**Analysis Of Short-Circuit And Gas Cross Leakage Using A Segmented Cell In PEFCs**

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## Introduction

Among well-known symptoms for failure or degradation of the membrane electrode assembly (MEA) of a PEFC are gas cross leakage, in which a gas leaks from one side to the other through a pinhole, and short circuit, in which the anode and the cathode are electrically contacted by carbon fiber from the gas diffusion media or catalyst layers. It has been difficult, however, to estimate the degree of these failures and to determine their positions.

In this presentation we will introduce a technique to detect, evaluate and position the failures.

## Experimental

The analysis technique uses a segmented cell in which the current collector of the hydrogen side is divided into 16 segments (Fig. 1).

Fully humidified hydrogen and nitrogen are supplied, respectively, to the hydrogen (anode) side and the air (cathode) side of the cell. The back-pressure of nitrogen gas is set to be equal to or lower than that of hydrogen. This pressure condition enables us to distinguish cross-leakage from normal gas cross-over, which is gas transfer by gas dissolution into the membrane and diffusion through it. Voltammetry is applied with the cathode side electrode as the working electrode and the anode side electrode as the counter and reference electrode at a scan rate of 0.01 V/min. This slow scan rate makes the capacitive current, due to the electric double layer or surface ad(de)sorption, negligible.

## Results and Discussion

A durability test was performed on an MEA with Nafion 111 membrane. Figure 2 shows voltammograms of Segment 15 with (a) and without (b) the gas pressure difference between the two sides. Clearly the pressure difference boosts the oxidation current, which is independent of the potential. This result indicates that gaseous hydrogen leaks from the anode side to the cathode side and is oxidized. The amount of hydrogen leaked in this area can be roughly estimated from the current as:

$0.0075(A)/ (2F) = 3.9 \times 10^{-7}$ mol $H_2$/s

=8.7 ml/s. (standard condition)

Figure 3 shows another example. The current for Segment 4 shows normal behavior. The current for Segment 12 linearly increases with the potential. This ohmic behavior indicates the occurrence of a short circuit. The short-circuit resistance can be estimated from the gradient as:

600mV/6mA

=100 Ω

## Conclusion

The developed analysis technique, slow scan voltammetry with gas pressure difference using a segmented cell, can quantitatively detect area-by-area short-circuit and gas cross leakage in an MEA. We believe that this is a powerful tool to diagnose an MEA during its durability test.

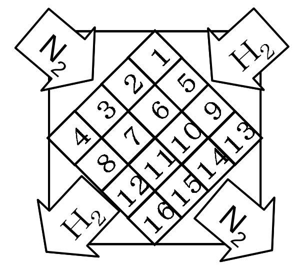


**Figure 1** Pattern diagrams of Segmented Cell

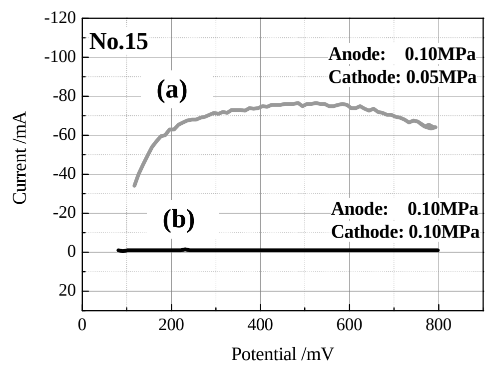


**Figure 2** Voltammograms of Segment 15 at 0.01 V/min (a) with 0.05 MPa pressure difference and (b) without it after a durability test.

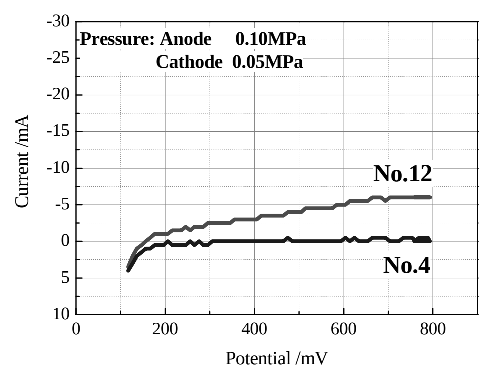


**Figure 3** Voltammograms of Segments 4 and 12 at 0.01 V/min. with 0.05 MPa pressure difference after the same durability test.