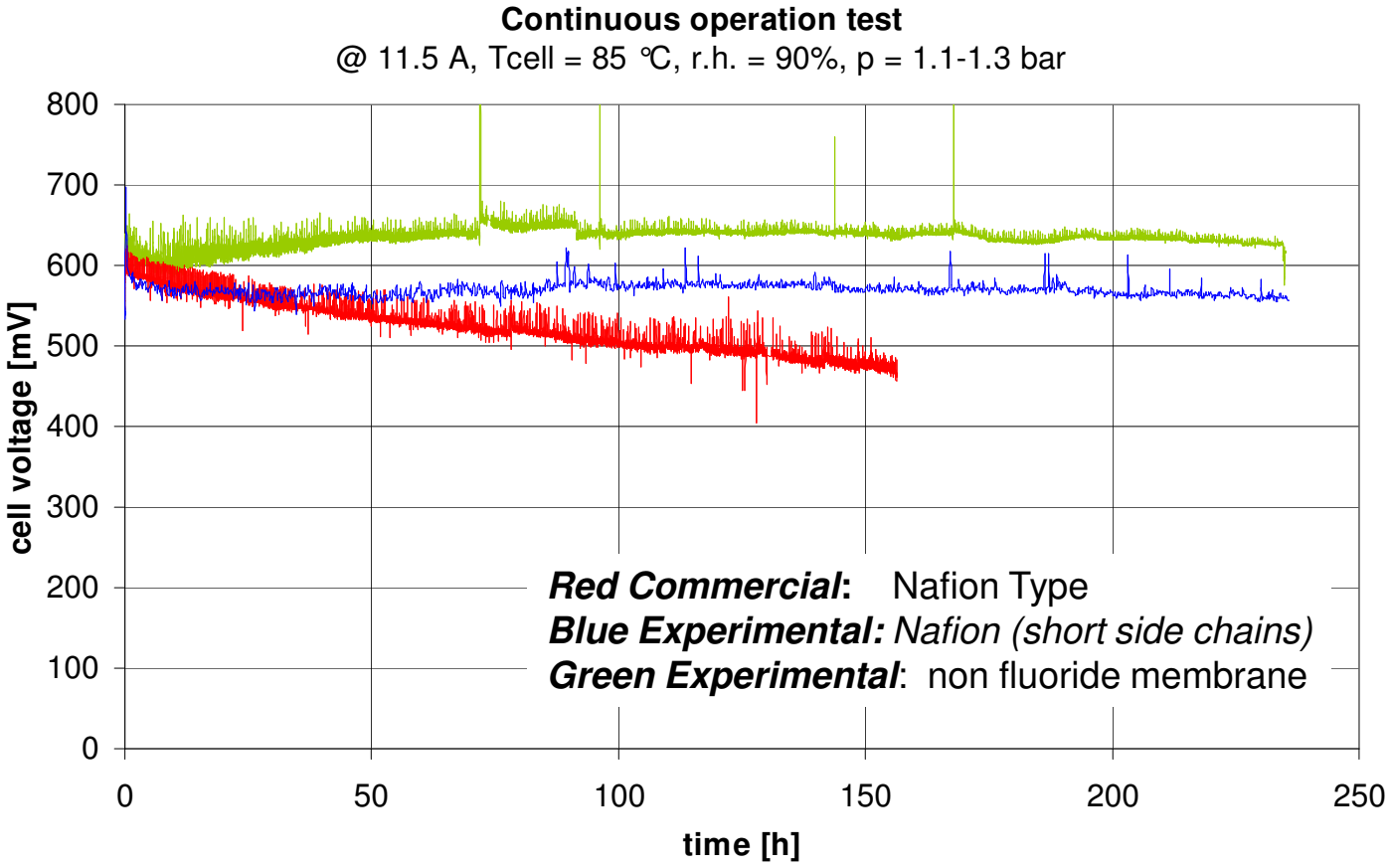
Long term behavior - no variation of humidification (500h) *(commercial / Nafion)*



Long term behavior with variation of humidification (500h) *(commercial / Nafion)*

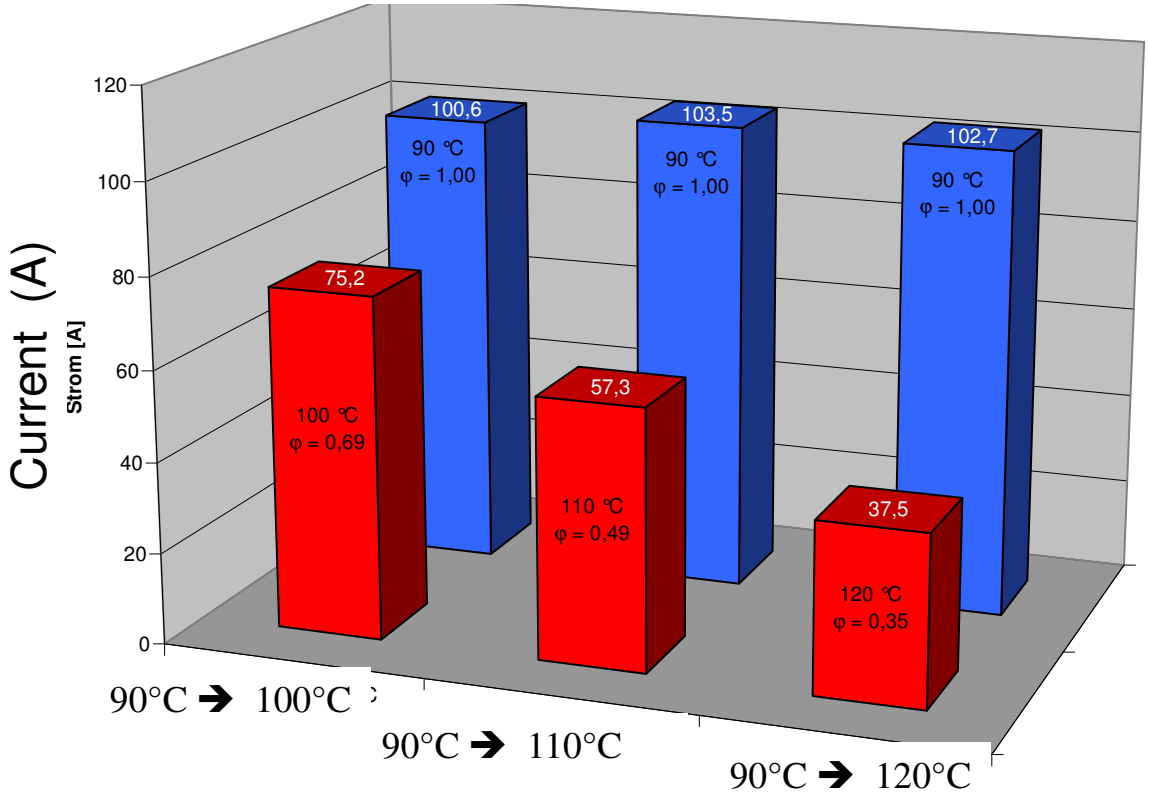


Long term behavior of membranes



Results

Investigation of Performance increasing operation temperature (up to 120 °C)



φ - Humidification

Ambient pressure
at cathode and anode

λ Cathode: 2

λ Anode: 1,5

Backing: SGL Sigracet
25 BC

Main Problem with Test Bench

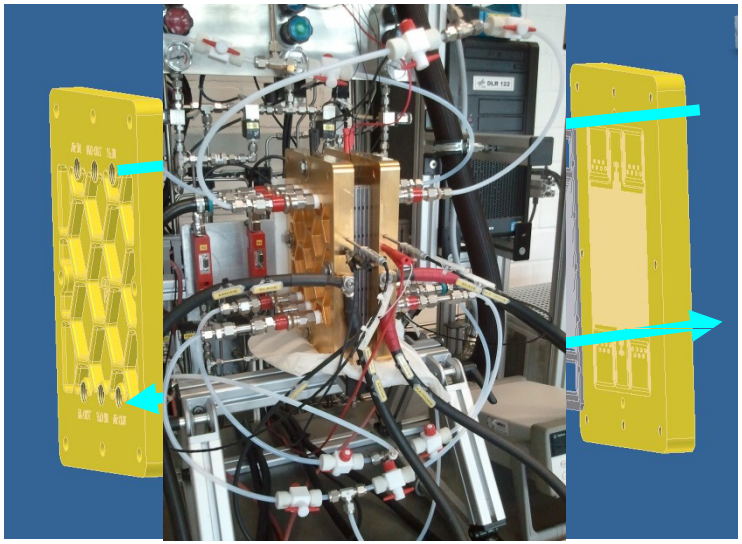
- Time to increase the temperature is to long

- All results not for 45 minutes

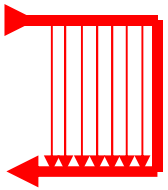
  All results are results of more than 2,5 hours !!

Next Steps

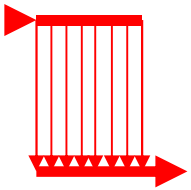
- Realization of short stack (few cells) with changeable design:



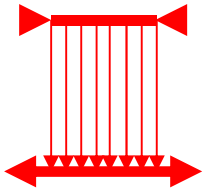
C-Design:



Z-Design:



I-Design:



Investigation of impact depending on flows

⇒ Performance

⇒ Degradation

⇒ Regeneration (maybe reversible Degradation effects)

Summary

Development of 130 °C Stacks

- Bipolar Plate Design / Sealing / **MEA**
- Measurements at 120 °C
- Long term behavior of stack up to 100 °C successful
- Investigations up to 120 °C demonstrates reversible feasibility

- Decrease of performance will be compensate with diagnostic like segmented cells

- New membrane material will improve the performance too (non Nafion based)