Experimental report

26/01/2021

Proposal: UGA-105 **Council:** 10/2019

Title: Influence of new Gas diffusion layer structures on the water distribution in operationg proton exchange membrane fuell cell

Research area:

This proposal is a new proposal

Main proposer: Arnaud MORIN

Experimental team:
Marie FONTANA
Arnaud MORIN
Florian CHABOT
Fabrice MICOUD

Local contacts:
Lukas HELFEN
Alessandro TENGATTINI
Nicolas LENOIR

Samples:
Pt
C
PTFE

Instrument	Requested days	Allocated days	From	To
D50 T	2	2	24/02/2020	26/02/2020

Abstract:

Report UGA-105: 24 – 26/02/2020

Influence of new gas diffusion layer structures on the water distribution in Operating Proton Exchange Membrane Fuel Cell

Morin Arnaud, Fontana Marie, Florian Chabot, Fabrice Micoud, Sandrine Lyonnard.

A proton exchange membrane fuel cell (PEMFC) is an electrochemical device that converts the energy stored in hydrogen and oxygen into electricity. The reactions taking place in the fuel cell only produce water as the product and the operation of the fuel cell is environmentally friendly. The fuel cell will be the clean locomotive for electrified transportation system (passenger vehicles, buses, and trains). However, the fuel cell has not yet been widely commercialized due to the use of expensive and rare platinum group metal (PGM) as a catalyst. Increasing fuel cell performance and durability is an effective way to reduce its cost by lowering the amount of material, and especially platinum, needed for a given power output. As all the phenomena governing operation and degradation are dependent and coupled by the water, it plays a crucial role in PEMFC. However, its intrinsically heterogeneous distribution is still not possible to predict and is greatly influenced by one component of the heart of the electrochemical conversion device, which is named Gas Diffusion Layer (GDL). The GDL is made of two different parts, one highly porous support consisting of hydrophobized carbon fibers (about 150 µm in thickness) and the second one called microporous layer (MPL) with a thickness ranging between 20 and 50 µm with lower pore size compared to the support (Figure 1).

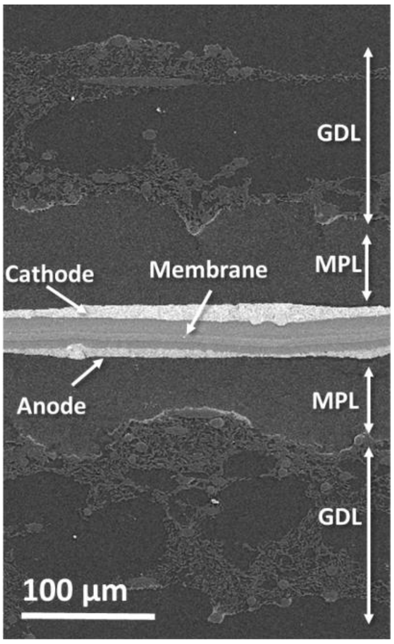

Figure 1. SEM cross-section of a Membrane-Electrodes Assembly (MEA)

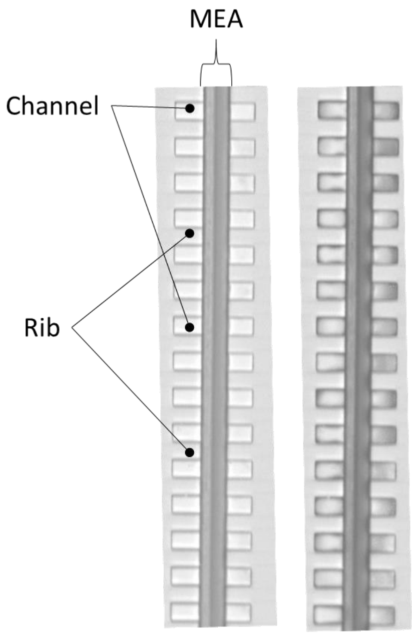

Figure 2: Images of the cell. (Left) Dry. (Right) Wet image, e.g. during operation.

During the experiment, we have measured using neutron imaging the water distribution across the Membrane Electrode Assembly (MEA) with different GDL material at the cathode side only. We studied four different GDL, one with commercial microporous layer, one without microporous layer, and two with a home-made microporous layer made of carbon nanotube forests. The effect of relative humidity (50%, 98 and 100%RH) and the current density (0.05, 0.2, 1.0, 2.0 A/cm² and maximum current density) on the water distribution was studied for the four types of GDL. Figure 2 shows the dry (left) and wet, that is to say during operation (right). On Figure 2, the water appears in black on the wet image.

The images of the water distribution were obtained after averaging, filtering and realignment. From the images of the water distribution, we extracted averaged water profiles across the cell, and knowing approximately the positions and thicknesses of the components, we estimated the averaged water content across the MEA (Figure 3). Thus, we have been able to characterize the water distribution in the cell for different types of microporous layer. This will help to understand the difference in performance induced by the different MPL structures.

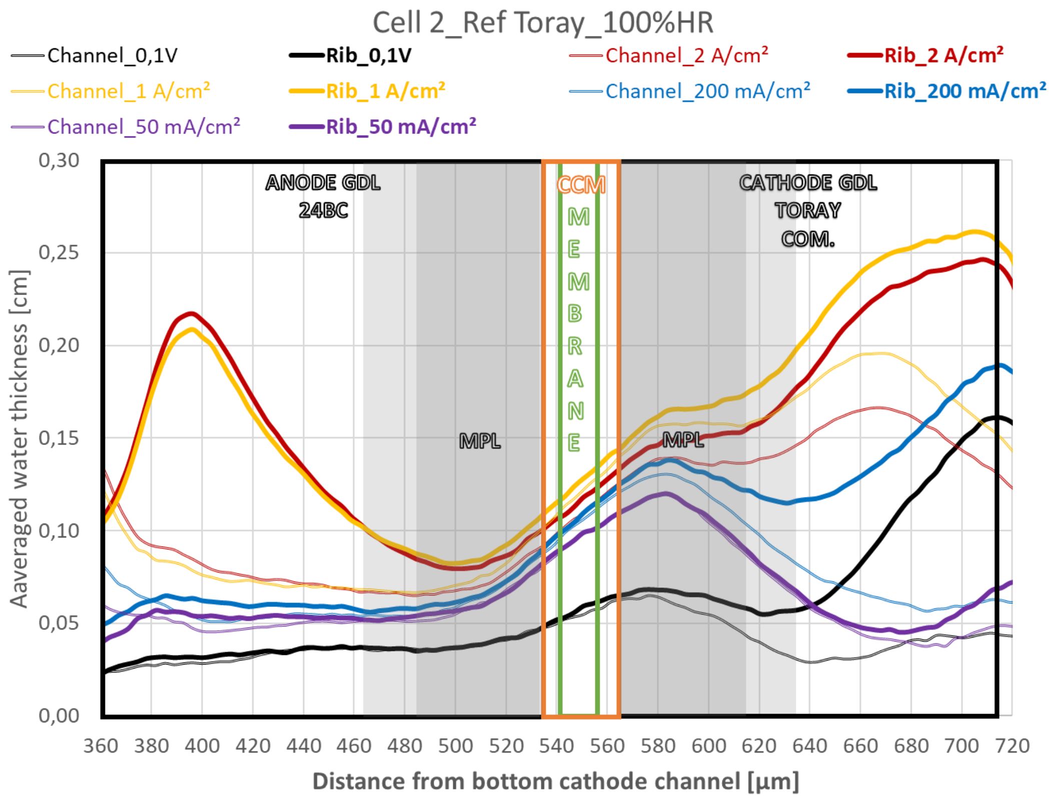

Figure 3: Water content profiles across the MEA, extracted from the images of the water distribution.