Current collector

Hyd

Anode

Water cooli

Current feeder

3D CFD Simulation of a PEM Fuel Cell Electrochemistry

The project demonstrates ability and simplicity of COMSOL Fuel Cell & Electrolyzer Module to simulate PEM fuel cell electrochemistry within acceptable accuracy.

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abstract

Fuel cells are considered one of the most promising alternatives to conventional energy sources due to their high energy efficiency and low emissions. Accurate modeling of the fuel cell electrochemistry is crucial to optimize fuel cell performance. In this study, we evaluated the capability of COMSOL Multiphysics software for simulating fuel cell electrochemistry.

We used the Fuel Cell & Electrolyzer Module in COMSOL to simulate the electrochemical reaction in a proton exchange membrane (PEM) fuel cell. One of the objectives is to generate a polarization curve, which is a plot of current density versus cell voltage. We compared the polarization curve generated by COMSOL with the experimental data from a reference journal and a very good correlation is obtained.
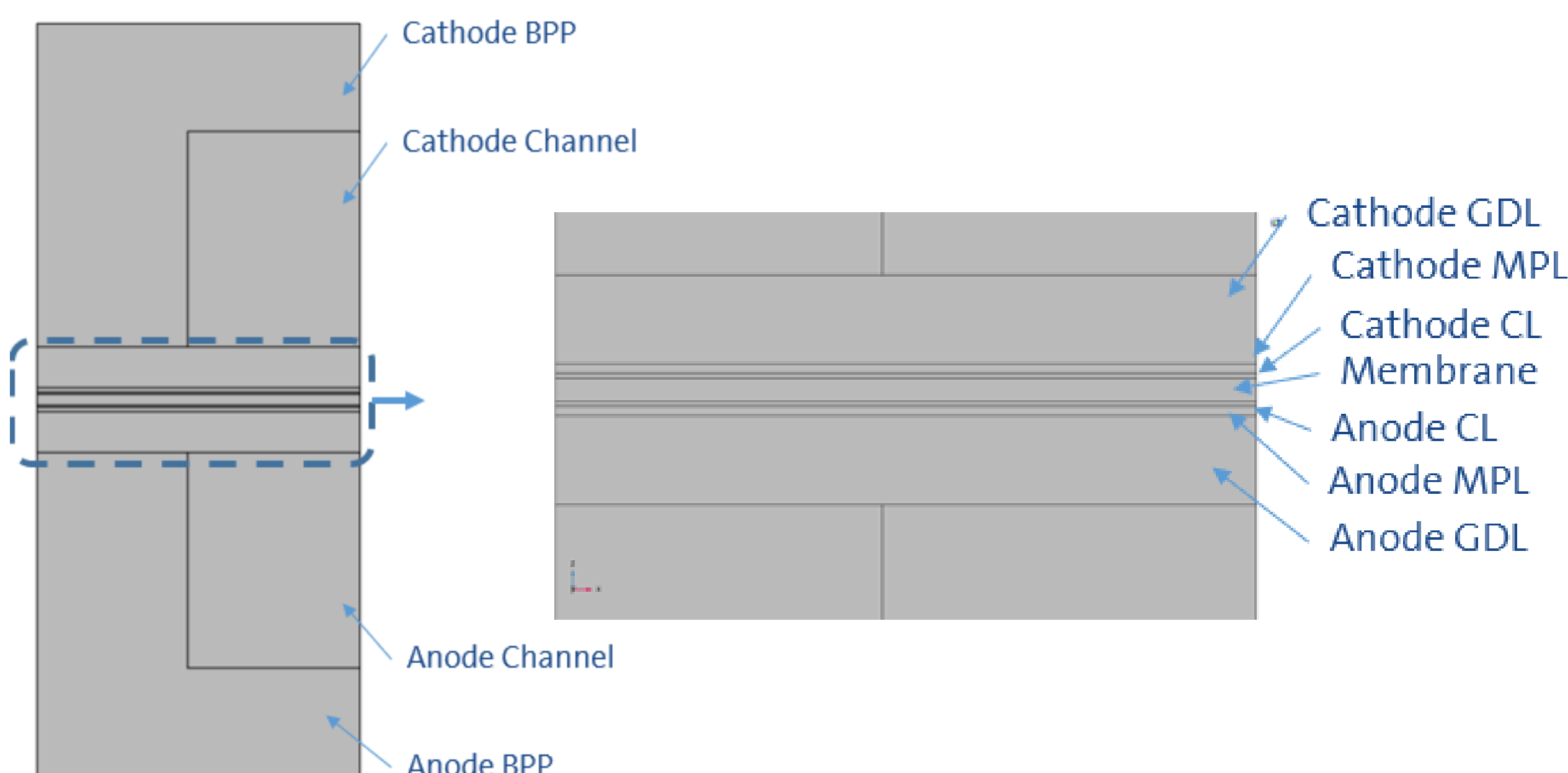
Cathode BPP
Cathode Channel
Cathode GDL
Cathode MPL
Cathode CL
Membrane
Anode CL
Anode MPL
Anode GDL
Anode Channel
Anode BPP

Fig 1 : Front view of the 3D model with different components labeled

Methodology

Fig. 1 shows the schematic of a typical PEM (Proton Exchange Membrane) fuel cells. A polymer membrane is placed between CLs (Catalyst Layers) and GDLs (Gas Diffusion Layer), MPLs (Micro Porous Layers) and BPPs (Bi-polar Plates) are placed on anode and cathode sides. Hydrogen is supplied through anode BPP and air (or oxygen) enters through cathode BPP. Only half of the rib and channel are considered in this study to improve numerical calculation efficiency.

The 3D model developed in this study is implemented in COMSOL Multiphysics software. The mesh is generated using the Mapped and Swept operations. In total, 50,000 Mapped mesh (quadrilateral) cells are generated.

Results

The polarization curves obtained from this numerical model are compared to the experimental data using the detailed 3D PEM fuel cell model developed in this study. The simulation parameters were (T = 353.15 K, RHa = 0.84, RHc = 0.59, λa = 2 and λc = 1.5). The results are shown in Fig 2, and it can be seen that the simulation results agree reasonably well with the experimental data.

The distribution of relative humidity across the length of channel is shown in Fig 3 at 0.52 V.
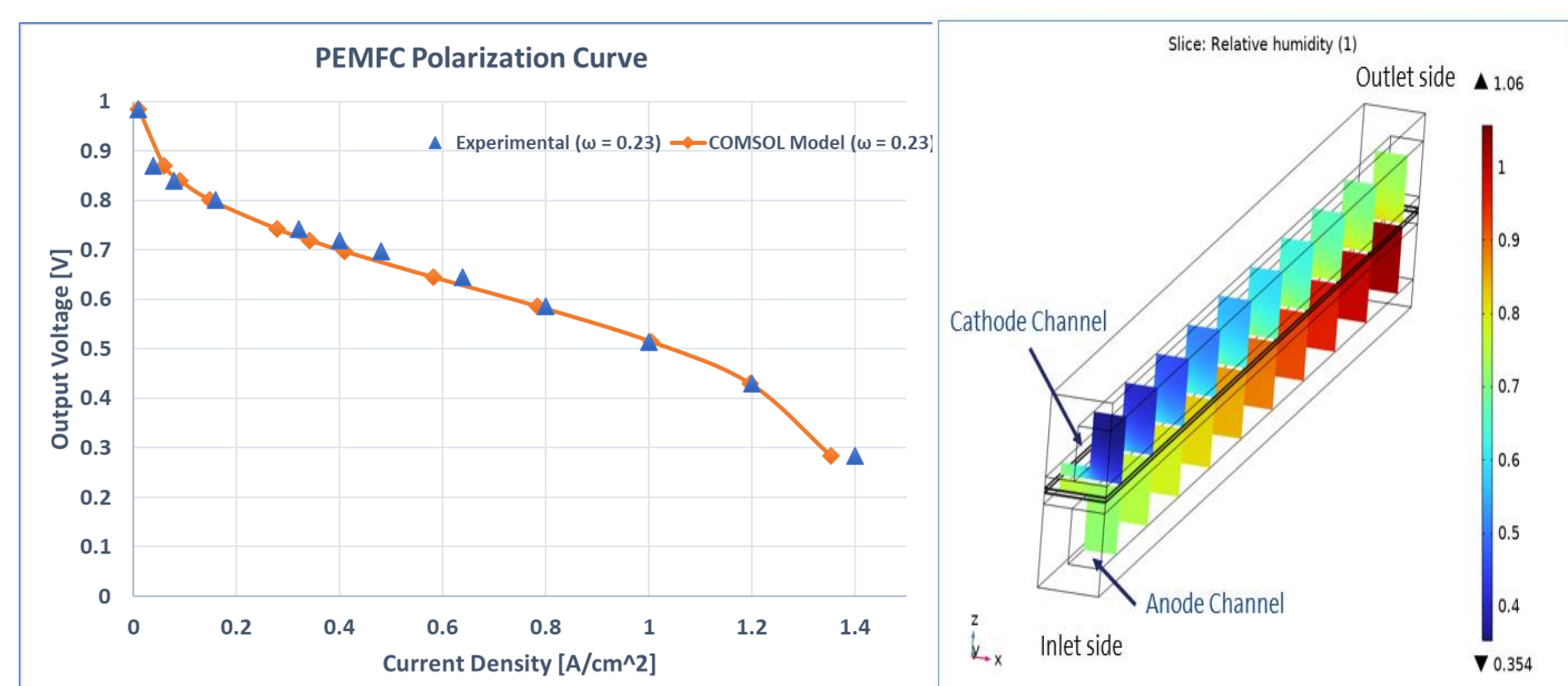

Fig 2 : Polarization curve compared with simulation and experimental data. Fig 3 : Distribution of Relative Humidity in the channel

REFERENCES

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Fuel Cell & Electrolyzer Module documentation.