Investigation of the Impact of Interfacial Delamination on Polymer Electrolyte Fuel Cell Performance

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Performance loss can result from local or partial interfacial delamination between the catalyst layer and diffusion media, or peeling of the catalyst layer from the membrane. Under frozen conditions, experimental freeze/thaw testing of a polymer electrolyte fuel cell (PEFC) has revealed damage due to a local delamination in the soft goods, resulting in an increase of an ohmic resistance [1-3]. Additionally, imperfect mating between the adjacent micro porous and catalyst layers under normal operating conditions can lead to performance losses. To study the impact of local delamination on performance, a two-dimensional anisotropic model was developed. To identify key parameters independently of particular material properties, a dimensionless ratio approach was taken. Localized interfacial delaminations of the polymer electrolyte membrane (PEM)|catalyst layer(CL) and CL|diffusion media were found to increase ohmic resistance significantly. Figure 1 shows the voltage contour and current density for single delamination at the PEM|CL interface with a width of 50δ, where δ is the electrolyte thickness, $18\mu m$. Significant ohmic resistance increase was attributed to current dead zones near interfacial delamination, as shown in the current density vector plot Fig. 1b.

As interfacial delamination width and area fraction increases, the ohmic resistance sharply increases in a non-linear manner. The in-plane resistance and in-plane-to-thru-plane resistance ratio of PEFC components adjacent to the delamination were determined to be the key controlling parameters which govern the ohmic resistance increase. The membrane is a critical component because of its relatively low conductivity and very thin cross-section. Finally, it is shown that under frozen conditions, small interfacial delaminations can result in a greater ohmic loss due to the decreased membrane conductivity compared to normal operating conditions.

[1] S. Kim and M. M. Mench, "Physical degradation of membrane electrode assemblies undergoing freeze/thaw cycling: Micro-structure effects," *Journal of Power Sources*, 174, 206 (2007).

[2] S. Kim, B. K. Ahn, and M. M. Mench, "Physical degradation of membrane electrode assemblies undergoing freeze/thaw cycling: Diffusion media effects,"*Journal of Power Sources,179,140* (2007).

[3] S. Kim, C. Chacko, R. Ramasamy, and M.M. Mench, "Freeze-induced damage and purge based mitigation in polymer electrolyte fuel cells," *Meet. Abstr. - Electrochem. Soc.* **702**, 575 (2007)

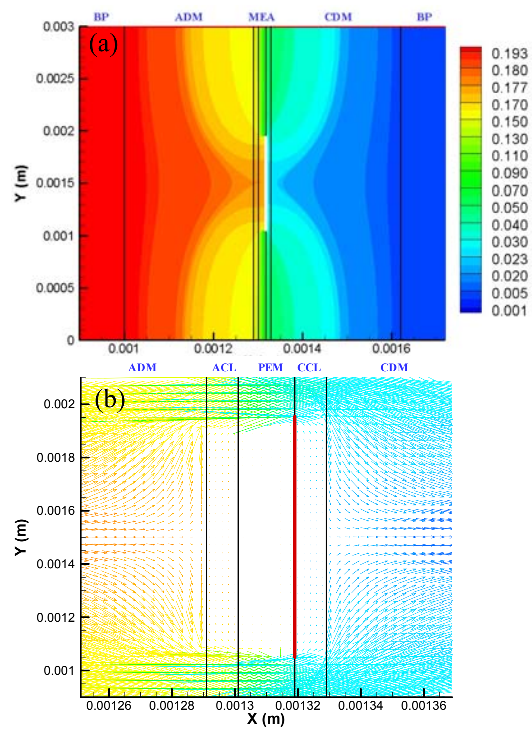

Figure 1: Voltage contour (a) and current density vector (b) for single interfacial delamination at PEM|CL with width, $W=50\delta$ and membrane thickness, $\delta=18\mu m$.