Degradation of Gas Diffusion Layers in PEM fuel cells during drive cycle operation

Rangachary Mukundan[1],
John Davey[1], Karen Rau[1], David Langlois[1], Dusan Spernjak[1], Kateryna Artyushkova[2], Ruediger Schweiss[3], and Rodney L. Borup[1]

[1]Los Alamos National Laboratory
PO Box 1663, MS D429, Los Alamos, NM 87545
[2]University of New Mexico,
Dept. of Chemical and Nuclear Eng. Albuquerque, NM 87131
[3]SGL Carbon GmbH
Werner-von-Siemens-Strasse 18, DE-86405 Meitingen / Germany

The durability of PEM fuel cells is a major barrier to the commercialization of these systems for stationary and transportation power applications.[1] While the degradation of the membrane and catalyst layers have received the most attention, gas diffusion layer (GDL) degradation is poorly understood.[2] Given the significant improvements in durability and performance achieved with state of the art membranes and electrodes, the degradation of gas diffusion layers can now have significant impact on overall PEM fuel cell durability. The degradation and performance of GDLs are especially important when using very thin (ultra low loaded) and very thick (non-precious metal catalyst) catalyst layers. Moreover, the GDL performance is also critical during wet cold start operations. In this presentation we elucidate the effect of GDL durability on fuel cell performance under simulated drive cycle[3] operation. We will also present data from ex-situ accelerated stress tests (AST) with XPS characterization to identify GDL degradation mechanisms.

Two different GDLs provided by SGL carbon were used in this study. The baseline GDL used was a Sigracet® 25BC GDL which was modified by addition of carbon nanotubes to the MPL (25BN). Two cells were assembled with these different GDLs using MEAs provided by Ion Power, Inc. The cells were then subjected to current cycling from 0.02 A/cm2 to 1.2 A/cm² (the high RH portion of DOE recommended drive cycle[3]) for extended periods. The performance of the two cells is illustrated in Figure 1 where the cell performance with the 25BC GDL degraded significantly in < 400 hours while the cell with the 25BN GDL showed little degradation even after 600 hours.

Impedance analysis indicated that this degradation in cell voltage was primarily from mass transport losses (low frequency arc in Fig 2a). Similar behavior was observed with GDLs that were aged ex-situ in peroxide (Fig. 2b). Moreover XPS studies revealed the presence of a higher concentration of surface oxides on the aged GDLs. These results indicate that the oxidation of GDLs can lead to significant PEM fuel cell performance loss and these losses can be captured accurately by an AST involving the ex situ ageing of GDLs in a peroxide solution.

References

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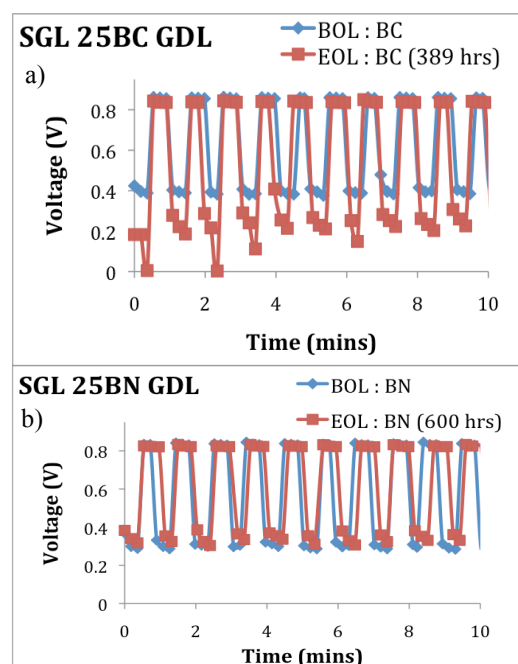
Figure 1. Performance during potential cycling of two fuel cells using different GDLs. a) baseline 25BC GDL and b) 25BN GDL with carbon nanotubes in the micro-porous layer.
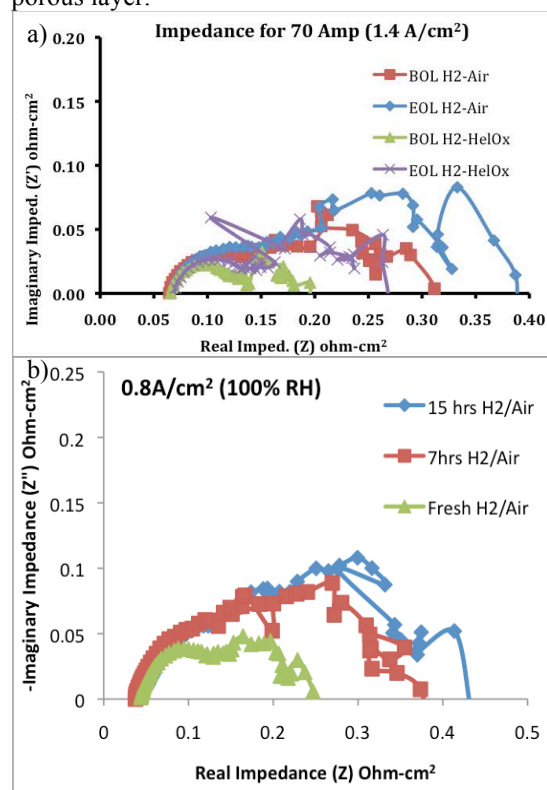

Figure 2. Impedance spectra at high currents showing similar mass transport increase in both a) in situ and b) ex situ aged GDLs.