Understanding How Electrodes Influence AEMFC Behavior: Lower Flowrates, 3.5 W/cm^2 Peak Power, 1000+h Stability and CO_2

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Over the past few years, significant progress has been made in the performance of AEMFCs. Now, it is almost routine to find AEMFCs that report peak power densities that exceed 1 W/cm^2, and there are regular reports of AEMFCs operating near 2 W/cm^2 [1–3] as well as one recent study that achieved 3.4 W/cm^2. [4] Much of this progress has been made through electrolyte development and a new understanding of AEMFC water dynamics. However, these large jumps in performance have been achieved under at least somewhat unrealistic conditions, such as high reacting gas flowrates and high purity O_2. Additionally, no cells to date have been reported that have sufficient durability (~2000 h), particularly at DOE-relevant current densities ($\geq$ 600 mA/cm^2) [5].

In this presentation, we will discuss how electrode design can help to concomitantly increase peak power, allow for lower reactant stoichiometries to be realized, and enable long-life AEMFCs (more than 1000 h of continuous operation) with the lowest voltage degradation rates to date. The reason that these can be achieved together is that we found a key controlling feature of our previous cell designs: extremely high water uptake due to the strong hydrophilicity of the ETFE-based ionomer that was being used. High water uptake caused significant swelling and cell flooding, which will be shown using results from *operando* neutron imaging coupled with *operando* micro X-ray computed tomography. Our approach was to increase the ability for the anode and cathode to balance water. This was done by employing less hydrophilic powder-type ionomers and introducing hydrophobic agents into the electrode formulation.

Finally, carbonation from the exposure of the AEMFC cathode to CO_2-containing ambient air has been a widely discussed issue in recent years. Despite this, there have been very few experimental studies that accurately capture the isolated effects of CO_2, particularly in high-performing cells. We will show that even in highly performing cells, the presence of carbonate anions can be severe, with the CO_2-related overpotential as high as 400 mV. The primary drivers for this high overpotential are increased charge transfer resistance at the hydrogen oxidation anode and a shift in anode pH (resulting in a Nernstian decrease in the cell operating voltage). Very little of the overpotential increase (typically < 20 mV is related to increased Ohmic resistance. We will discuss the dynamics of CO_2 uptake and removal and dynamics in AEMFCs – with a particular focus on the impact of CO_2 concentration, temperature, and gas flowrates.

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