Performance of Polymer-Electrolyte Fuel Cells with Ultra-Low Catalyst Loadings under Low Temperature Operation

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Polymer Exchange Membrane Fuel Cells (PEMFCs) have been proposed to replace Internal Combustion Engine (ICE) to provide a cleaner and more sustainable source of power. PEMFCs can deliver high power density at low temperatures using hydrogen as fuel and oxygen from ambient air as oxidant. For PEMFCs to be competitive with ICE powered vehicles, cold start issues need to be addressed to ensure that the PEMFC is able to deliver rapid and stable performance in order to operate at low temperature conditions. The operation of these devices at low temperatures presents unique challenges for both water and thermal management. For example, during sub-optimal temperature operation (*i.e.*, at < 65 ^{o}C) product water removal in the vapor phase is reduced, due to the low vapor pressure of water at lower temperatures. As a result, flooding of the diffusion media and catalyst layers may occur, and the performance of the PEMFC may be negatively impacted.

To meet the cost goal of PEMFC technology, considerable effort has been devoted to PEMFCs with ultra-low catalyst loadings (*i.e.*, $\leq$ 0.1 mg/cm^2 of Pt). Because of the power density demand, thin catalyst layers are very sensitive to the water-saturation levels of the gas diffusion media and the catalyst layers, which can result in cell performance that is highly temperature sensitive, more so than conventional PEMFC electrodes.

Nano-structured-thin-film (NSTF) catalysts [1], is a novel catalyst layer architecture that has been developed by the 3M Corporation to improve both performance and reduce the cost of PEMFCs. The reported advantages of these NSTF electrodes (relative to conventional CLs that utilize catalysts dispersed on carbon supports, *i.e*., Pt/C) include: *i)* NSTF has higher specific activity for oxygen reduction, *ii)* mitigates durability issues associated with carbon supports, *iii)* demonstrates lower Pt dissolution rates, and *iv)* has significant high volume all-dry roll-good manufacturing advantages [1]. However, these ultra-thin catalyst layers are sub-micrometer in thickness and thus present their own unique water- and thermal-management challenges, especially at low operating temperatures.

United Technologies Research Center (UTRC) is part of a DOE-supported project, led by Lawrence Berkeley National Laboratory (LBNL), focused on understanding PEMFC performance at low operating temperatures [2]. UTRC has found that the NSTF cells are highly temperature sensitive relative to PEFCs with conventional CLs and comparable Pt loadings. Some recent results on the performance of NSTF electrodes under low temperature conditions are the subject of this presentation.

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References

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