Multiphysical simulation of the temperature field in a PEM fuel cell

Fabian Gumpert[1], Lara Kefer[1], Susanne Thiel[2], Maik Eichelbaum[2], and Jan Lohbreier[1]
 [1]Nuremberg Institute of Technology, Applied Mathematics, Physics and Humanities, Germany
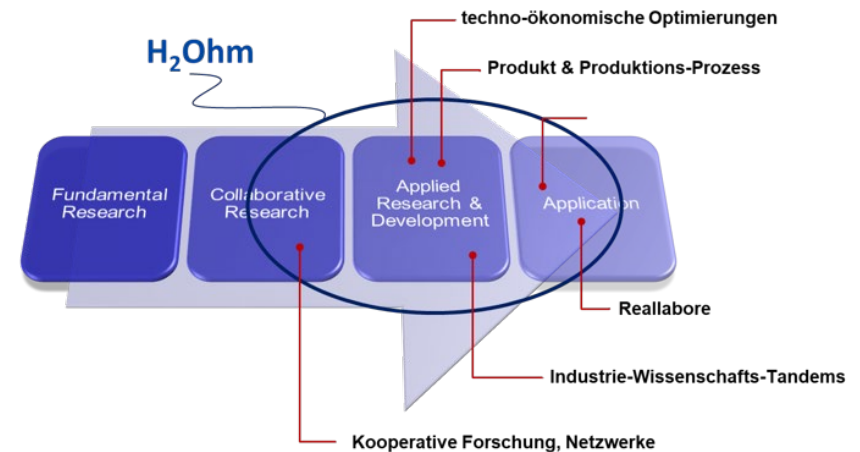[2]Nuremberg Institute of Technology, Applied Chemistry, Germany

Future Campus Driveline

H2OHM

Cooperation of
- MAN Truck & Bus
- Technische Hochschule Nürnberg Georg Simon Ohm
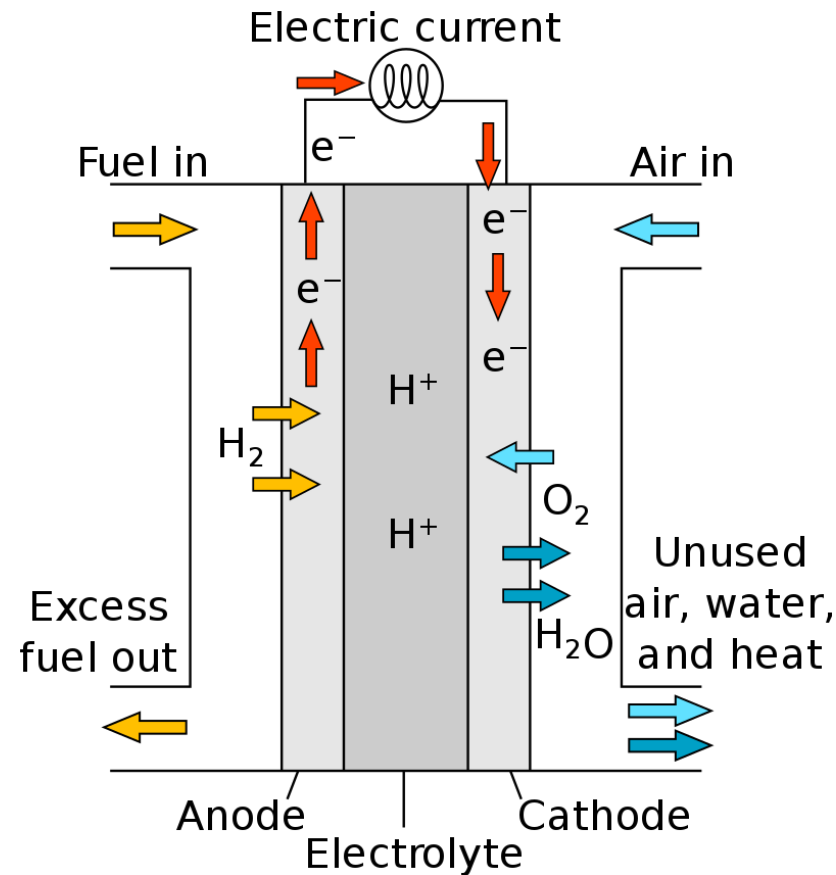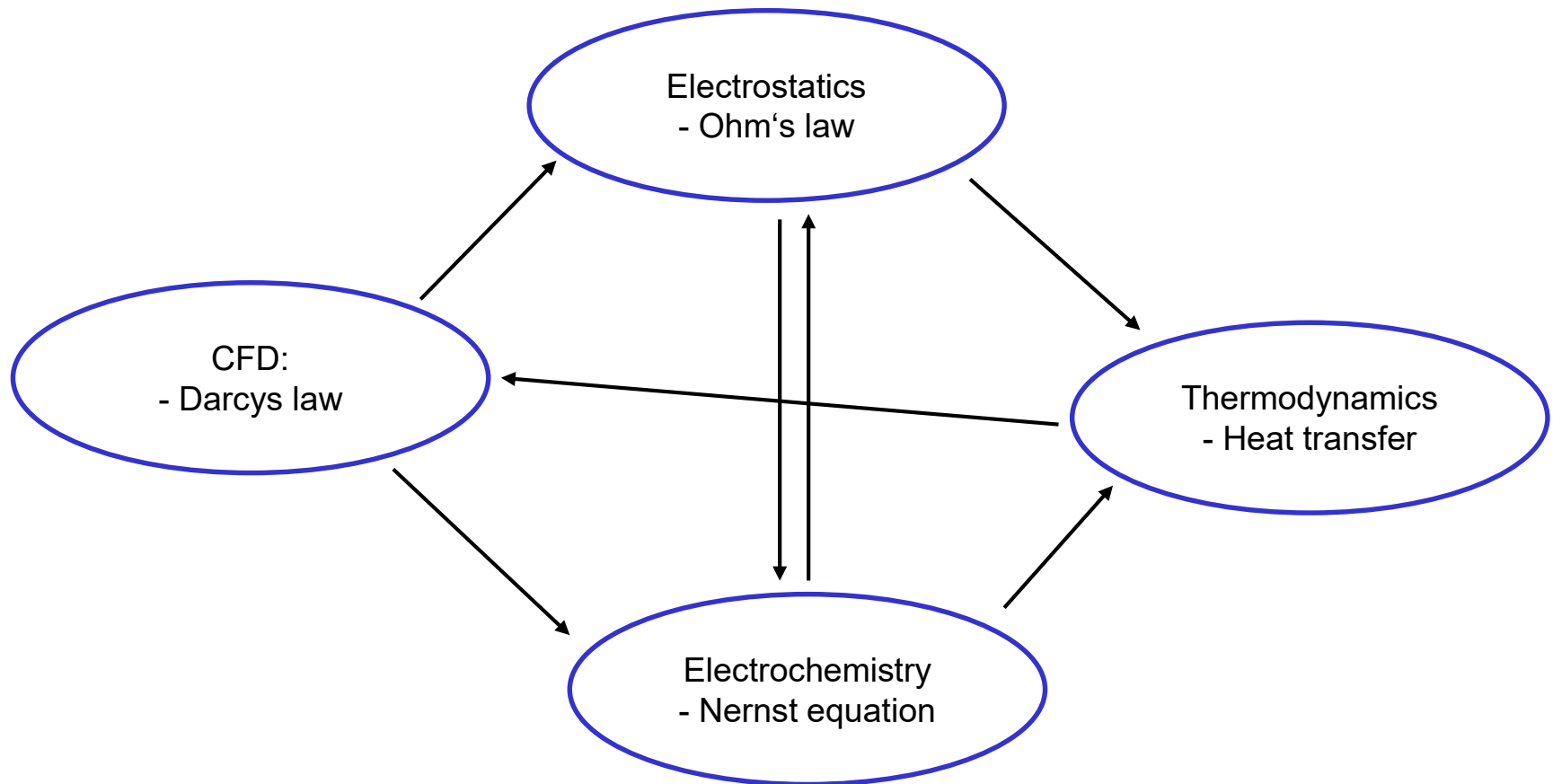- Friedrich-Alexander-Universität Erlangen-Nürnberg

Cooperation of
- inhouse research units
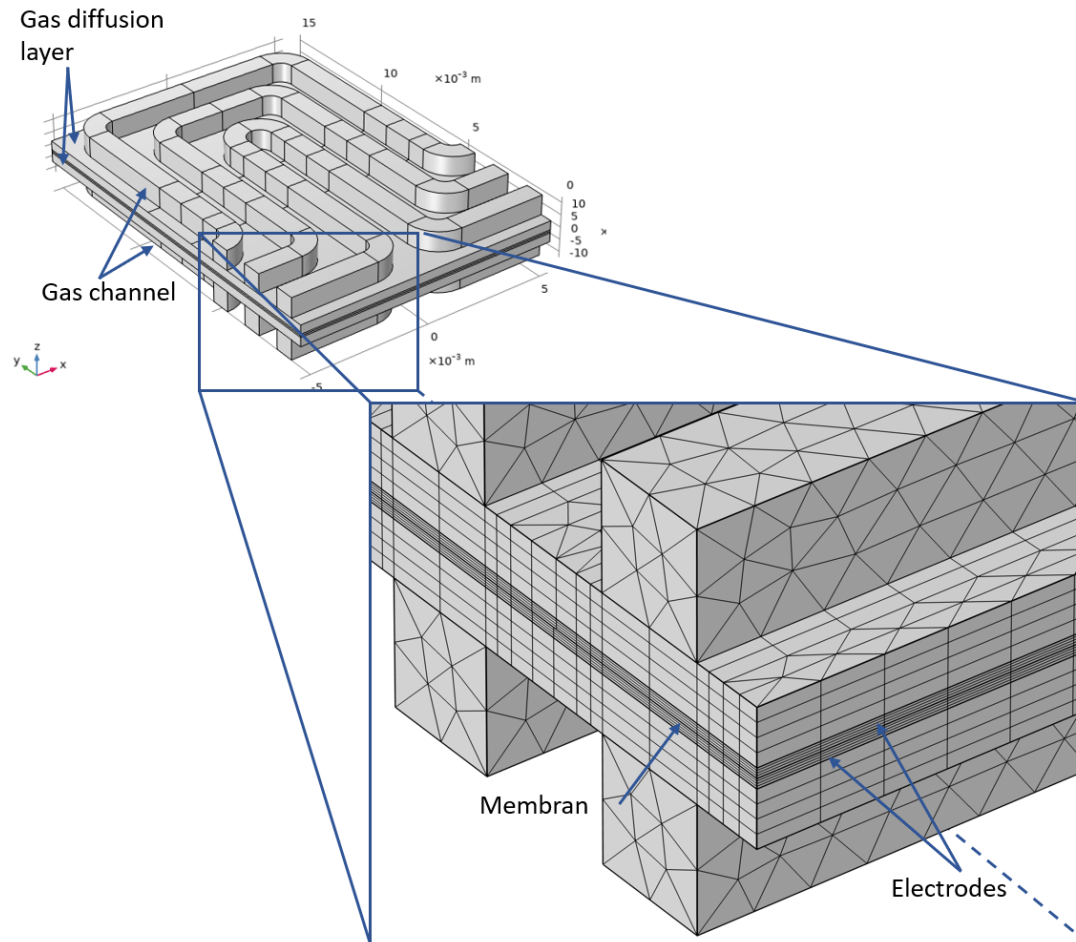- regional companies

What do we simulate?

en.wikipedia.org/wiki/Proton-exchange_membrane_fuel_cell

PEM fuel cell, a truely multiphysical task

→ Complex dependencies of the different regimes

Simulation model

Gas diffusion layer

Gas channel

Membran

Electrodes

DOF:
247k

Computation time:
1h (stationary study)

Fabian Gumpert
Department of Applied Mathematics, Physics and Humanities

Temperature field PEM fuel cell
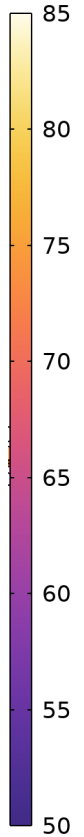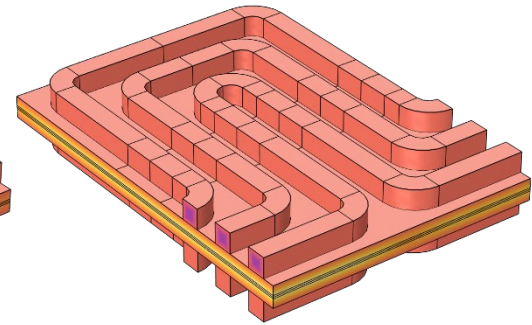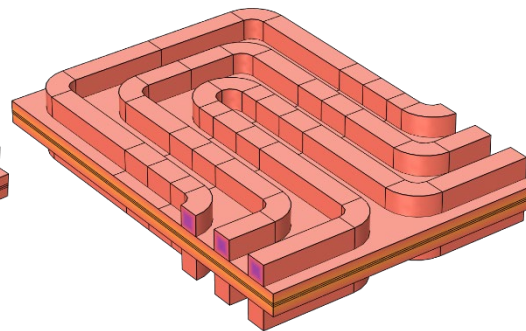
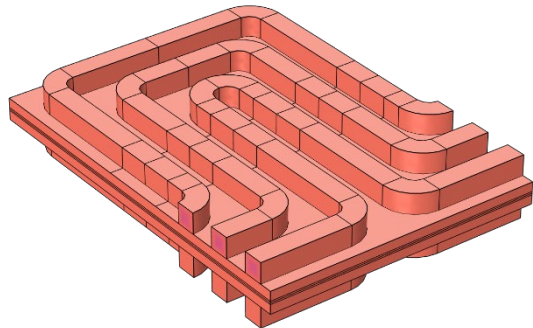$2000 \ A/m^2$ $10000 \ A/m^2$ $18000 \ A/m^2$ $[°C]$

60 °C
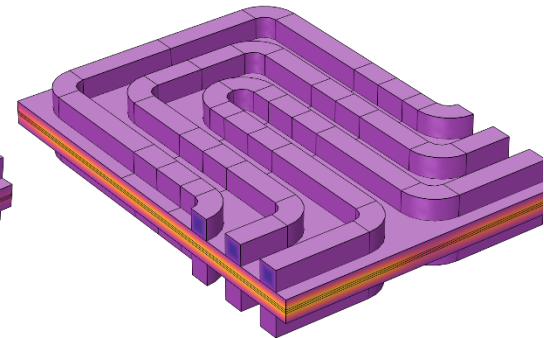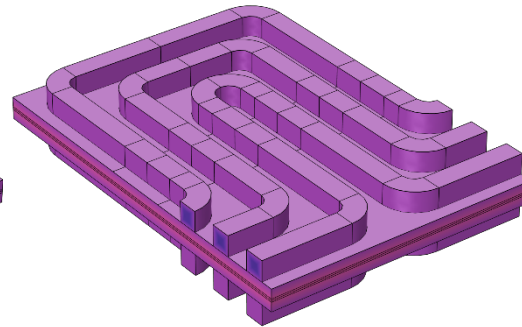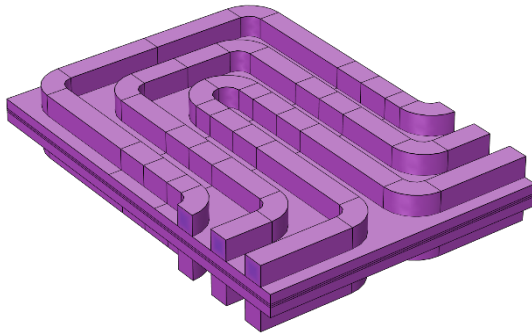
70 °C

→ Membrane temperature can be much higher than on the outside

Temperature field membrane
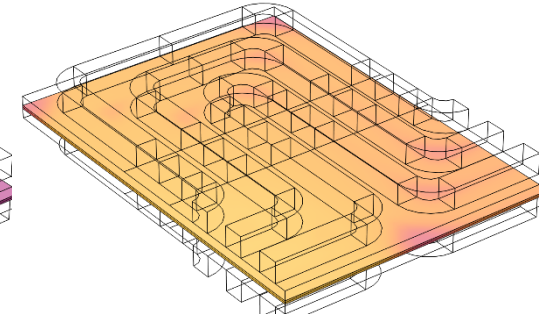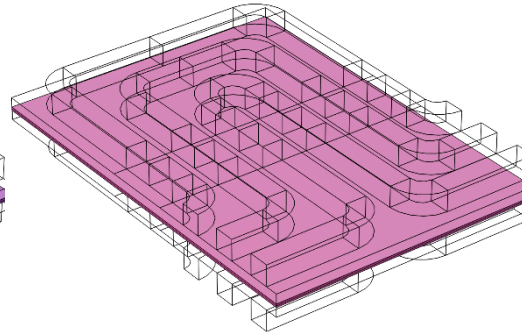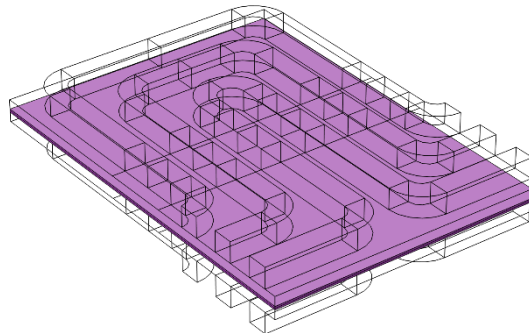
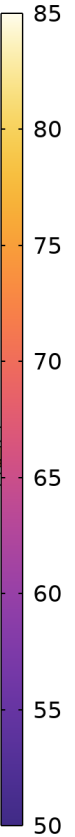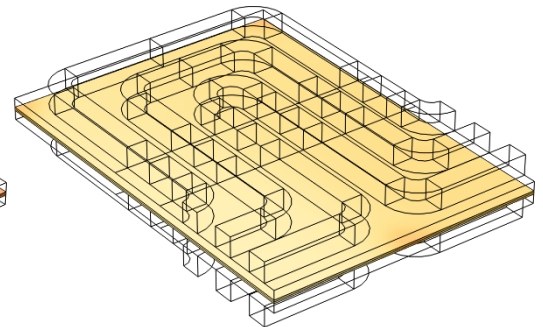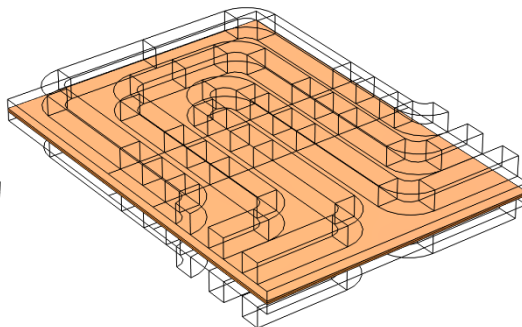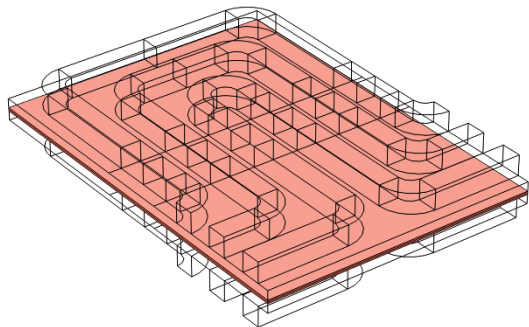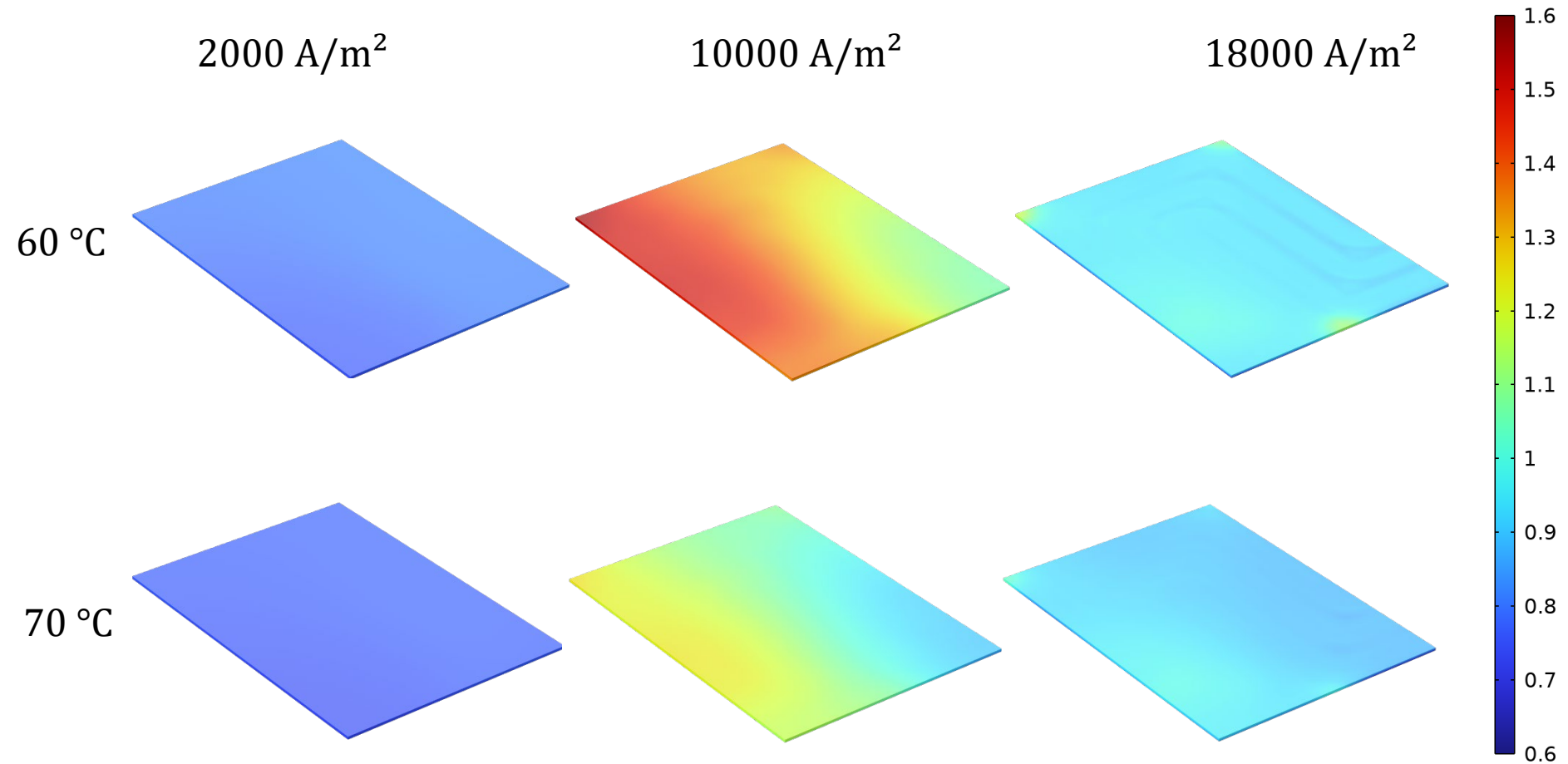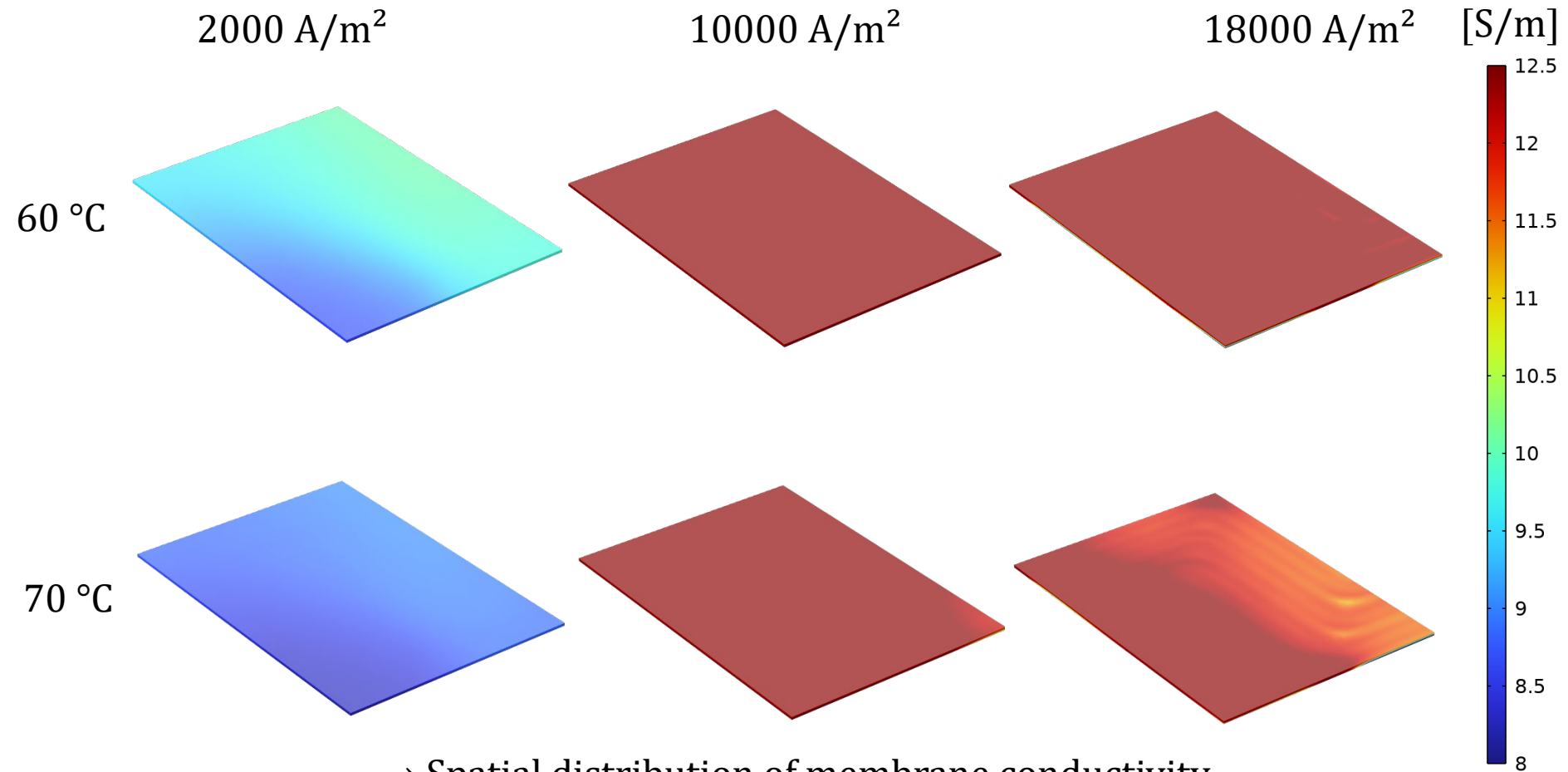→ Spatial distribution of membrane temperature
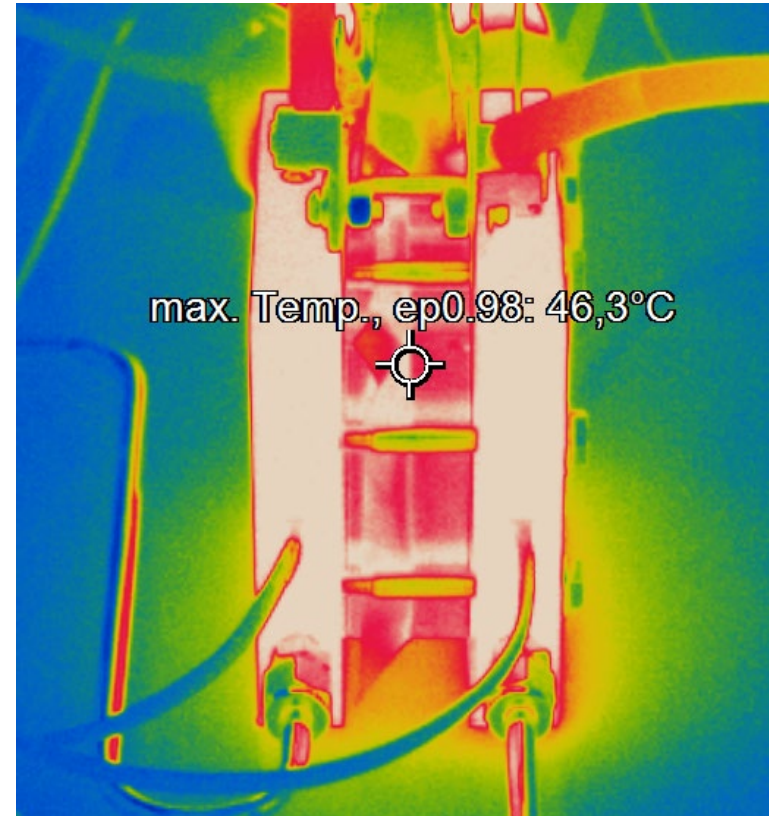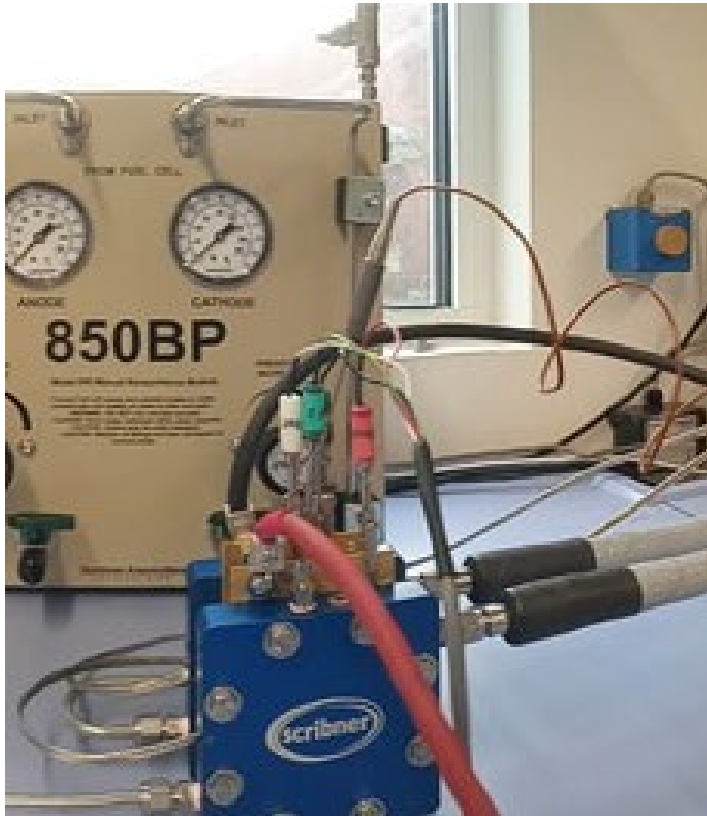
Water activity (relative humidity)

→ Spatial distribution of membrane humidity

Electrolyte conductivity

→ Spatial distribution of membrane conductivity

Temperature information from thermal imaging?
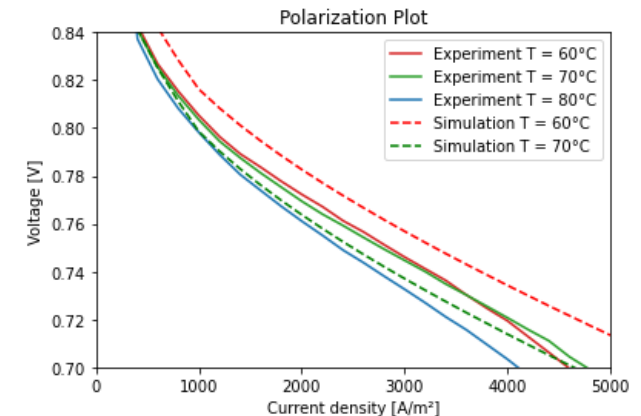

max. Temp., ep0.98: 46,3°C

→ External thermal imaging can not help

U-I-Characteristic: Simulation and Experiment
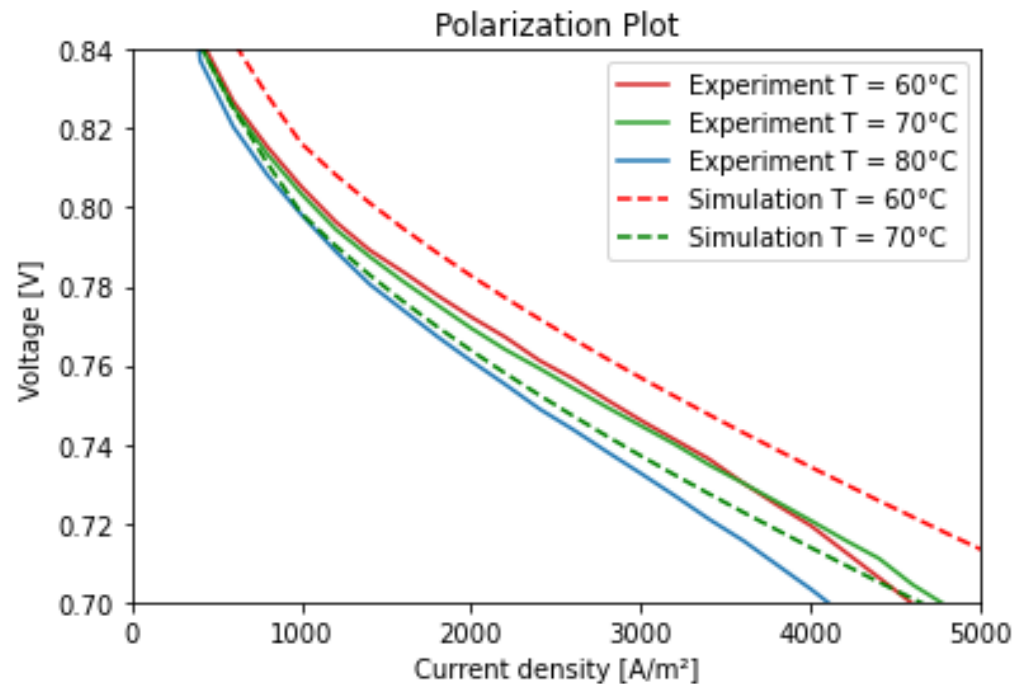
Conclusion

- Temperature influence on PEM fuel cell performance can be roughly modelled.

- Qualitative validation based on analytical correlations between humidity, temperature and conductivity was conducted.
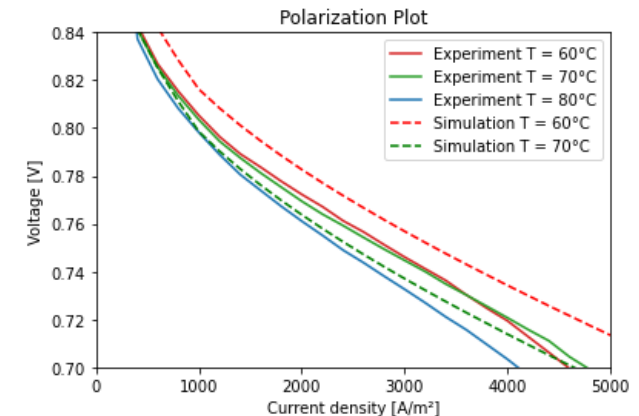
Conclusion

- Temperature influence on PEM fuel cell performance can be roughly modelled.

- Qualitative validation based on analytical correlations between humidity, temperature and conductivity was conducted.

Outlook

- Estimation of temperature due to H2 mass flows
- In-situ temperature measurements
- Further improvement of material parameters
- Two-phase simulations with water condensation implemented

DFG proposal submitted!

Thank you for your attention!

Website:
www.th-nuernberg.de/cp4x

Fabian Gumpert
fabian.gumpert@th-nuernberg.de

Prof. Dr. Jan Lohbreier
jan.lohbreier@th-nuernberg.de