# Time Evolution of Local Potentials during PEM Fuel Cell Operation with Dead-Ended Anode

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Operating a proton exchange membrane (PEM) fuel cell with dead-ended anode may lead to local fuel starvation due to the excessive accumulation of liquid water and possibly nitrogen and oxygen (because of membrane crossover) in the anode compartment. High concentrations of these species entail a dilution of hydrogen and/or a diffusion barrier leading to the fuel cell performance decrease. Such fuel-starvation events may remain undetected but could lead to significant rise of the anode (and thus cathode) potentials and accelerate carbon corrosion and catalyst degradation, which can be particularly damaging to the cell performance [1-3].

By monitoring simultaneously the local potentials and current densities during operation, we can assess the impact of events such as local fuel starvation during steady-state and transient operation modes (including dead-ended mode, startup and shutdown). We present experimental results obtained with a 2D segmented cell (Fig. 1) with reference electrodes along the (parallel) gas channels, used to record local anode and cathode potentials. Apart from the reference electrodes, this cell is similar to that described in [4]: active area of 1 cm by 30 cm, 5 parallel channels, and 20 segments along the cathode channel length. The segments are numbered from 1 to 20 in the direction of the air flow: segment #1 = air inlet/$H_2$ outlet (Fig.2). The reference electrodes are supplied with hydrogen through an independent channel on the anode side and are electrically isolated from the anode flow-field plate. To complement the electrical measurements and evaluate carbon corrosion, $CO_2$ emissions were measured at the anode and cathode exhaust.

The membrane-electrode assemblies (MEAs) were fabricated by Ion Power, Inc. In the example shown in Figures 1 and 2, the MEA consisted of a 25 µm thick multilayer membrane (XL by DuPont[TM]) and 210 µm thick SGL Carbon 24BC gas diffusion layer (GDL) with a micro-porous layer (MPL) on both anode and cathode. The catalyst layers consisted of Pt supported on Vulcan XC72 carbon with anode/cathode Pt loading of 0.08/0.2 mg$_{Pt}$/cm². 

The fuel cell was operated at a constant (average) current density in dead-end mode. In the example shown in Fig. 2, the operation time between two successive hydrogen purges was 1600 s (greater than in real-use conditions). In the segments located close to the anode outlet, the anode and cathode potentials started to rise 20 to 40 seconds after the $H_2$ outlet was closed. After 300 seconds, the anode potential in segment #2 rose from 0 V to 0.2 V while the cathode potential rose from 0.73 V to 0.92 V. Simultaneously, the fuel cell voltage decreased

only from 0.73 to 0.72 V. During this test, the highest anode potential was 0.6 V and the highest cathode potential was 1.24 V (segment #3 at 1600 s). Local cathode potentials in the upstream portion of the cell (segments #9 through #20) were close the cell potential throughout the cell operation.

Aging protocols consisting of repeated dead-end operation sequences were also performed to assess the impact of hydrogen starvation on the local fuel cell performance. We observed non-uniform ECSA losses and performance degradation along the cell area. The damage was more pronounced in the regions suffering the longest from fuel starvation: i.e. close to the exit of the anode compartment.
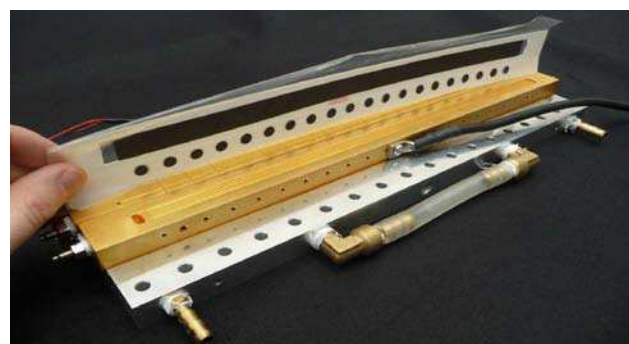
**Figure 1.** Anode flow-field plate (not segmented) and the MEA of the segmented-cathode PEM fuel cell with reference electrodes along the gas channels.
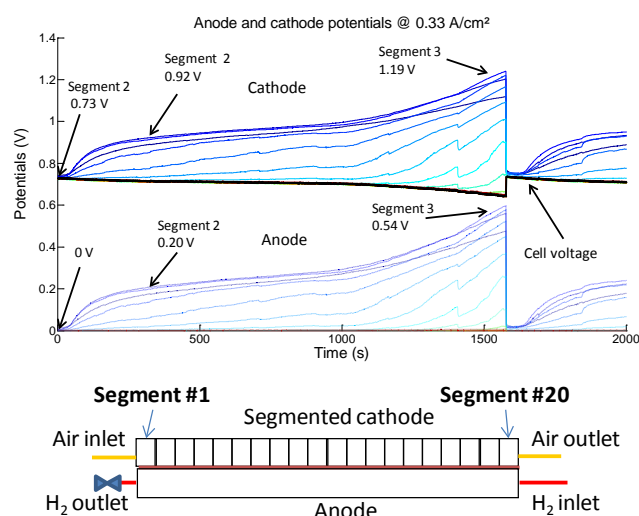


**Figure 2.** Time evolution of the anode and cathode local potentials along the gas channel between two successive purges of the hydrogen compartment. The hydrogen outlet remained closed during 1600 s. Each purge lasted 1 s.

**References:**

1. R. Borup, et al., *Chemical Reviews*, **107** (10), 3904-3951 (2007).

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