Current Distribution on PEM Fuel Cells with Different Flow Channel Patterns

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Introduction:

Fuel cells are a promising technology for electric power generation, suitable for several mobile and stationary applications. Flow channels are important for supplying reactant gases in the fuel cell, and they can be designed in various patterns, such as serpentine and interdigitated. They differ greatly in the reactant distribution, and consequently, in the current distribution over the plate. Joule effect links current to heat generation, and variations in current densities throughout the cell may cause uneven heat generation, jeopardizing water and heat management.

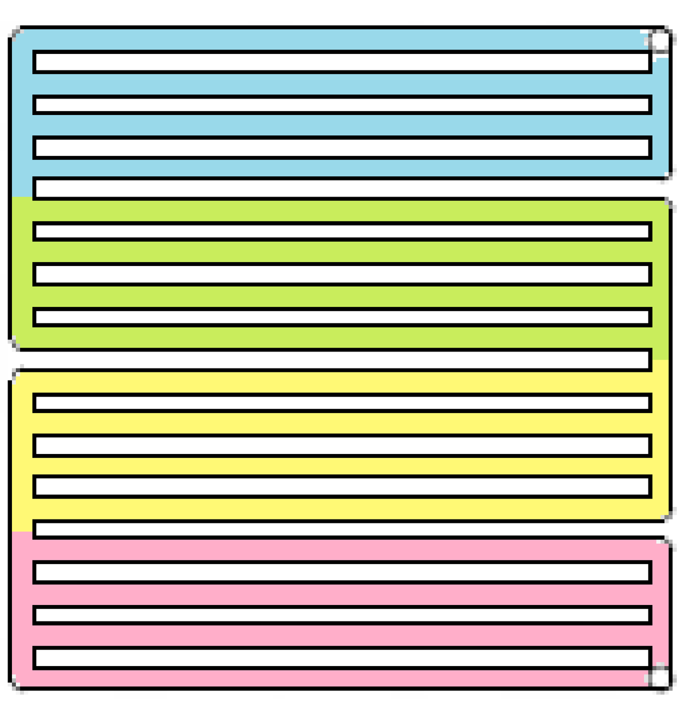

Figure 1. Serpentine pattern

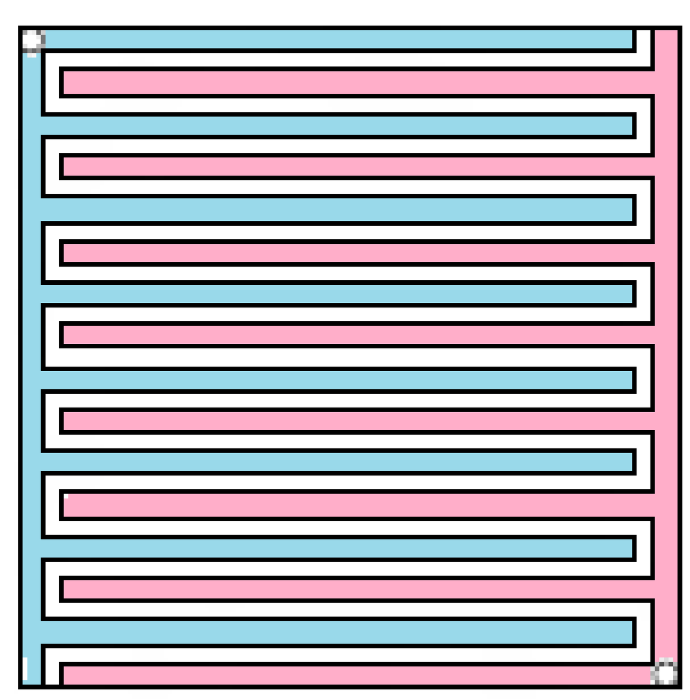

Figure 2. Interdigitated pattern

Computational Methods:

Both models are described by the same physics interfaces in the software. Electrochemical reactions and charge transport were modeled using the Secondary Current Distribution interface. Free and Porous Media Flow interface was used for modeling momentum transport. Diffusion of reactants and products was modeled with the Transport of Concentrated Species interface.

The geometric model was built in layers, from the bottom up: H_2 channels, anode GDL, catalyst layer, proton exchange membrane, cathode catalyst and GDL, and O_2 channels. The mesh was completely structured, consisting of hexahedral elements.

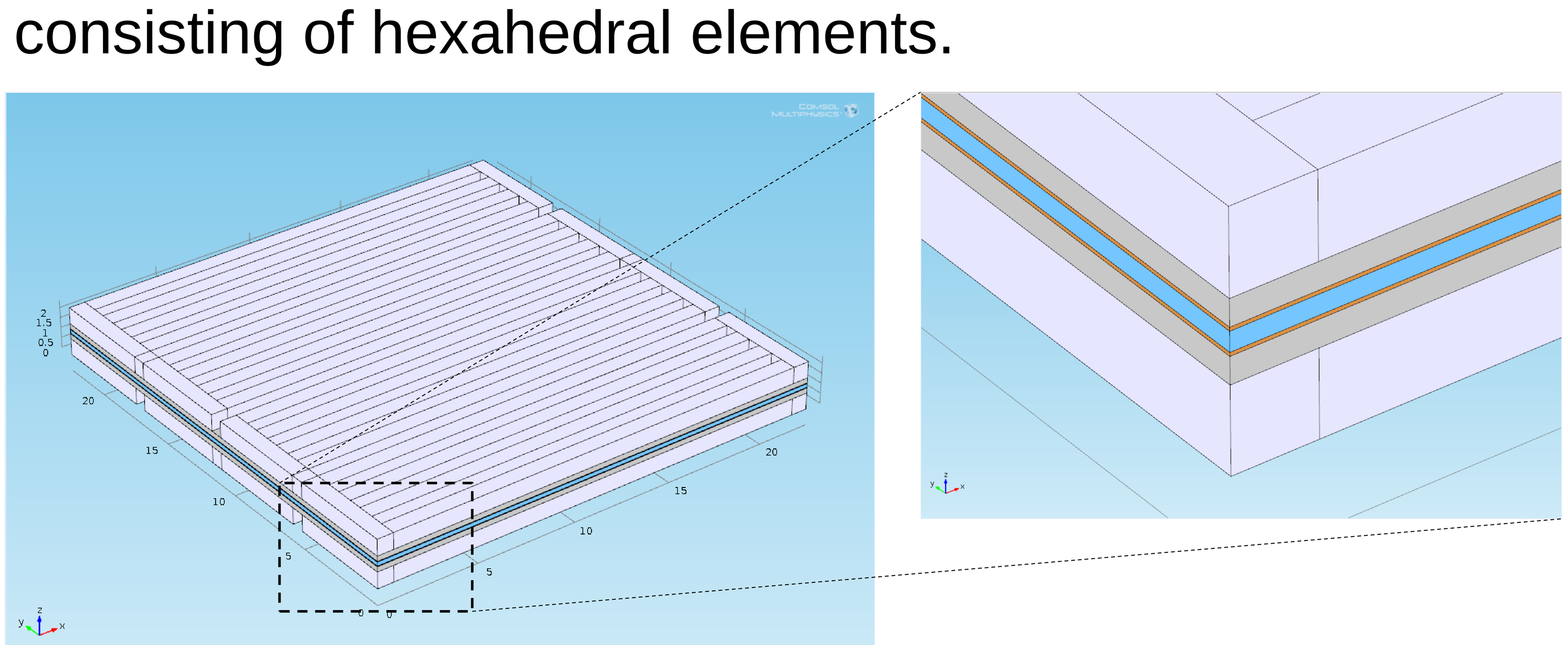

Figure 3. Geometry for serpentine pattern

Results:

Comparison of the polarization curves shows that performance is not significantly affected by pattern design. However, when analyzing current distribution in the membrane midplane, it was seen that in the serpentine pattern most of the current generation occurs close to the inlet, while in the interdigitated plate, current is better distributed over the area of the cell.

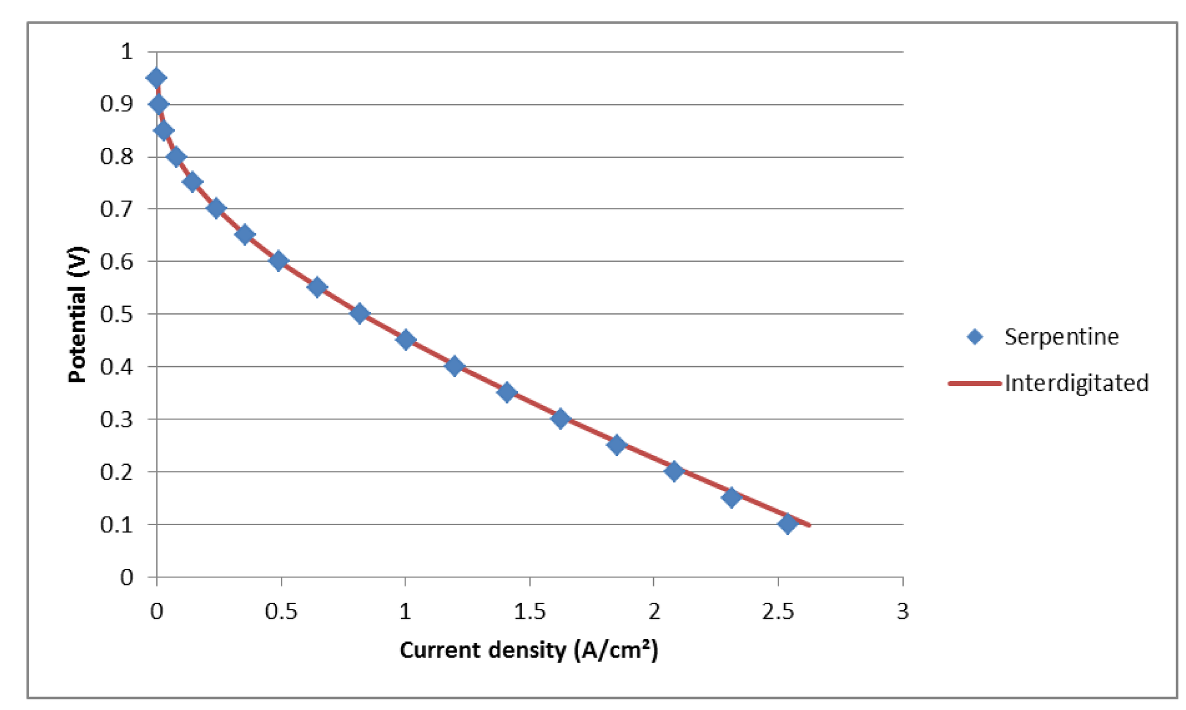

Figure 4. Polarization curves for serpentine and interdigitated patterns

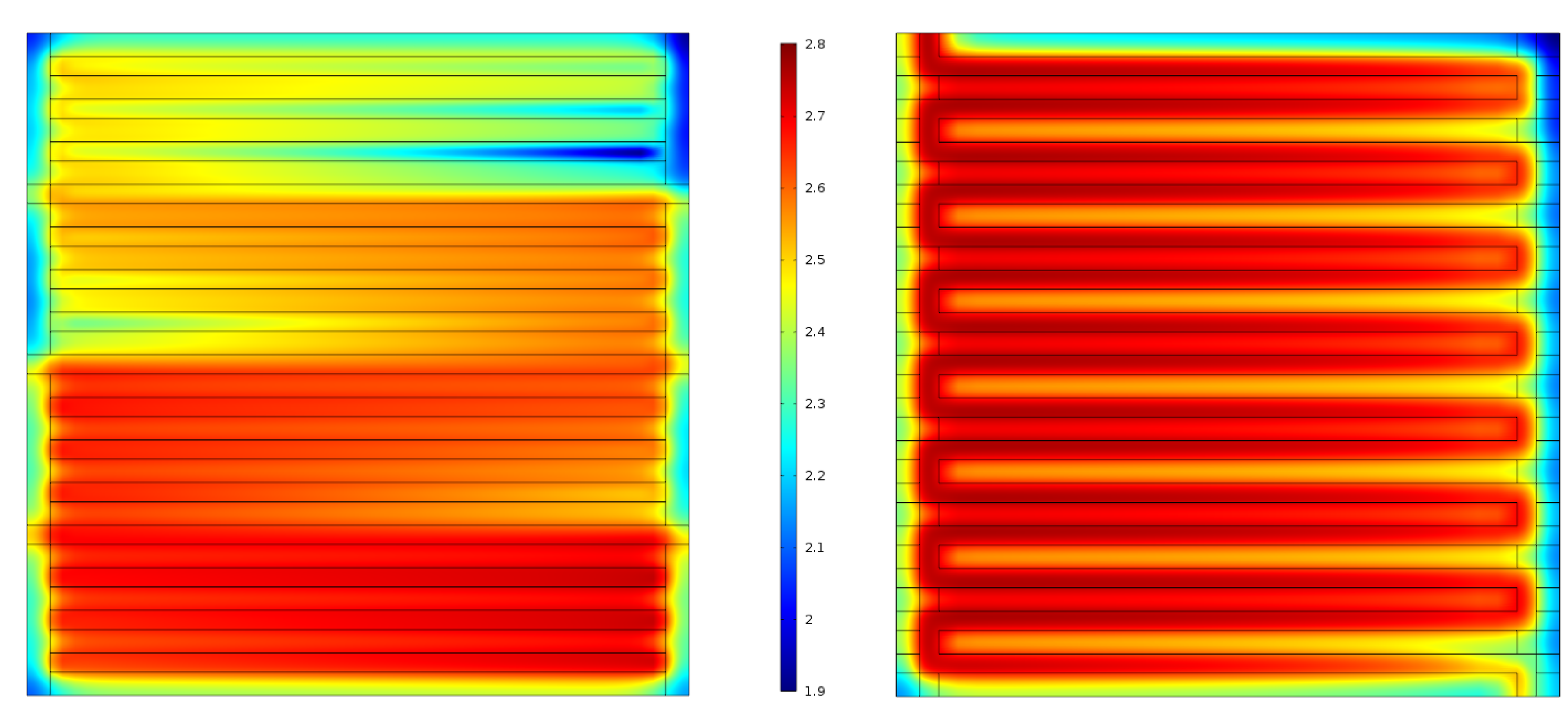

Figure 5. Current distribution for serpentine (left) and interdigitated (right) patterns

Conclusions:

The interdigitated pattern provides a more uniform current distribution throughout the fuel cell, resulting in uniform heat generation. This facilitates water and thermal management, and may enhance the fuel cell performance.

References:

1. Y. M. Ferng et al. A three-dimensional full-cell CFD model used to investigate the effects of different flow channel designs on PEMFC performance, *Int. J. Hydrogen Energy*, **32**, 4466-4476 (2007)
2. E. Robalinho. *Desenvolvimento de um modelo numérico computacional aplicado a uma célula a combustível unitária de 144 cm² do tipo PEM.* PhD Thesis, São Paulo, SP, Brazil (2009)

Acknowledgements:

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