EFFECT OF CURRENT FLOW ON BIPOLAR PLATE/GAS DIFFUSION LAYER INTERFACIAL CONTACT RESISTANCE IN PROTON EXCHANGE MEMBRANE FUEL CELLS (PEMFC)

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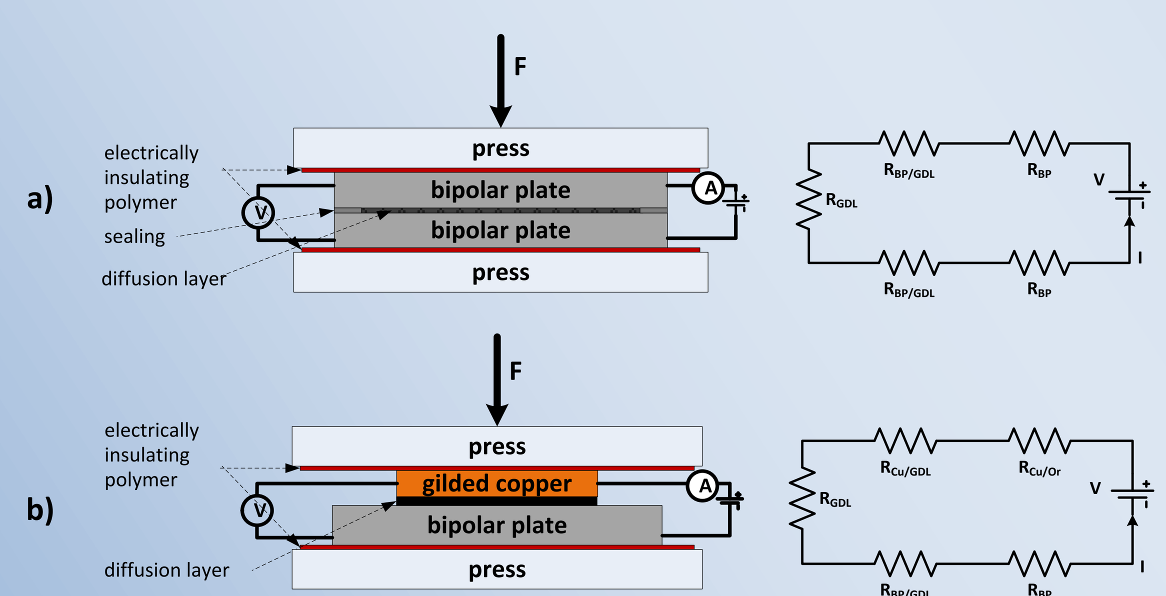
1.Abstract

Stainless steel bipolar plates can be excellent alternative to graphite bipolar plates due to their better mechanical properties and the easy and low-cost manufacturing process. Yet, they are chemically instable in the corrosive environment of PEMFCs. The thin oxide layer that is developed on the plate's surface causes a significant increase in the interfacial contact resistance (ICR) between the plates and gas diffusion layers. In an effort to characterize various stainless steel samples, before and after their exposure to the corrosive environment of a PEMFC, the interfacial contact resistance (ICR) between the plates and a commercial gas diffusion layer (GDL) was studied as a function of the pressure applied on the assembly. It was observed that, besides the expected decay behavior of ICR as a function of the clamping pressure, the value of the current applied to the assembly impacts greatly the obtained values for the ICR, irrespective of the applied pressure. This indicates that the observed phenomenon is a combined effect on the contact interface of the applied pressure on the elements and their thermal behavior due to Ohmic heating generated by the high currents.

2. Experimental

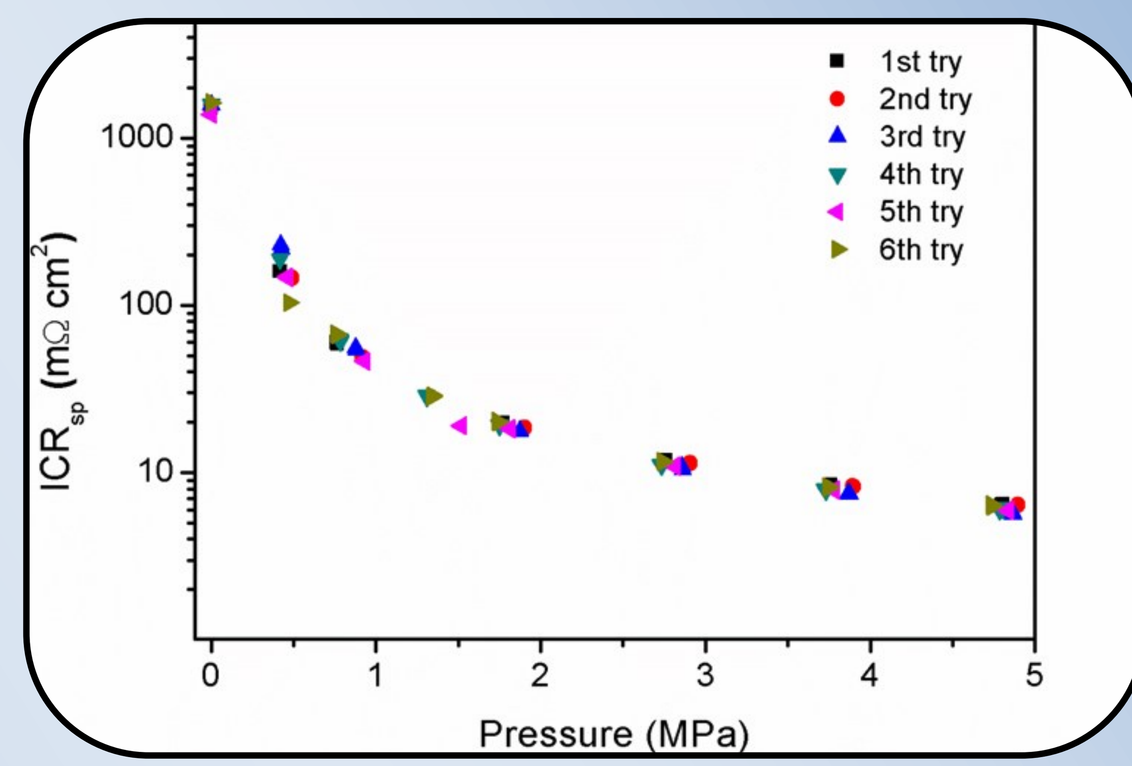
The ICR was determined between commercial 316L stainless steel bipolar plates (Paxitech SAS) with a serpentine flow channel geometry of a 25cm^2 nominal area, and commercial H2315/I6 gas diffusion layer (Freudenberg) that were pressed together by means of an in-house press. The real contact surface area on the interface was $A_{contact}$ = 10,07938 cm^2.

The ICR was studied in the range of 0-500 N/cm^2 of pressure applied to the assembly using the assembly displayed; the ICR value was determined by means of galvanostatic potentiometry and electrochemical impedance spectroscopy, taking into account the equivalent circuits shown below.



Schematics of the experimental setup and equivalent circuits of: a) GDL between two bipolar plates and b) GDL between a bipolar plate and a gilded Cu-electrode.

3. Effect of clamping pressure on ICR

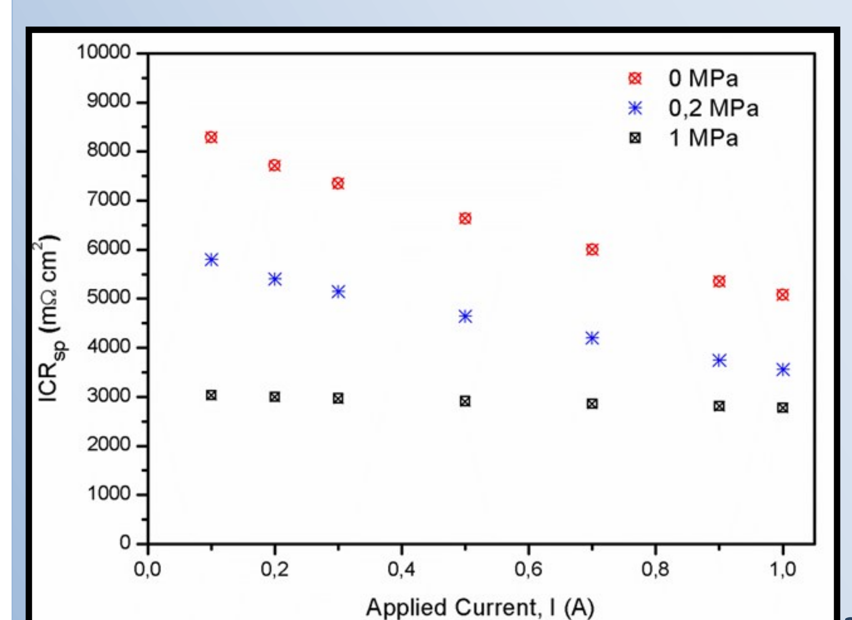


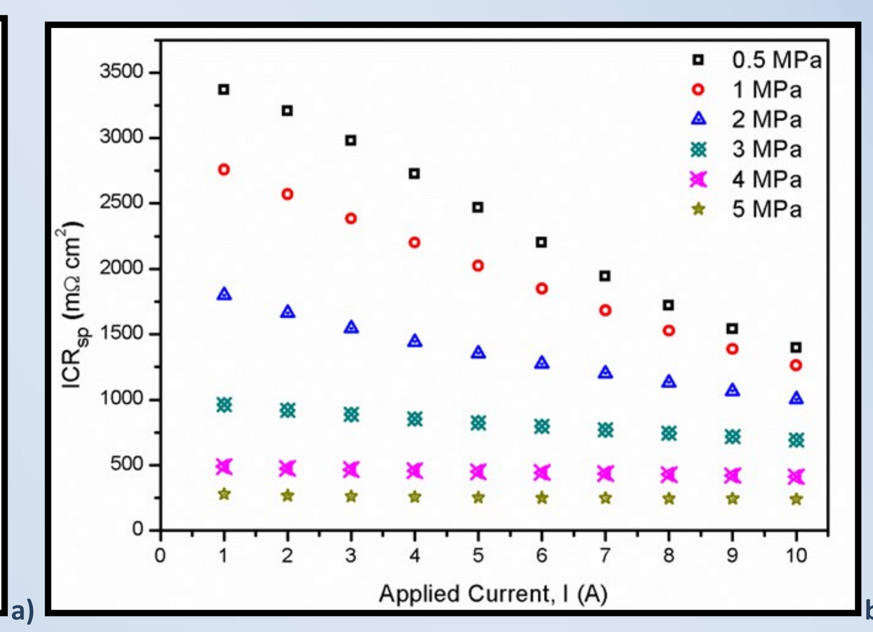
ICR as a function of applied pressure (T = 68°C, I = 1A).

The contact resistance exhibits a decay behavior as a function of the clamping pressure on the assembly, in agreement with previous reports, which can be described with good accuracy according to the following equation:

$$ICR_{sp} = a * (P_{contact})^b$$

4. Effect of current on ICR

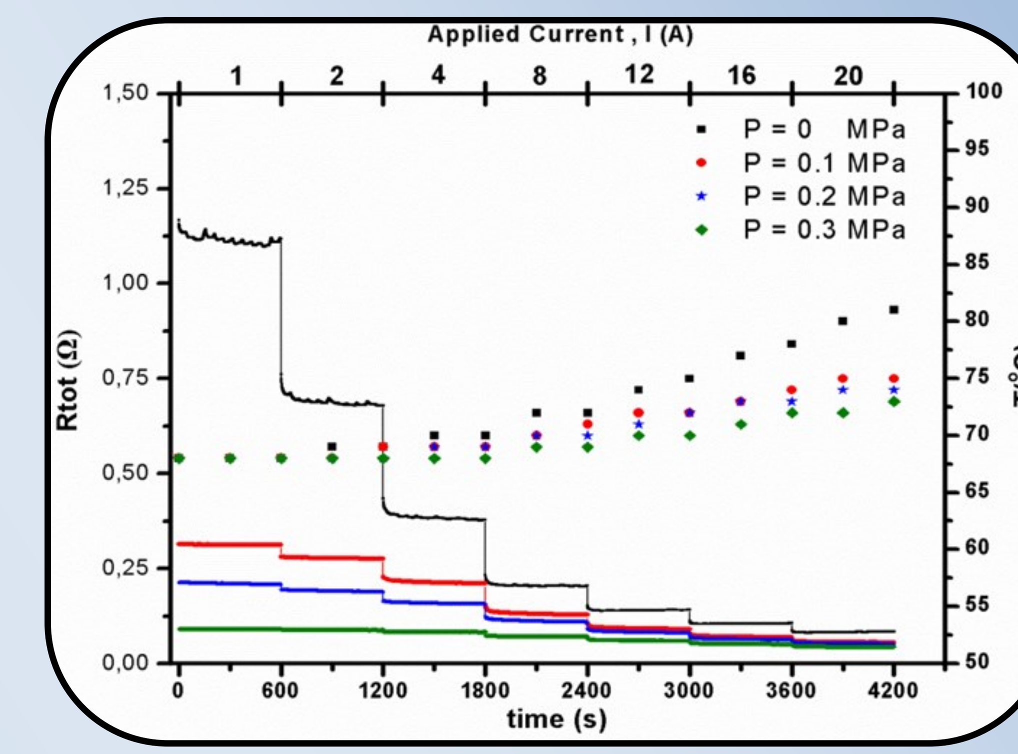




ICR determined by EIS over a wide range of current flowing through the assembly: a) low current range (0-1A), b) high current range (1-10A)

ICR values display an almost linear decrease as the current flowing through the assembly increases. A 54% decrease is observed at 0.5 MPa over the high current range while at 5MPa the decrease is limited at 13%. A combined effect of the clamping pressure and the current alters significantly the interfacial contact resistance.

6. ICR & heat generation:



Total resistance of the, R_{tot}, of the assembly determined by galvanostatic potentiometry. Current was increased up to 20A in 600s steps. Initial temperature of the assembly T= 68°C.

As portrayed above, an increase in the current flowing through the assembly, besides a drop in the resistance at the interface, results in a temperature increase of the assembly as well. This indicates that Joule heating due to contact resistance on the interface between the GDL and the bipolar plate causes a increase of the temperature, which is more eminent when the contact resistance has high values, namely at low clamping pressures, where the GDL and the bipolar plate are not in good contact. This temperature increase seems to affect the interface characteristics. It has been suggested that the local temperature increase causes thermal expansion of the carbon fibers of the GDL, thus improving the interfacial contact and yielding lower values for the ICR.

7. Conclusions:

Ex-situ measurements of the interfacial contact resistance between a fuel cell's bipolar plate and gas diffusion layer have been conducted. The decay behavior of ICR as a function of applied pressure observed is in agreement with previous reports in the literature. In addition, the effect of the current flowing through the assembly on the contact resistance is highlighted. Specifically, it is shown that at high current values and low clamping pressure the ICR decreases significantly, which is probably a result of the improved contact between the elements as a consequence of the ohmic heat generated at the interface. This explanation is enhanced by the observed increase in the assembly's temperature at high currents. The stability and reproducibility of the results obtained in this work, allows for the proper identification and understanding of the parameters that influence the contact resistance between the cell's elements and will allow for the further study of new coated stainless steel samples as bipolar plates, aiming at minimizing the ohmic losses in fuel cell performance that are caused by the contact resistance between the cell's elements.

Acknowledgements:

The authors would like to thank the Ministère de la Région Wallonne for funding (project INNOPEM n°1117490).