

New single cell hardware for the study of metallic grids for PEMFC electrodes

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Metallic grids are used as contacts for portable proton exchange membrane fuel cells (PEMFCs) using ‘air-breathing’ electrodes. In such cells, they work as current collectors in anode and in cathode, allowing for the transport and exchange of reactants and water with the ambient. Due to its double roll, as current collector and transport medium, the metallic grid contact has a tremendous impact on the response of a portable PEMFC. It is necessary, for this reason, to have rigorous and reproducible knowledge of its behavior and response in the fuel cell. Very few studies can be found about the behavior of grid contacts in comparison with typical flow field plates, usually considered in standard single cell testing protocols.

In order to have the possibility to apply standard testing of grid metallic contacts in fuel cells, as developed by the International Electrotechnical Commission under IEC/TC 105, a new single cell hardware set up has been prepared and tested, which includes the possibility for the integration of a metal grid in anode and/or cathode to obtain single cell response. The thin metallic microgrid has been inserted between the catalytic layer and the gas diffusion media, bypassing current through the gas diffusion medium. Measurements with this single cell set up will provide information on properties of metallic grids relevant to their behavior as current collectors in a fuel cell, mostly conductivity, (water) mass transport, and stability.

Experimental

The new single cell hardware was built departing from a standard single cell model. While maintaining the same anode chamber, a current collector grid was placed in between the cathodic Catalyst Coated Membrane (CCM) and the Gas Diffusion Layer (GDL), as shown in Figure 1.

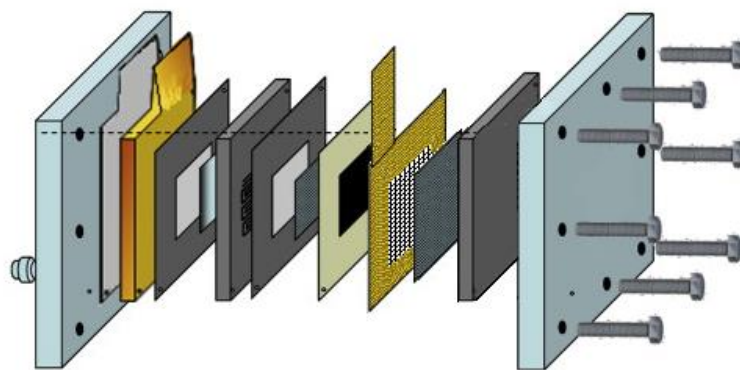


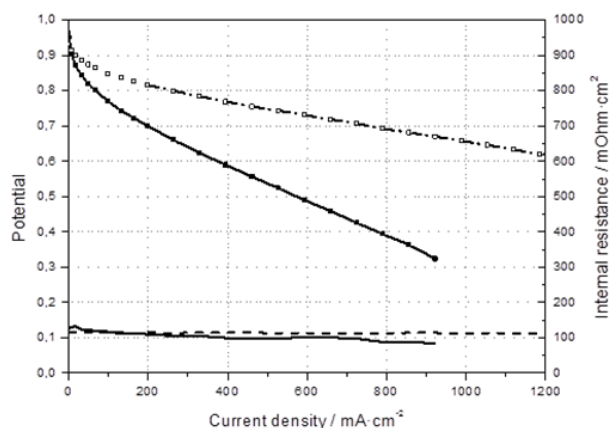
Figure 1. Schematic of the cell with cathodic metallic-grid

Cathode catalyst layers were deposited directly on top of Nafion membranes (NR212, 51 μ m, Ion-Power) by using the electrospray deposition technique, with 0.25 mgPt \cdot cm⁻² (E-TEK, 20 wt%) and 15 wt% Nafion ionomer (Aldrich). The electrospray setup and operation conditions were described elsewhere [1]. The cathodic GDL used was a (ELAT E-TEK, LT1200W, PEMEAS). In the anode, a commercial GDE was used (FCETC LLGDE, Pt/C 40%, 0.3 mgPt \cdot cm⁻²). For comparison, standard cell hardware was used with two FCETC commercial electrodes. The metallic contact was made from an expanded nickel microgrid (DEXMET 3Ni7-050) mounted on a gold-plated brass frame. The grid was attached to the support with silver paint in order to ensure a good electric conductivity. Electric current at the cathode is collected directly by the grid contact without passing through the GDL as result of its higher resistance.

Cells with metallic grid contact in cathode were tested in a test bench under standard conditions: 80 °C cell temperature, H₂ and O₂ at 1 barg pressure, 1.5/3.0 stoichiometry, and 100% RH. The area of Pt in the cathodic CL was measured with the underpotential hydrogen deposition method.

Results

Some results of polarization curves and internal resistance at 1kHz in a metallic-grid cell in comparison with a standard cell are shown in Fig.2. Despite the lower current densities compared with the standard cell, metallic-grid cell shows a polarization curve with a correct shape. The parameters of the curve, Tafel slope (b) and dc internal resistance ($R_{i,dc}$) are also given.



Cell	b	$R_{i,dc}$
	mV/dec	mOhm cm ²
Standard	67	111
Grid	74	348

Figure 1. Polarization curves and internal resistance (left) and cyclic voltammetry at 25 mV·s⁻¹ (right) comparing a standard cell (dashed lines) with the metallic-grid cell (solid lines). Table: Polarization curves parameters, from the fitting to the equation $E=E_0 - b \log(i/i_0) - i \cdot R_{i,dc}$.

It is especially remarkable the low 1kHz internal resistance achieved with the new hardware. While for low current densities resistance is slightly higher compared to the standard cell, above 150mA/cm² the internal resistance is reduced to 15-20% lower values. This reduction may reflect the bypassing of the cathodic GDL by the grid contact. The increased resistance at low currents could be a consequence of a higher heat dissipation by the grid contact in close proximity with cathodic catalyst layer. No significant changes in the platinum area measured using UHD method were detected, therefore, the lower response of the grid cell must be explained by different causes. One possible cause may be a problem with water and oxygen transport through the grid and cathodic catalyst layer, in which case the cell is working under (water) transport properties limitation caused by the grid contact. This cause may explain the high $R_{i,dc}$ and b values obtained for this cell, which reflect a flooded cathodic catalyst layer. Another possible cause could be ascribed to a different (lower) compression of the assembly, which we suspect is altered by the metallic grid. However, more experiments will be performed to corroborate the different hypotheses. These results demonstrate the utility of the setup to study these properties. More experiments will be performed to analyze the behavior of the grids in single cell configuration and study the impact of the gas diffusion media as internal or external component with regards to the current collector.

Conclusions

A new cell setup integrating a current collector grid has been assembled and tested in our laboratory to study the behavior of this component with MEAs under standard testing protocols. First results show that the cell is able to operate with a low internal resistance when placed between the cathodic CL and cathodic GDL. This promising diminution of the cell internal resistance, especially at high current densities, is the first step to integrate current collectors into PEMFC electrodes.

Acknowledgements

The authors acknowledge the Ministry of Economy and Competitiveness for financial support under contract E-LIG-E (ENE 2015-70417-P).

References

- [1] A. M. Chaparro, M. A. Folgado, P. Ferreira-Aparicio, A. J. Martín, I. Alonso-Álvarez, L. Daza. J. Electrochem. Soc., 157 (2010) B993-B999.