SU/SD, a Materials Solution

GM Haugen, GD Vernstrom, LL Atanasoska, and RT Atanasoski
3M
3M Center, 201-2W-17, St. Paul, Minnesota 55144-1000

In this presentation we will cover our efforts in developing an anode that both protects the anode and cathode catalyst from going to corrosive potentials during startup and shutdown transients without the need for cell monitoring and cumbersome and costly gas switching protocols. Fuel cell catalyst degradation is typically addressed using a system approach to minimize, but not eliminate the potentials experienced by controlling the rate of gas turnover[1]. The system approach, being an active system, can lead to a catastrophic stack failure if there is are failures in the control/sense loop. We have taken a passive preventative materials approach to the issue. We have constructed an anode that consists of a low loading Pt (10-50 ug/cm^2), Ir based OER catalyst (8-40 ug/cm^2), and the use of other catalysts to either reduce the anode ORR and/or stabilize the durability of the anode catalyst all on 3M's NSTF non carbon stable support[2 3]. It is by using this material set we have demonstrated excellent reversal tolerance and startup shutdown durability. This can be seen in Figure 1 where reversal performance at beginning of life and after 1300 SU/SD cycles.

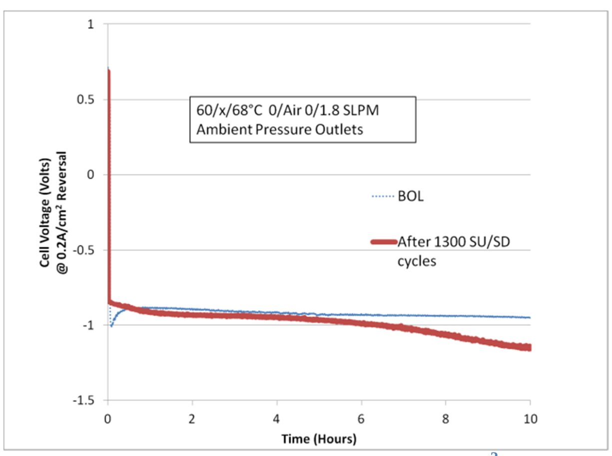

Figure 1. Reversal performance at 0.2 amps/cm^2 at beginning of life and after 1300 SU/SD cycles.

We will also report reversal performance as a function of OER loading, current density, relative humidity and cell condition at BOL (beginning of life) and EOT (end of test). Further, segmented cell work will examine the reversal current distribution as a function of reversal time and startup shutdown gas cycling aging.

In addition, we will present our efforts at deconvoluting the degradation mechanism(s) that are manifest in gas switching startup shutdown transients. This is done through a series of experiments breaking down the individual mechanisms - potential cycling, electrochemical cycling, gas switching in-situ and ex-situ, combustion, dissolution etc. The tools we have used to elucidate these effects are unique test protocols, electrochemical characterization and aging, TEM, XRD, and infrared imaging. In our observations, nothing is as destructive as the gas cycling compared potential cycling and electrochemical cycling. That being said we do not see an effect of gas cycling on catalyst durability when done ex-situ prior to transfer to the catalyst coated membrane. The full understanding of the degradation mechanism(s) involved has not completely formed but planned experiments being carried out should complete the picture before the conference.

In summary, we will show the validity of using a passive preventative materials approach to the SU/SD catalyst durability issues and document our performance under reversal and SU/SD gas cycling. To complement this we will show results detailing our understanding of the reversal and SU/SD mechanisms.

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[1] Y Yu, H Li, H Wang, XZ Yuan, G Wang, M Pan, Journal of Power Sources 205 (2012) 10– 23

[2] RT Atanasoski, DA Cullen, GD Vernstrom, GM Haugen LL Atanasoska:"A Materials-Based Mitigation Strategy for SU/SD in PEM Fuel Cells: Properties and Performance-Specific Testing of IrRu OER Catalysts", *ECS Electrochem. Lett.*, **2** (3) F25-F28, 2013.

[3] RT Atanasoski, LL Atanasoska, DA Cullen, GM Haugen, KL More, GD Vernstrom: "Fuel Cells Catalyst for Start-up and Shutdown Conditions: Electrochemical, XPS, and TEM Evaluation of Sputter-Deposited Ru, Ir, and Ti on Pt-Nano-Structured Thin Film (NSTF) Support", *Electrocatalysis*, **3**, 284–297, 2012.