Advanced Characterization of PEMFC with Open Flow Field Architecture

OBJECTIVE AND SIGNIFICANCE: Proton exchange membrane fuel cells (PEMFCs) are energy conversion devices that offer high power densities at low operating temperatures making PEMFCs the most promising technology for many applications, such as automobiles, back-up power generating units, and portable devices. Commercial PEMFC systems utilize open flow field (OFF) architectures ensuring high power generation and excellent performance at high currents.

The project objective is to conduct a detailed evaluation of PEMFCs employing OFF design using advanced approaches like electrochemical impedance spectroscopy (EIS) and segmented cell system.

BACKGROUND: Application of a conventional land-channel (L-C) flow field architecture for PEMFC results in non-uniform performance over the active area of membrane electrode assembly (MEA) due to incremental O_2 consumption from air stream, water production and accumulation. These results lead to higher performance of the inlet of the fuel cell and lower performance at the outlet. To address this nonhomogeneous performance, open flow field architecture is applied for commercial PEMFCs (Figure 1). The main benefits of metal based OFF are its high durability, cost-effectiveness, low mass transport losses and uniform performance. Moreover, OFF increases utilization of MEA geometrical area.

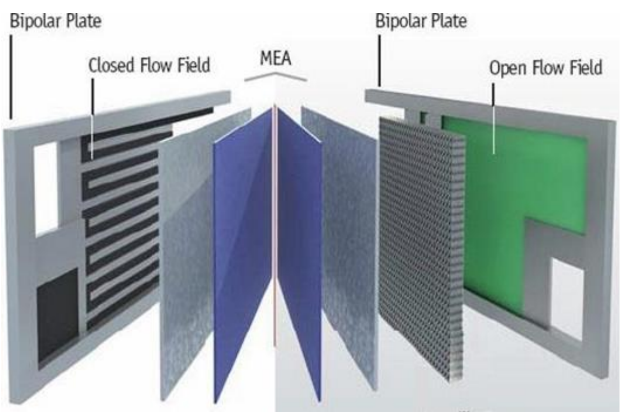

Figure 1. Schematic representation of fuel cell with open flow field.

Previously, HNEI developed a segmented cell system to study non-uniform phenomena in a working fuel cell. The segmented cell system allows us to record current/voltage/impedance responses from 10 segments simultaneously and provide valuable information on local performance (Figure 2).

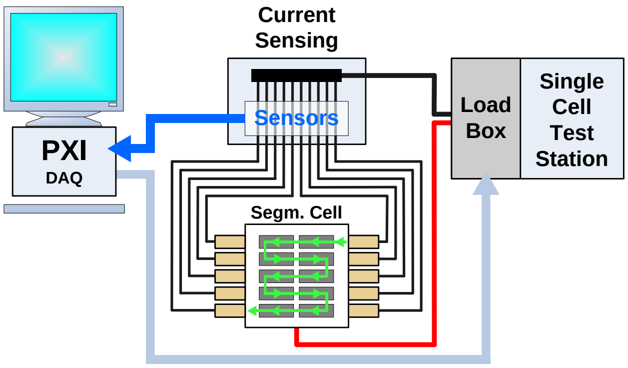

Figure 2. Schematic of segmented cell system.

PROJECT STATUS/RESULTS: During this project, feasibility of incorporation of the OFF to HNEI's segmented cell hardware was successfully demonstrated. Figure 3 on the following page shows polarization curves and high-frequency resistance (HFR) data recorded for L-C and OFF architectures and for selected locations of the MEA: Segment 1 (inlet), Segments 4 and 7 (middle), Segment 10 (outlet), and for the total cell.

Application of OFF led to higher performance of the MEA and provided uniform performance compared to L-C flow field design. At the same time, HFR values for both architectures were found to be very low and close (~30-50 mOhm cm^2). In addition, OFF ensured better heat transfer and heat dissipation, which is important for operation at high current.

An increase in performance for the OFF was attributed to minimal mass transport losses, highlighting the excellent gas transport and water management capabilities of Nuvera's flow field architecture.

Mass transport resistances (RMT) were determined for the OFF cell at different humidity levels (100/100, 100/50 and 50/50% RH) using distribution of limiting current approach developed at HNEI [1]. Results indicated that the mass transport resistance in gas phase ($R_{m, N2}$) and through the ionomer ($R_{film, CL}$) were lower compared to the L-C architecture contributing to the OFF cell's superior performance under high power-generating conditions (Table 1).

Table 1. Mass transport resistances determined for the OFF and L-C sample at different humidification, T=80°C.

Sample	RH [%]	$R_{film,CL}$ [s m^{-1}]	$R_{m,N2}$ @150kPa [s m^{-1}]
OFF	100/100	19.19	25.64
	100/50	37.65	30.97
	50/50	42.88	28.96
L-C [2]	50/50	46.12	93.35

Future work will include publication of the obtained results.

REFERENCES:

[1] T. V. Reshetenko, J. St-Pierre, J. Electrochem. Soc. 161 (2014) F1089.
[2] T. Reshetenko, O. Polevaya, Electrochim. Acta 387 (2021) 138529.

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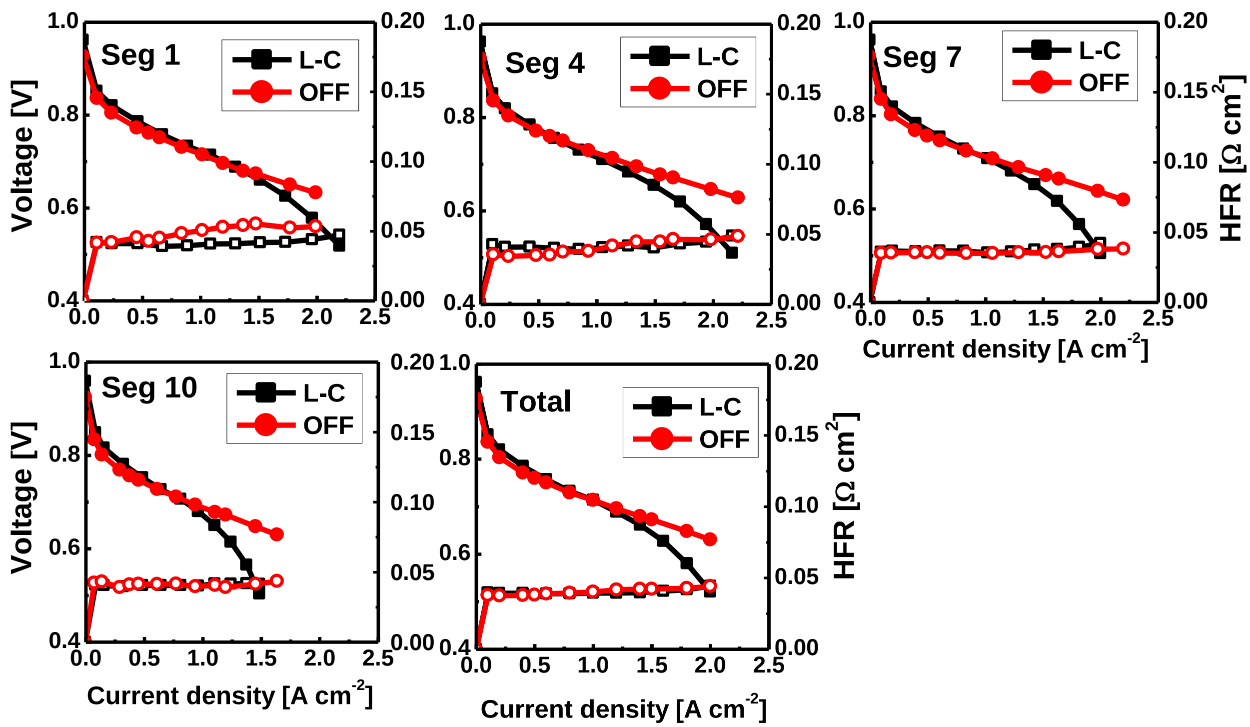

Figure 3. Local and total IV curves and HFR data for L-C and OFF flow field architectures. Operating conditions for An/Ca: H_2/air, 2/2 stoi, 100/50% RH, 150 kPa, 80°C.