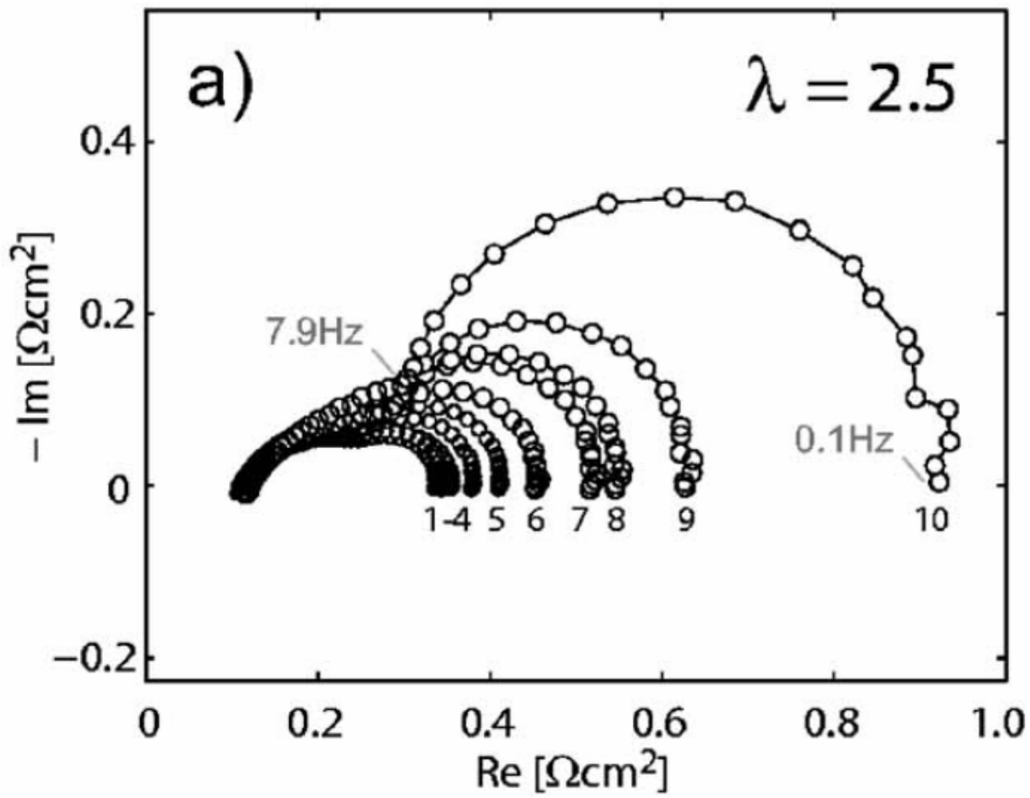
Apparatus for spatially resolved impedance spectroscopy on DMFC and PEM Fuel Cells with special regard to fuel concentration oscillations in gas channels

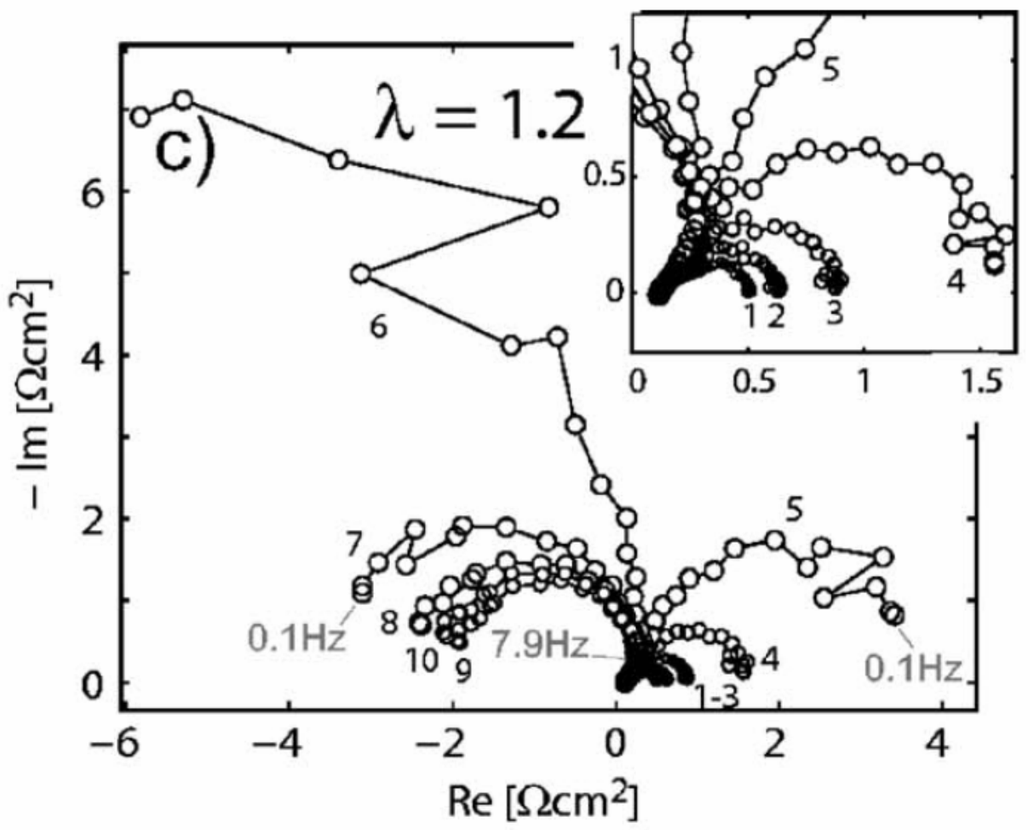
T. Sanders[a], T. Baumhöfer[a], D. U. Sauer[a], A. Schröder[b], K. Wippermann[b], J. Mergel[b], D. Stolten[b]

[a]Electrochemical Energy Conversion and Storage Systems
Prof. Dr. rer. nat. Dirk Uwe Sauer
Institute for Power Electronics and Electrical Drives (ISEA)
RWTH Aachen University
Univ.-Prof. Dr. ir. R. W. De Doncker

[b]Institute of Energy Research, IEF-3: Fuel Cells
Forschungszentrum Jülich GmbH

Motivation





- “Flipping” effect observed in measurements
- Caused by measurement method
- Not a consequence of MEA state

Source:
Oscillations in Gas Channels II.
I. A. Schneider et al.
Journal of The Electrochemical Society

Outline

- The cause for the measurement effect

- Influence of various factors
  - Model based

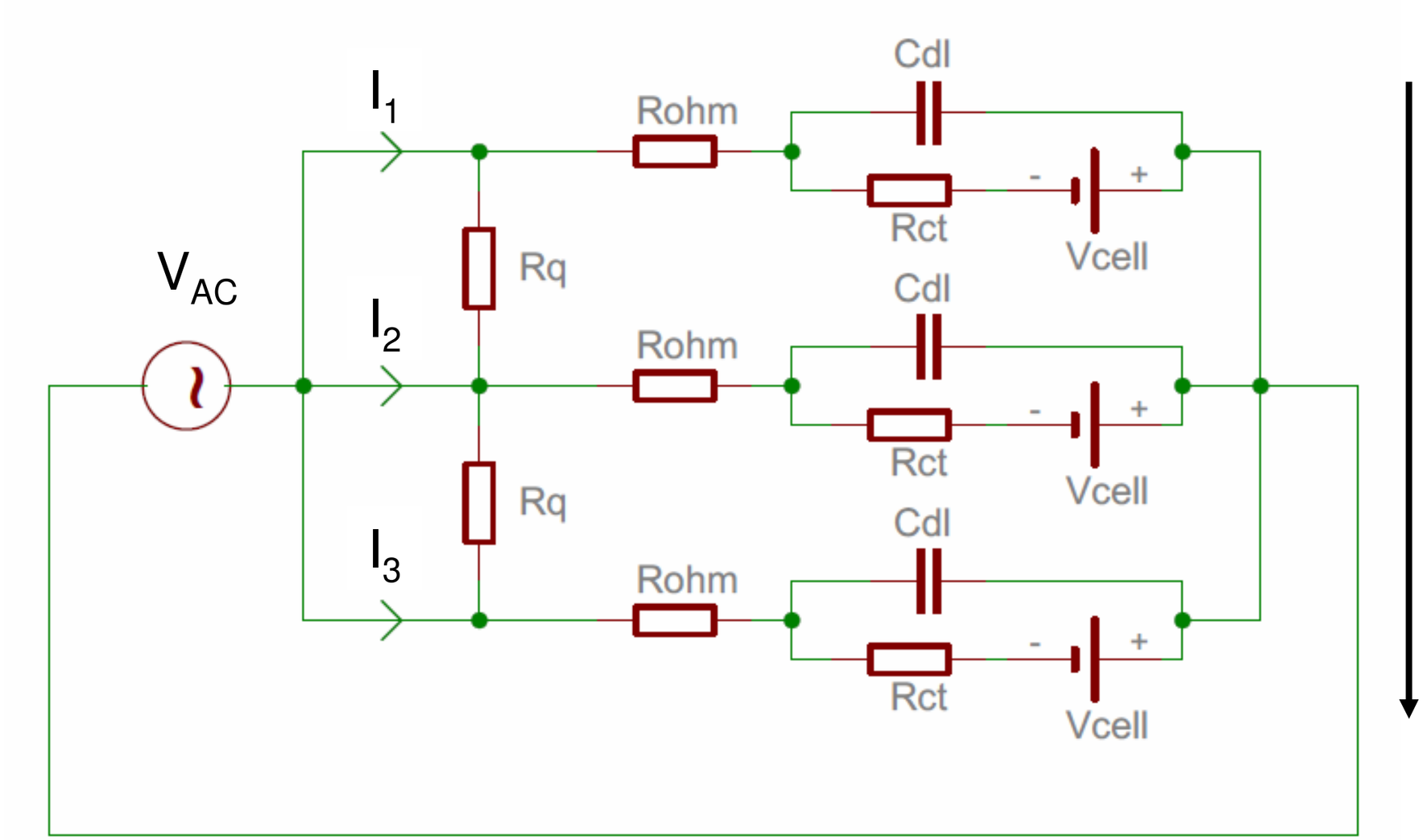
- An advanced measurement setup

- “EIScell” measurement hardware

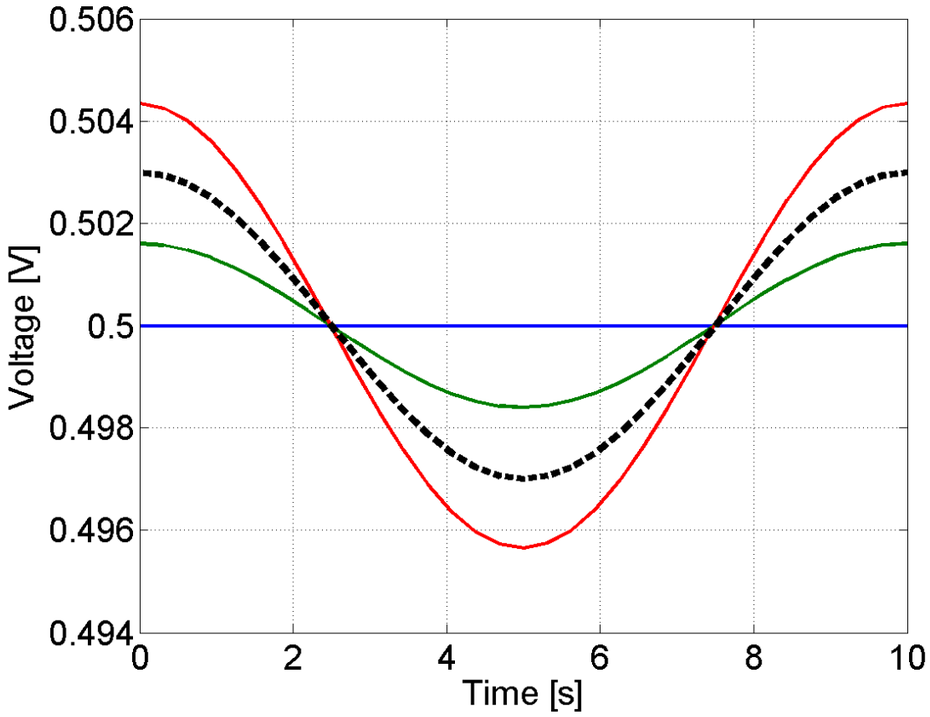
Commonly used measurement setup

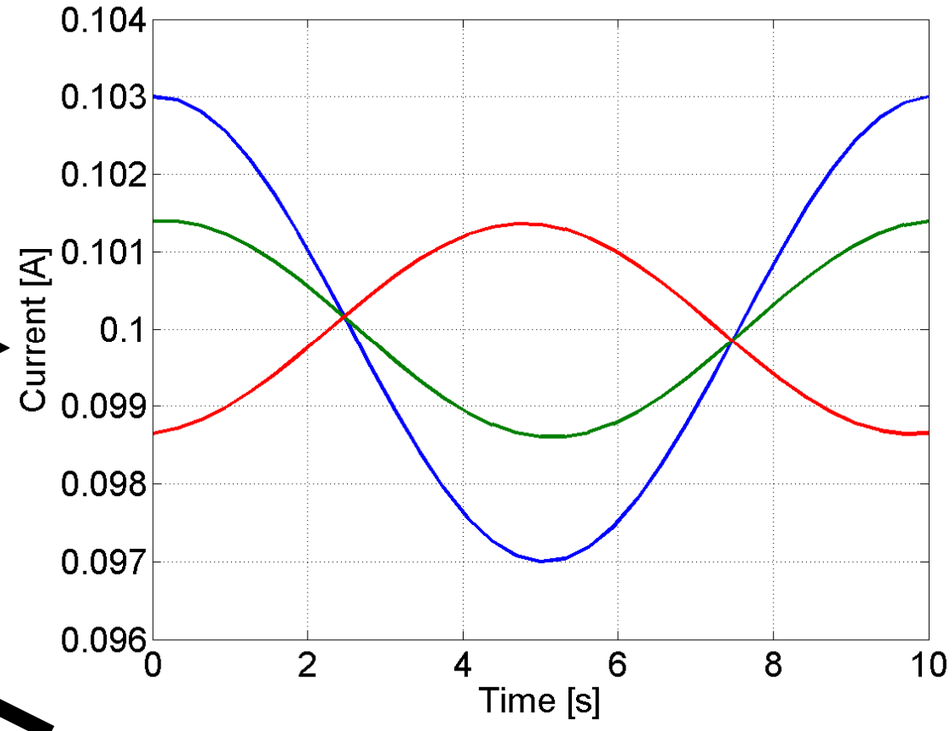
- The full cell is excited by one voltage source
- Spatially resolved current measurement

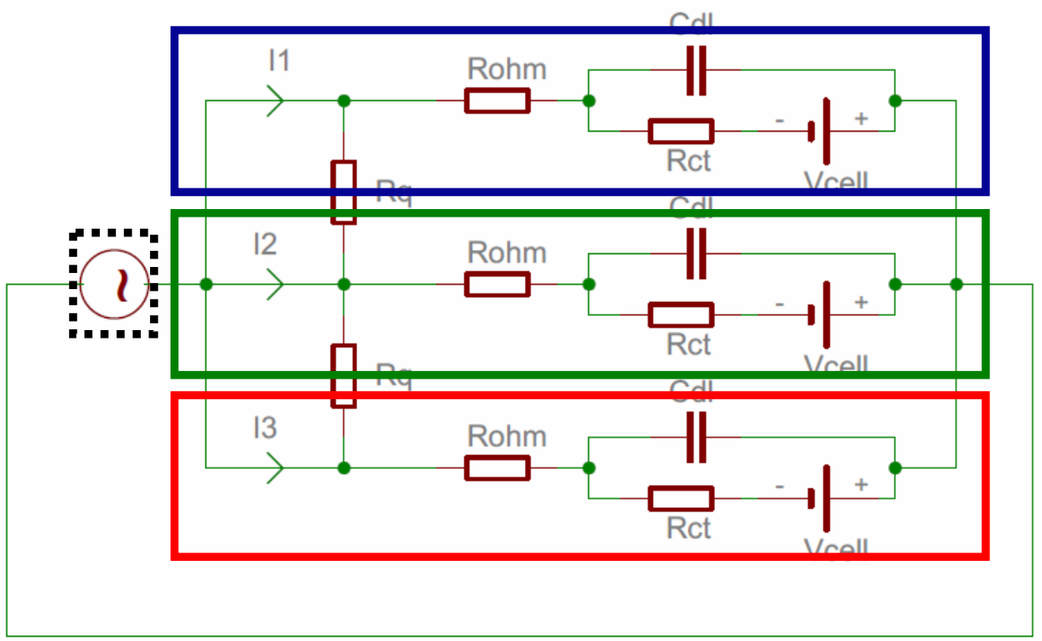
$$Z_n = \frac{V_{AC}}{I_n}$$



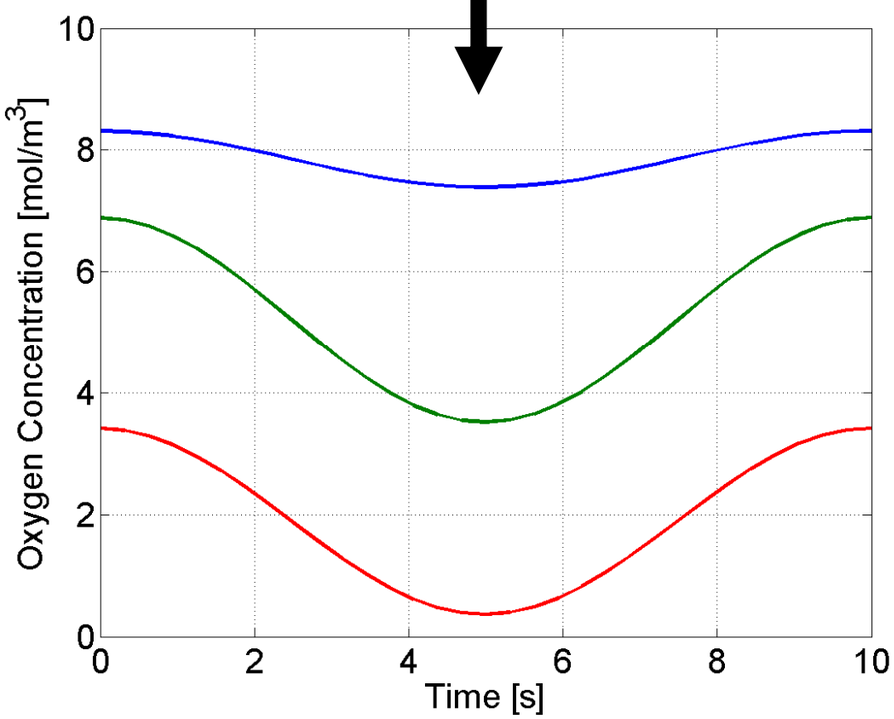
Influence of concentration oscillations







Oxygen flow



Influences

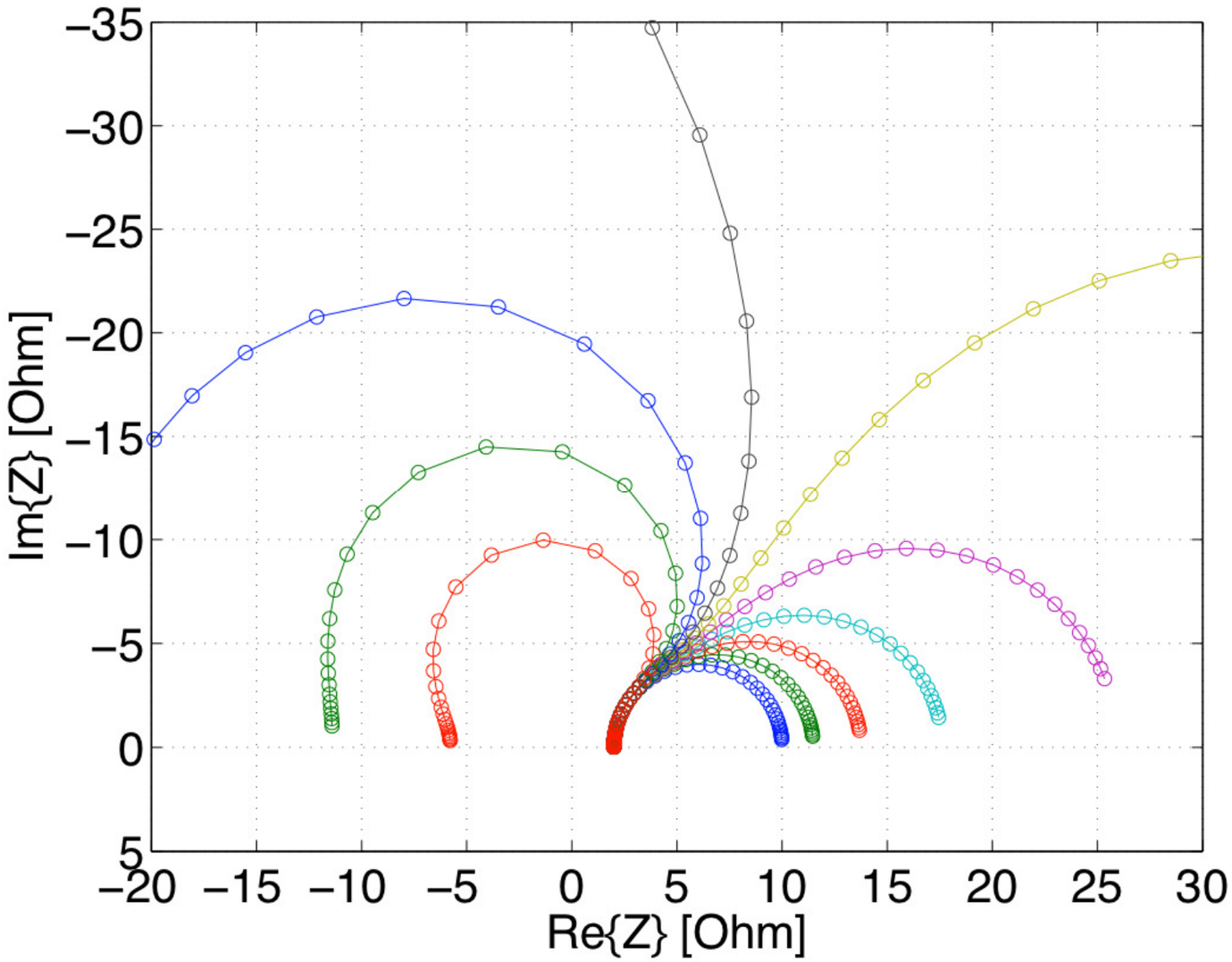
- Absolute oxygen concentration

$$\frac{dU_2}{dI_1} = \frac{RT}{z^2 F^2 q} \frac{1}{C_1}$$

- Frequency
  - Limited Diffusion

- Excitation amplitude
  - No influence

Spectra: 10 Segments, linear channel



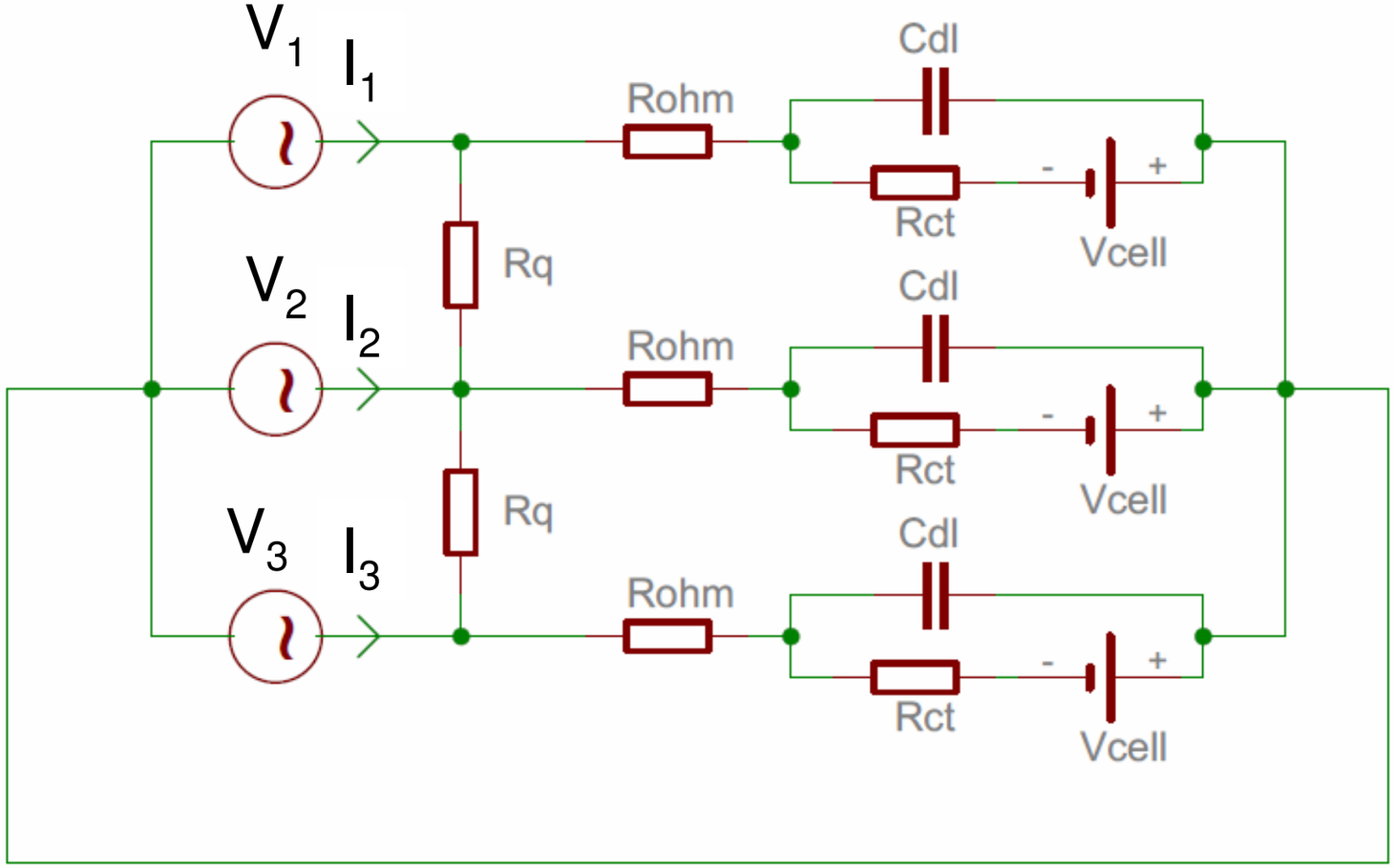
Advanced measurement setup

- Single excitation, sequential measurement
- Problem: in-plane resistance

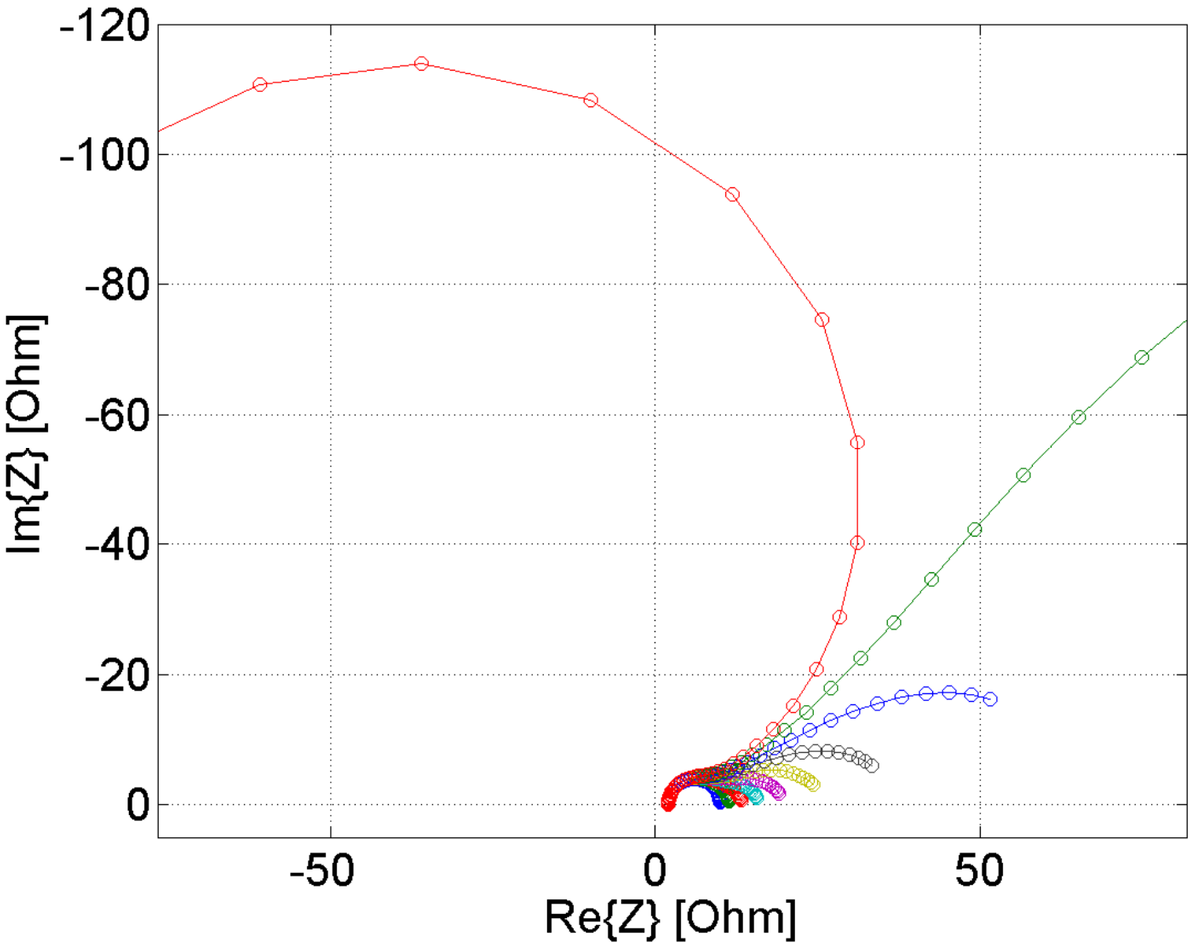
➔ Smaller concentration oscillation amplitude

➔ Influence only from neighboring segments

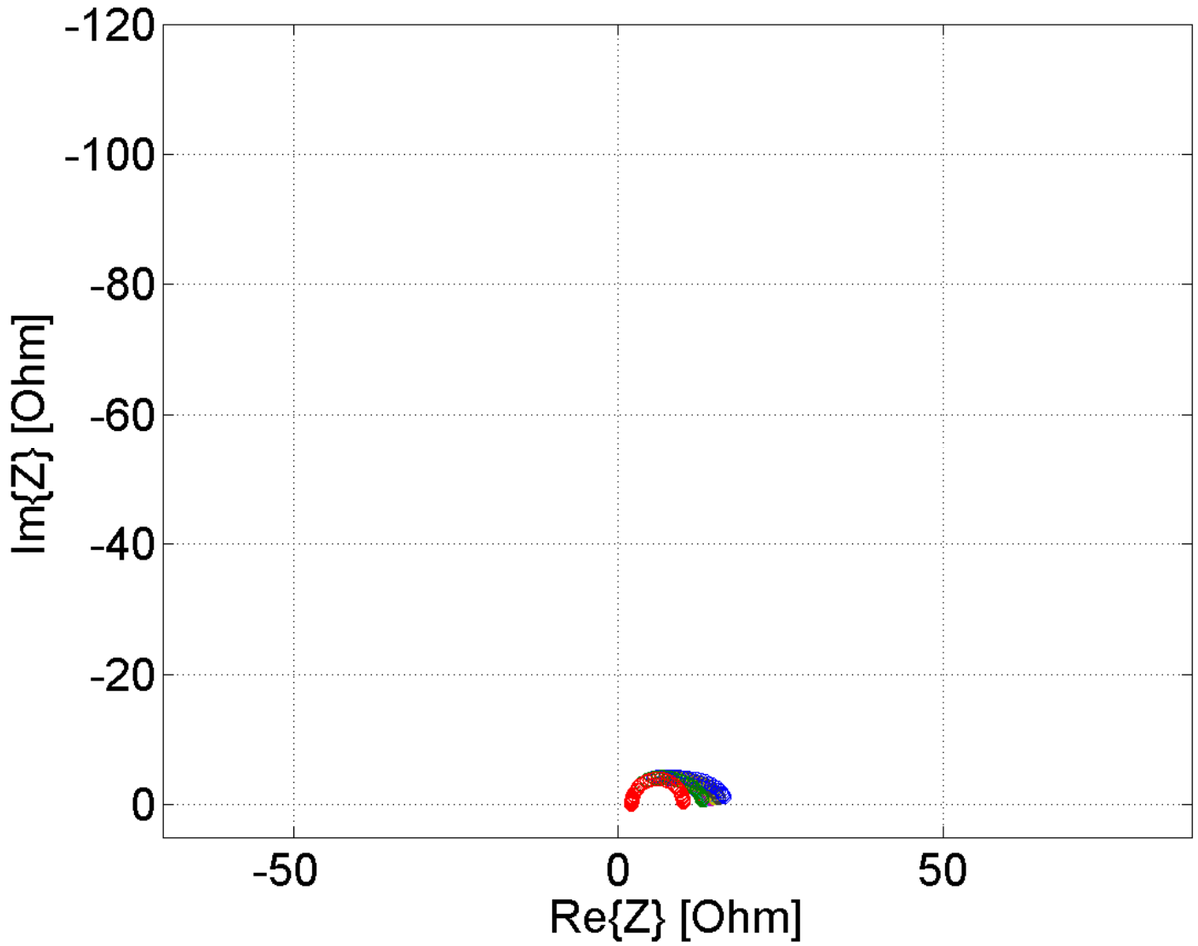
$$Z_n = \frac{V_n}{I_n + I_{n-1} + I_{n+1}}$$



Comparison

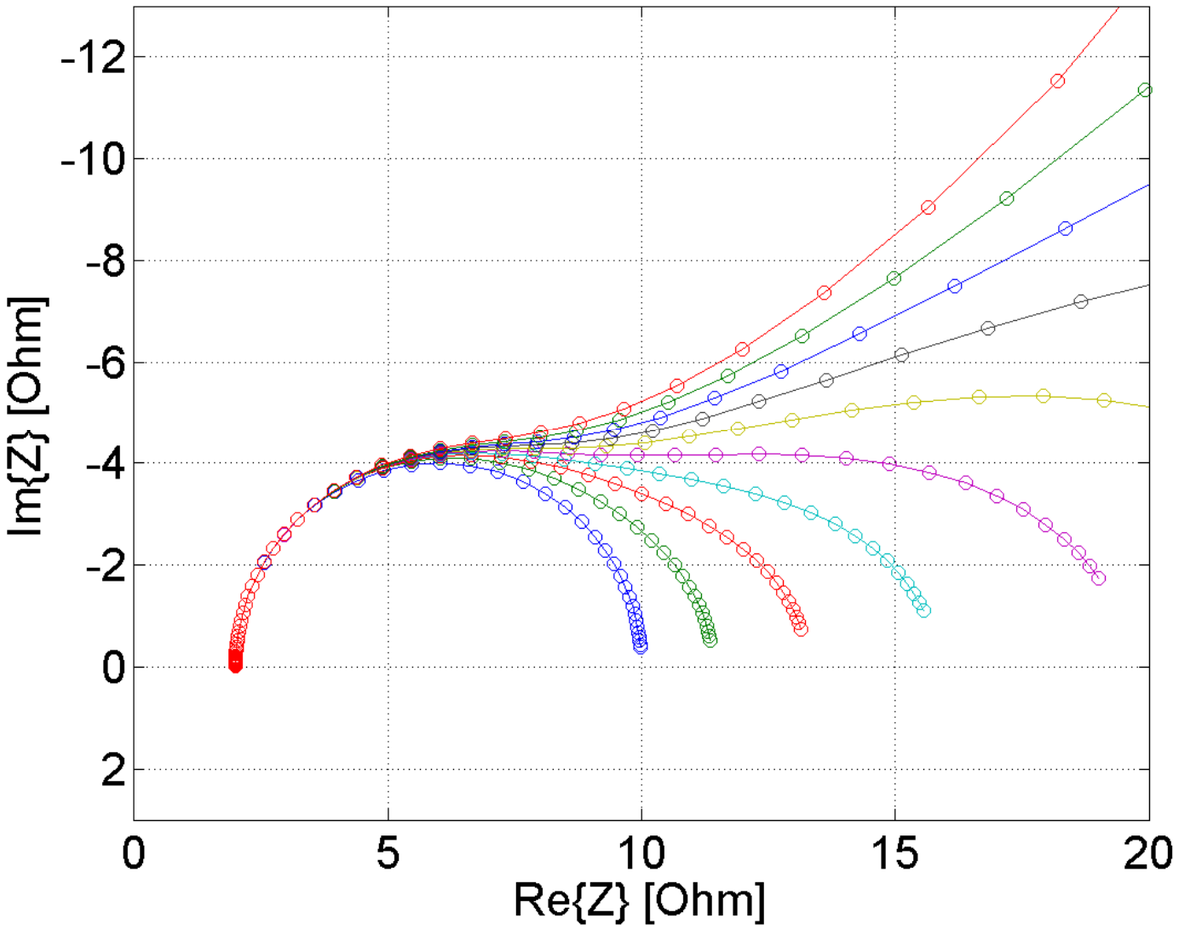


Cell excitation

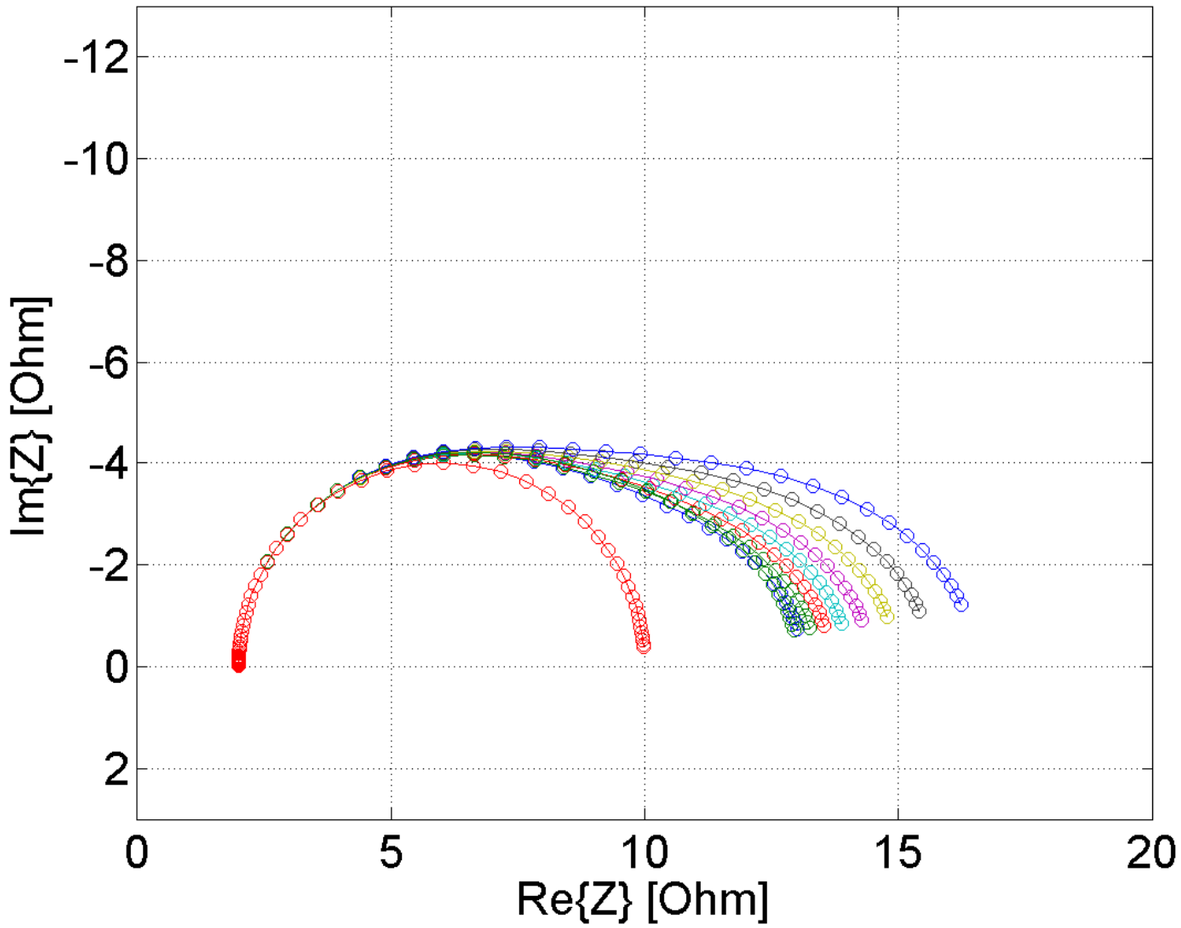


Single segment excitation

Comparison (Zoom)



Cell excitation



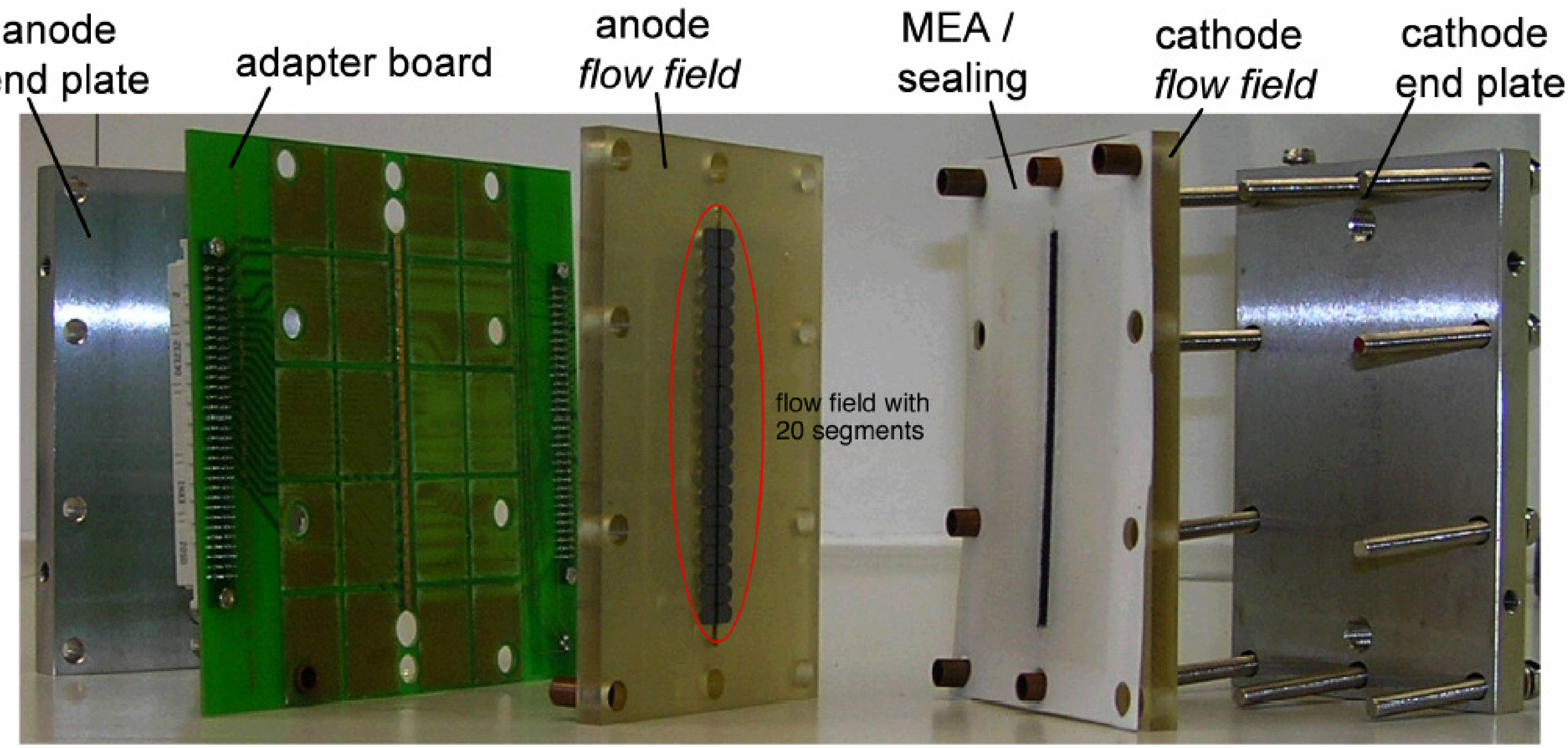
Single segment excitation

EIScell

- 54 independent channels
- ± 2.5 V, ± 2.5 A per channel

- AC response from all I,V
  - simultaneously
- DC measurements
  - I-V curves
- Automated
- Integration of test stand control

Contacting


anode
end plate
adapter board
anode
flow field
MEA /
sealing
cathode
flow field
cathode
end plate
flow field with
20 segments

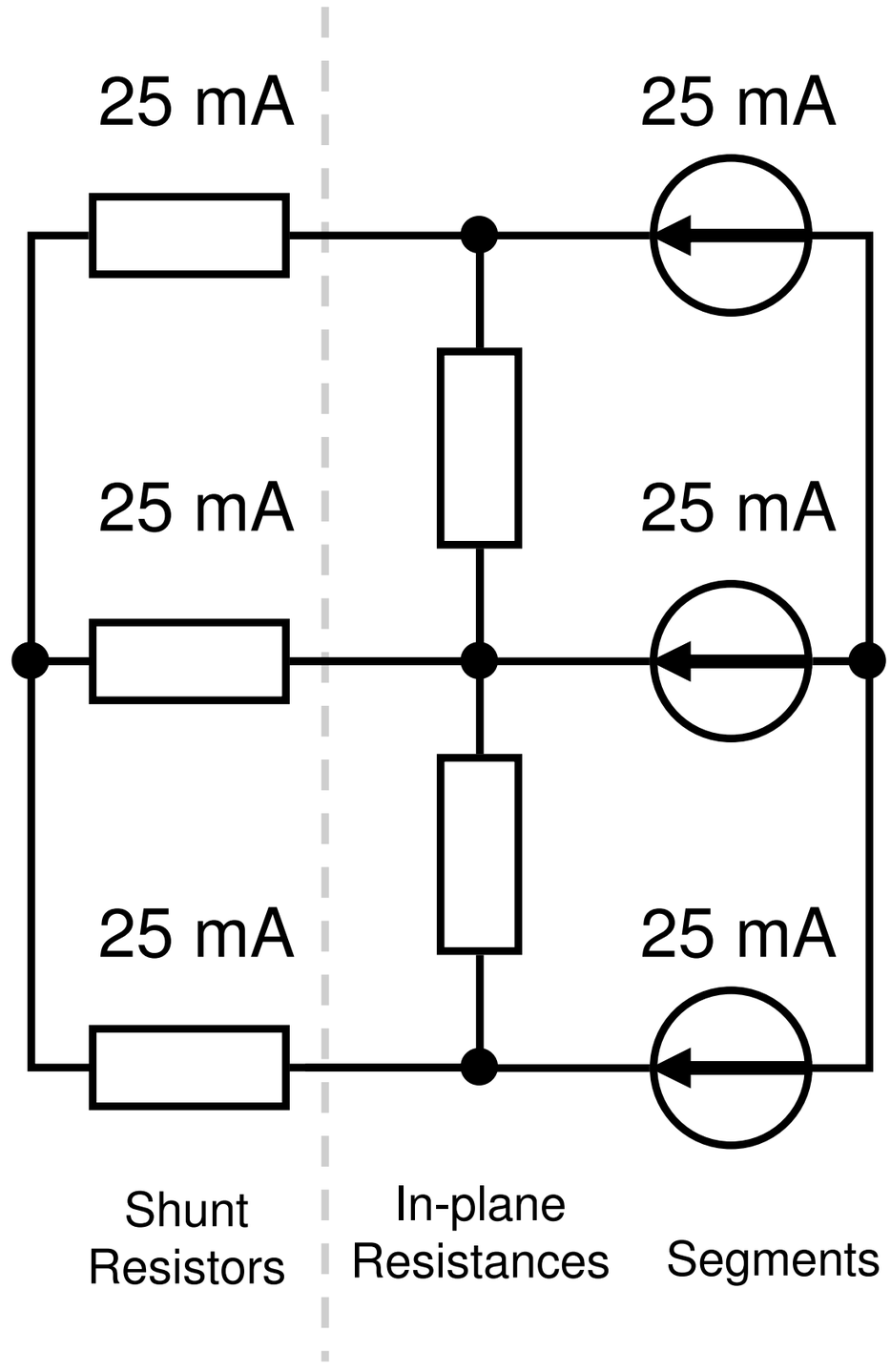
Shunt Resistors

- Voltage drop across shunt resistors leads to an equalization of measured currents

- For the given test cell resistances below 10mΩ would be needed

- Not suitable for measurement of small currents

$$V_{meas} = 1mA \cdot 10m\Omega = 10\mu V$$



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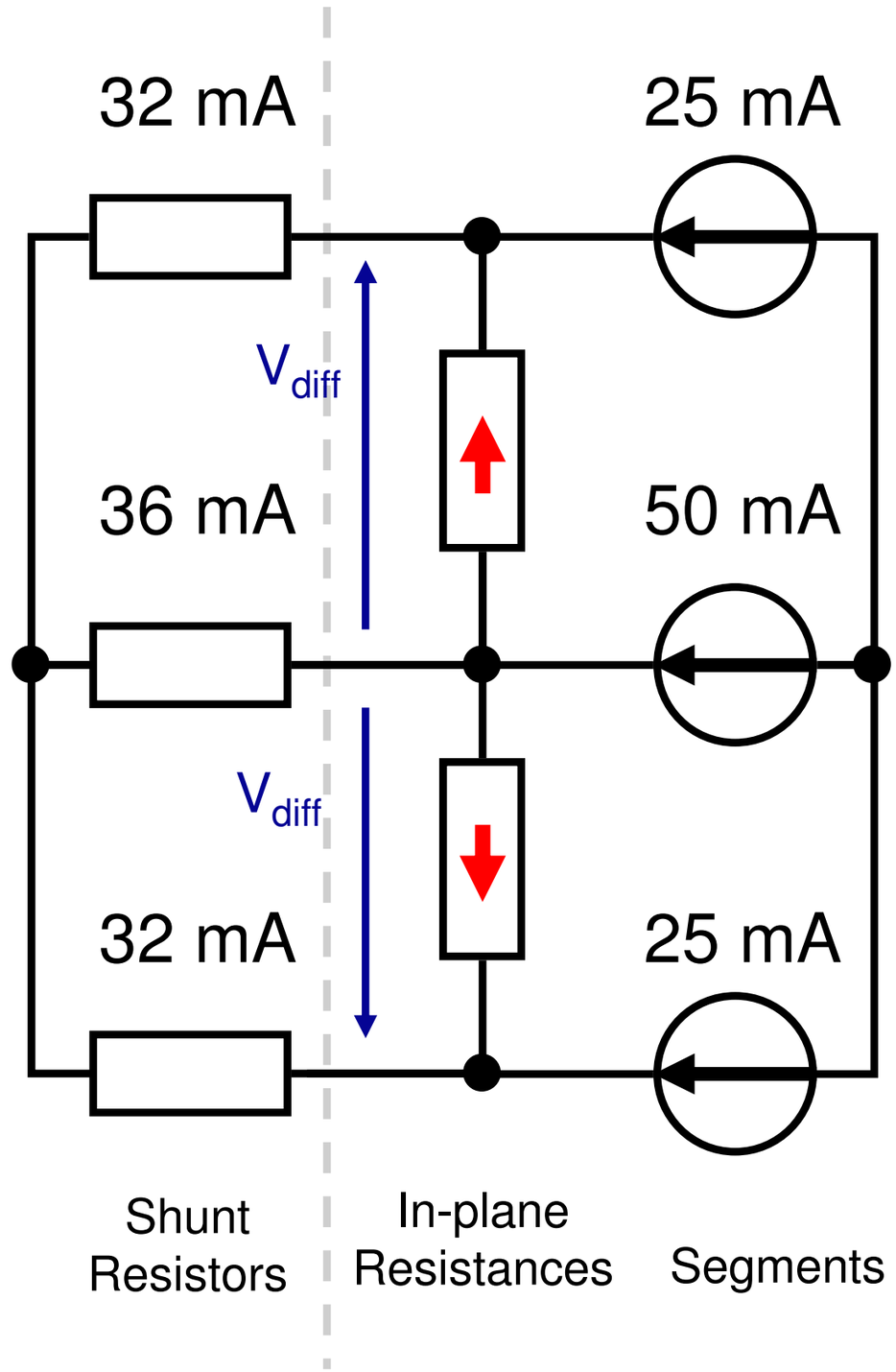
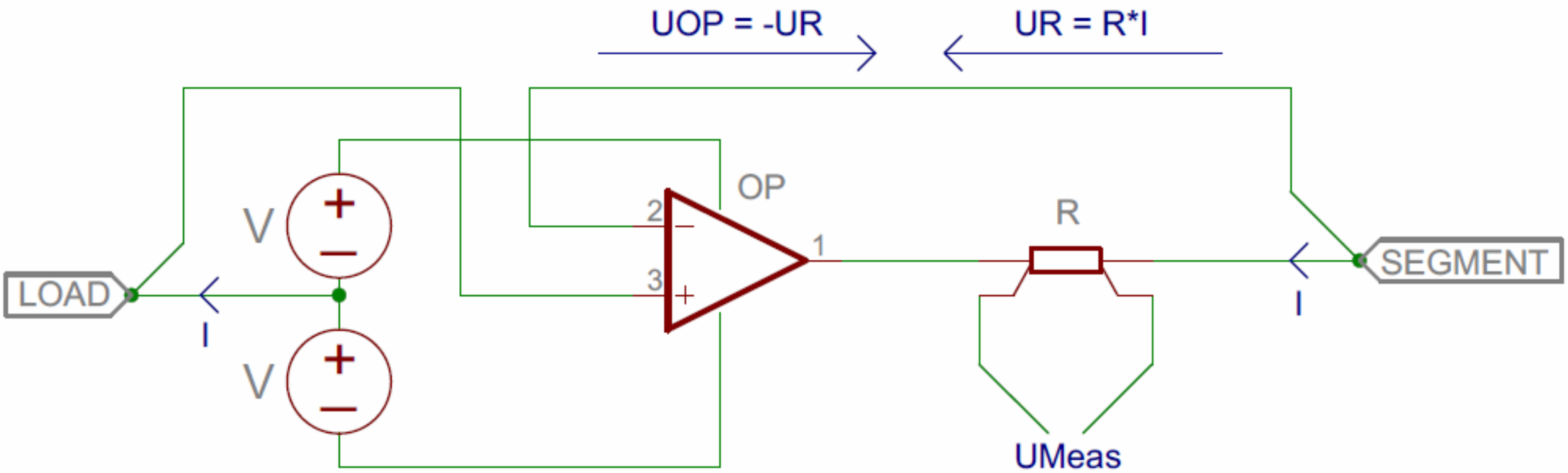


Compensated Shunt Resistor

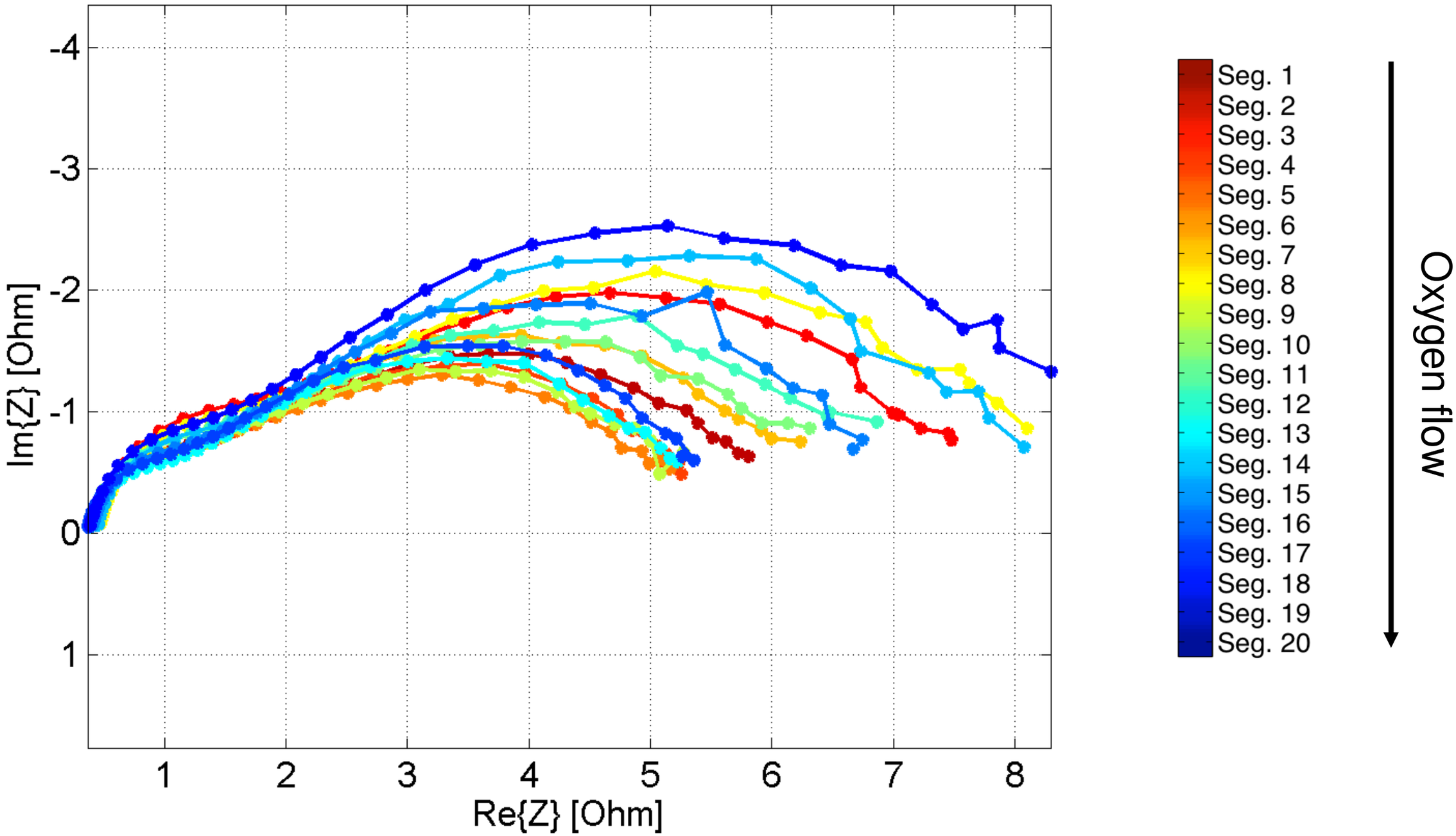
- Measurement signal range can be optimized (variable shunt resistance)

$$V_{meas} = 1mA \cdot 1\Omega = 1mV$$

- No influence by wire resistance (Kelvin connection)
- Parallel measurement up to high frequencies



First Measurement Results



Summary

- “Flipping” in spectra is no result from the MEA state, but a measurement influence caused by concentration oscillations.

- By using another measurement setup the effect can be reduced.
  - Magnitude of improvement dependent on relation between in-plane and segment impedance

- A compensated shunt resistor allows for precise spatially resolved current measurement without affecting the current distribution.

Thank you for your attention

bh@isea.rwth-aachen.de

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