Mass Transport Analysis of Interdigitated Flow Field and Patterned Gas Diffusion Layer

Alvaro Garcia-Padilla[1], Lorenz Gubler[1], Juan Herranz[1], Pierre Boillat[1,2]

[1]PSI Center for Energy and Environmental Sciences, 5232 Villigen PSI, Switzerland
[2]PSI Center for Neutron and Muon Sciences, 5232 Villigen PSI, Switzerland
Contact: alvaro.garcia-padilla@psi.ch

Type: Master thesis / Semester project

The energy transition requires a reliable integration of renewable energies with electricity storage technologies. Water electrolysis and fuel cells are promising solutions; however, they require enhancements to boost their worldwide release. Fuel cell efficiency and cost can be improved by using interdigitated flow fields (IFFs) to enhance gas transport compared to conventional parallel and serpentine designs[1]. The water accumulation and operation instability drawbacks showcased by these flow fields can be suppressed using patterned wettability gas diffusion layers (GDLs)[2] that are prepared by creating hydrophilic regions in the hydrophobic coating of the carbon fiber by altering the chemical composition. This is done using irradiation-induced polymerization grafting combined with a mask that allows the irradiation and subsequent modification of selected regions of the GDL[3].

Tasks

This master's thesis aims to characterize the mass transport limitations of oxygen in the porous media and catalyst later in different flow field architectures and GDL designs using pulsed gas analysis (PGA) and limiting current experiments. These two techniques aim to estimate the bulk and non-bulk diffusion losses of oxygen in selected designs after the optimization of these parameters. The PGA allows us to estimate the bulk diffusion losses as the voltage difference when flowing an oxygen-in-helium (so-called helox) mixture vs. air (i..e, O_2 in N_2) at the cathode. The latter difference is due to the lower oxygen diffusivity in helium than in nitrogen. Complementarily, the non-bulk diffusion losses are related to the oxygen partial pressure, for which the voltage difference of oxygen and helox mixture is considered[4]. On the other hand, the limiting current experiment will be used as an alternative approach for deconvoluting the transport losses. This is achieved by identifying the point where the current generated remains constant as the voltage is constantly decreased. The master's project will include GDL preparation, starting from pristine carbon fibers, applying hydrophobic coating, microporous layer coating, and hydrophilic grafting. The project will also include the electrochemical testing of the samples in the fuel cell test bench using a differential cell and its data analysis.

Requirements: Basic knowledge in electrochemistry and mass transport, and programming skills.

References

1. T. Van Nguyen and M. W. Knobbe, *J. Power Sources*, **114**, 70–79 (2003).

2. V. Manzi-Orezzoli, M. Siegwart, M. Cochet, T. J. Schmidt, and P. Boillat, *J. Electrochem. Soc.*, **167**, 054503 (2019).

3. A. Forner-Cuenca, J. Biesdorf, L. Gubler, P. M. Kristiansen, T. J. Schmidt, and P. Boillat, *Adv. Mater.*, **27**, 6317–6322 (2015).

4. P. Boillat, P. Oberholzer, A. Kaestner, R. Siegrist, E. H. Lehmann, G. G. Scherer, and A. Wokaun, *J. Electrochem. Soc.*, **159**, F210 (2012).