Analysis and Extension of a PEMFC Model

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Motivation

Analyzing model behavior

- Investigation of performance losses with respect to activation, ohmic charge transport and concentration limitation
- Reproduction of transport limitations considering correlated parameter variations

Challenges

- Identification of parameters with major influence and evaluation of their sensitivity on cell performance
- Implementing and coupling gas channels to provided model

Approach

Employing and Coupling provided model

- Macro-homogeneous, two-phase, one dimensional through-plane **M**embrane-**E**lectrode-**A**ssembly (MEA) model provided by Institute of Computational Physics (ICP) at ZHAW Winterthur (www.isomorph.ch) [1]
- Variation of **one** parameter at a time
- 1D gas channel implementation based on analytical approach [2]

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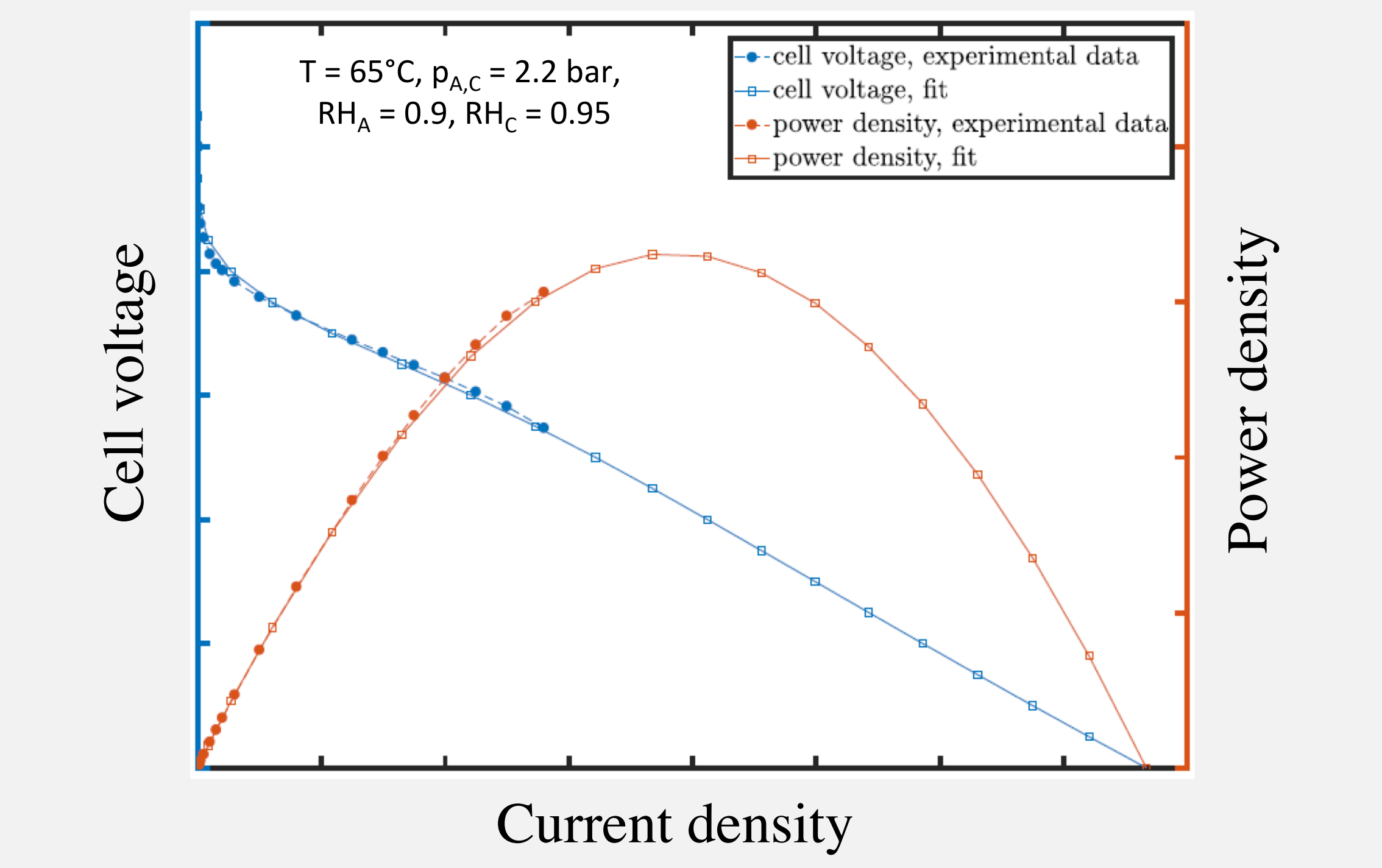
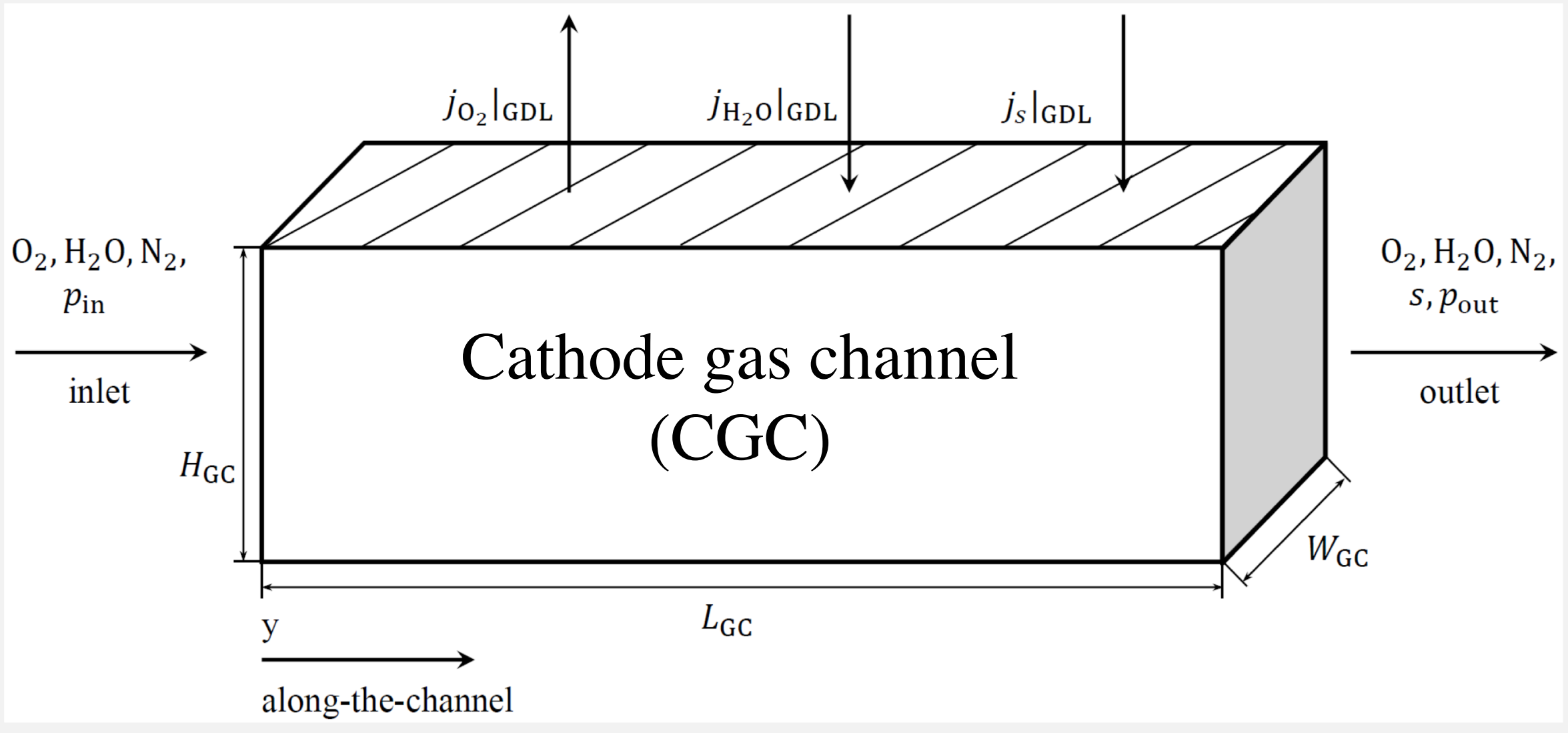
Modeling

Fit to experimental data



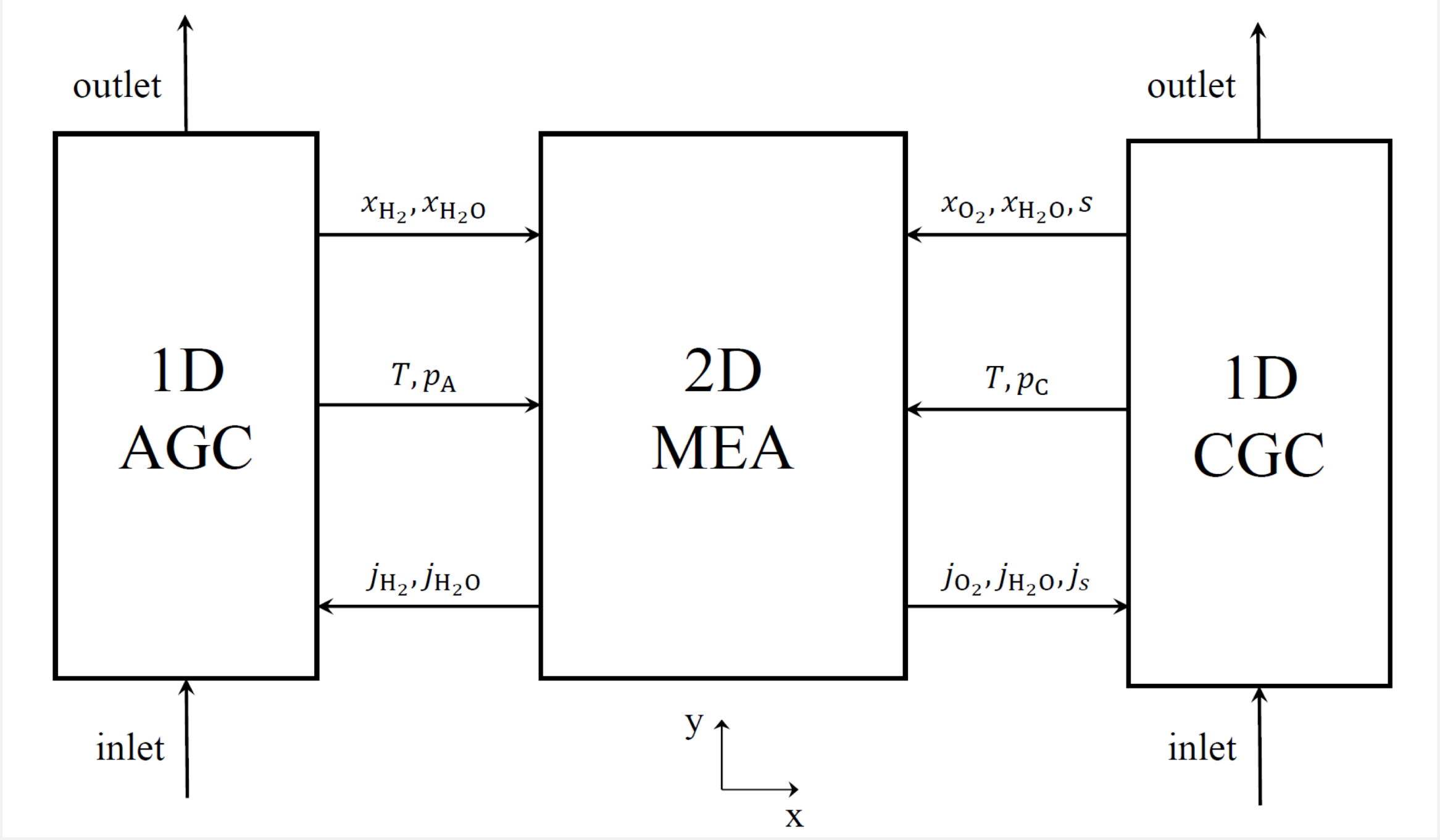
- Fit parameters (least square root)
  - fuel cross over correction η_{OCV}
  - exchange current density, cathode i_0
  - proton conductivity σ_p

1D CGC model



- Based on analytical approach [2]
  - Ideal gas, laminar flow, isotherm
  - Ideal evaporation and condensation at GDL|CGC interface (shaded area)

2D along-the-channel model

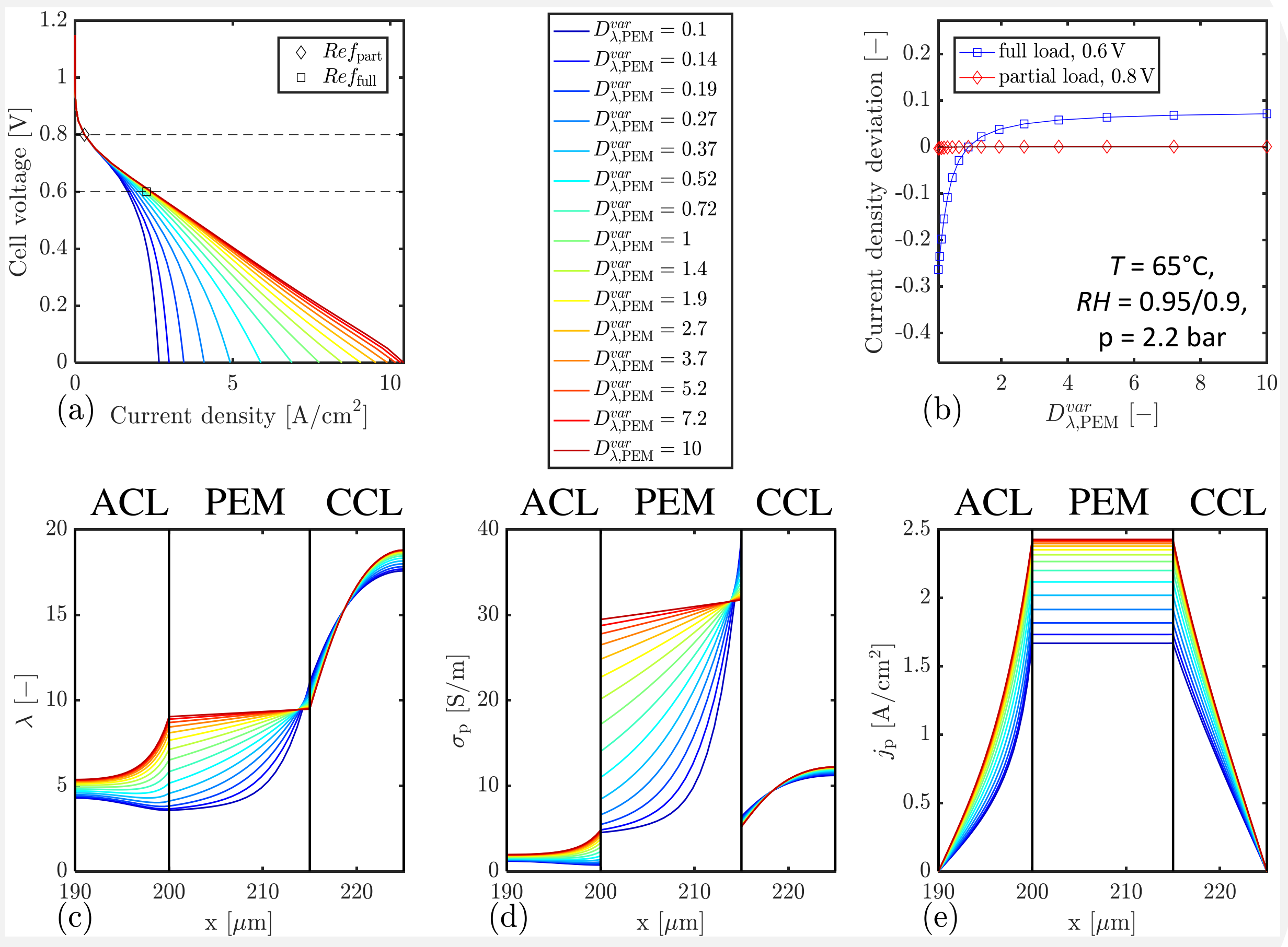


- Coupling variables change locally
- Solution is determined by solving fully-coupled equation system

Results of Sensitivity Analysis and Coupled Model

Variation of back diffusion coefficient[3] in 1D MEA model

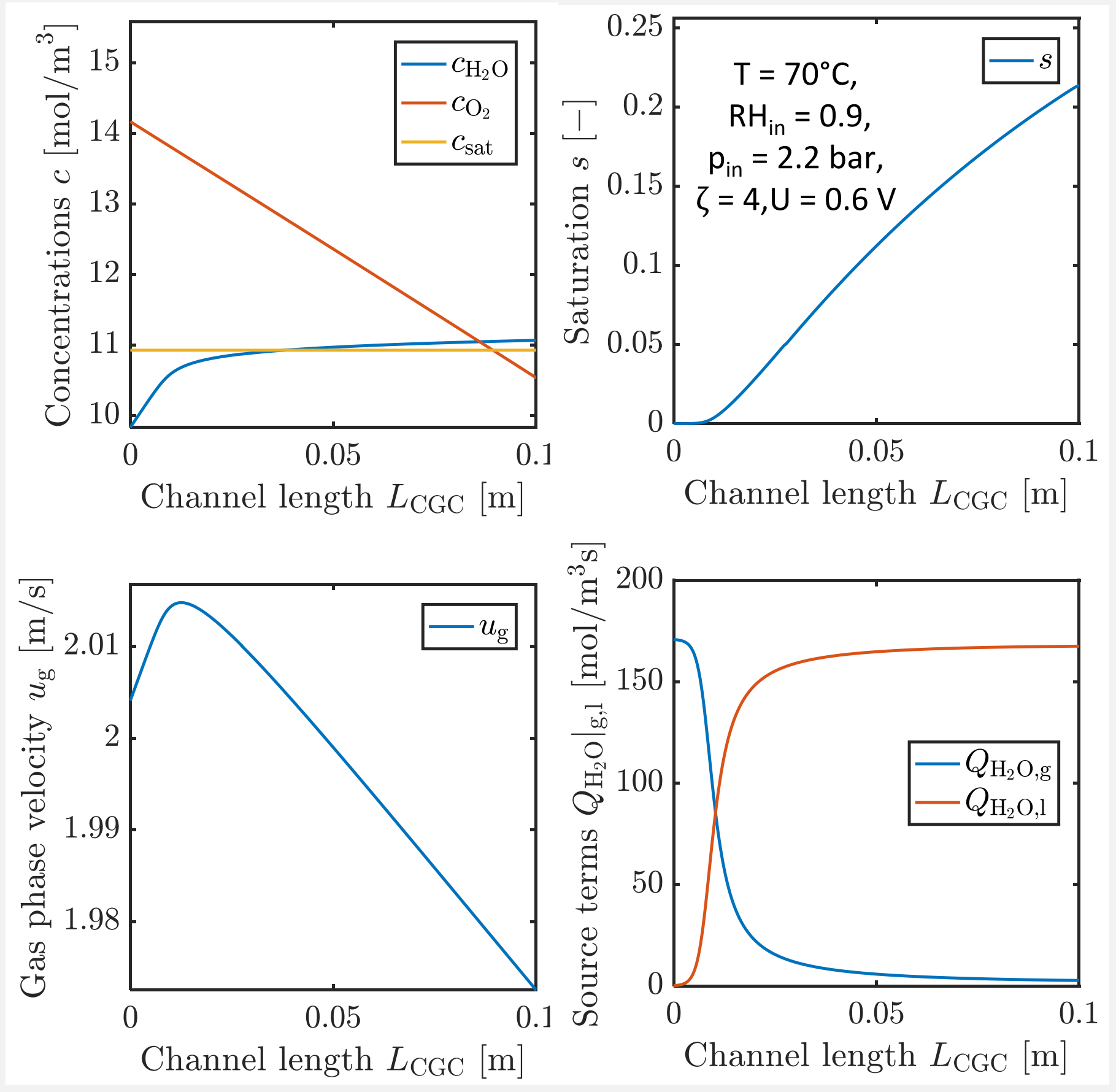
- High back diffusion leads to higher water content in electrolyte and, thus perfomance increase
- Low back diffusion shows transport limitation due to membrane dry out



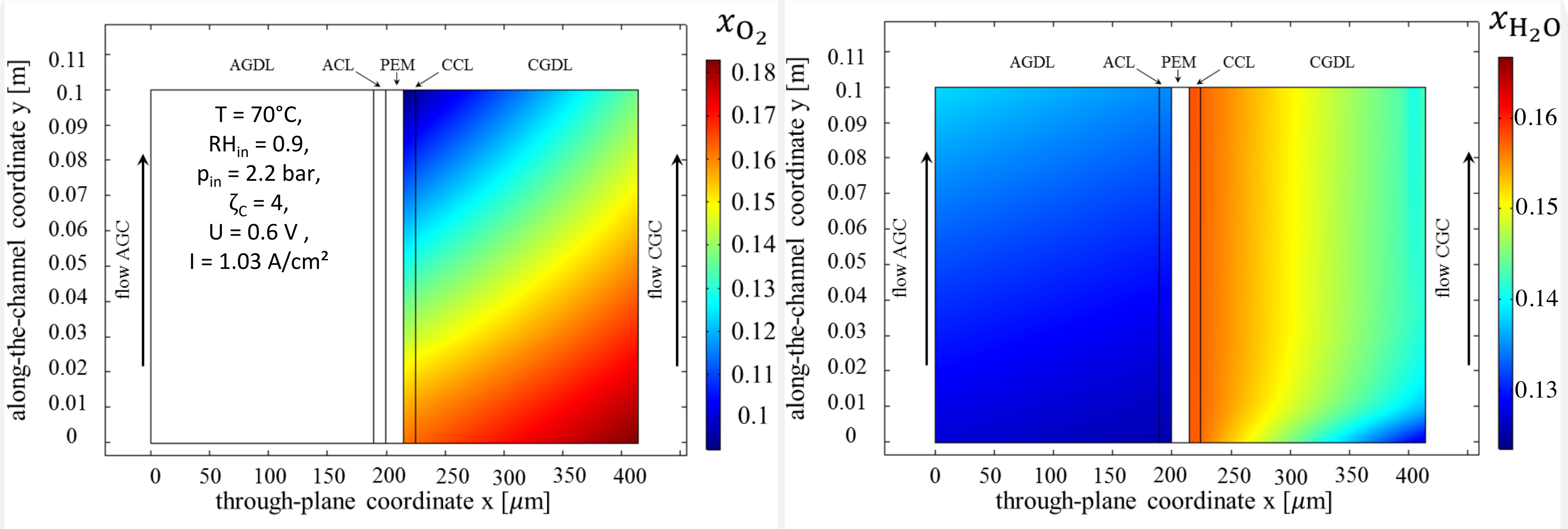
- In total, 48 parameters have been varied, 15 show great influence

2D along-the-channel model – cathode gas channel

- Oxygen decrease along the channel
- Gas phase saturates with water vapor along the channel
- Liquid water saturation increases after condensation occurs
- Velocity decreases due to gas-liquid interaction



2D along-the-channel model – MEA



- Oxygen depletion along-the-channel and through-plane
- Water vapor saturation along-the-channel

Summary and Outlook

Summary

- Sensitivity of all model parameters has been investigated
- Expansion by coupling of 1D gas channels to existing MEA-model

Outlook

- Material specific parameterization based on experimental data
- Improving robustness of solving process

Literature

[1] Roman Vetter and Jürgen O. Schumacher. „Free Open Reference Implementation of a Two-Phase PEM Fuel Cell Model“ (2018). Submitted to Computer Physics Communications.

[2] Yun Wang. „Porous-Media Flow Fields for Polymer Electrolyte Fuel Cells II. Analysis of Channel Two-Phase Flow“. Journal of the Electrochemical Society **156**.10 (2009)

[3] Ahmet Kusoglu and Adam Z. Weber. „New Insights into Perflourinated Sulfonic-Acid Ionomers“. Chemical Reviews **117**.3 (2017)

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