Locally Resolved Current Measurements in 200 cm^2 PEM Fuel Cells

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In a standard fuel cell experiment changing voltage or changing average current density of the cell is the only measurable response on variation of any of the parameters. The interpretation of the measurement with regard to optimization of the cell performance remains difficult. There are several options to gain more information from such experiments, one of those is measuring the current density locally resolved at different locations of the active area of the cell. Knowledge of the current distribution over the active area is useful for optimizing components and to support modeling.

In this work the principle of adopting a real cell for the local current density measurements was chosen, because inclusion of the measurement principle into a big stack should be possible. For this purpose a "semi-segmented" cell was newly developed (see Figure 1) which allows for local current density measurements but conserves the fluid dynamic properties, the electrical and thermal properties exactly equivalent to those of standard cells. The individual segments were placed along the flow path of the process air (1 at the air inlet, 4 at the air outlet). The semi-segmented part of the cell may also be included as a terminal plate in a stack.

Single cells can be operated in different regimes, constant current (CC) or constant voltage (CV) as the electrical regimes and constant flow (CF) or stoichiometric flow (SF) as the mass flow regimes. Out of the four possible combinations, the CC/SF regime is the one seen by a cell in a stack, and therefore of practical interest.

If the cell is operated under well humidified conditions (see Figure 2), the current density distribution in the cell is very homogeneous for λ(air) > 1.5. If the stoichiometry is lowered, then the segments at end of the air path start to produce less current due to oxygen depletion, and consequently the segments early in the air path have to produce more current. At λ(air) = 1.1 the current density in the first segment (1) is about twice as big than in the last segment (4).

The situation is completely different if the cell is operated with air of a dew point of 30 °C (see Figure 3). Still, the oxygen depletion effect is observed at the low stoichiometries, but at high λ(air), the order of the segments with respect to current density is reversed. The last segment in the air path (4) carries the highest current. This is due to the drying of the membrane (and increasing its resistance) early in the air path. The dew point of the air increases along the path due to the product water and the current density increases.

These results show, that these kind of measurements are a very useful tool for investigation of the water management in PE fuel cells.

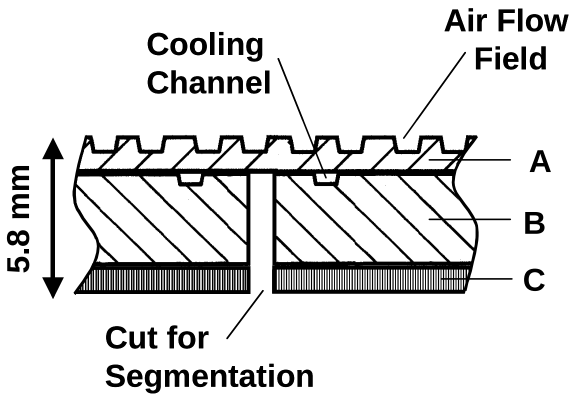

Fig. 1: Schematic of semi-segmented plate: A : molded low conductivity plate with flow field; B: high conductivity graphite plate; C: metal current collector.

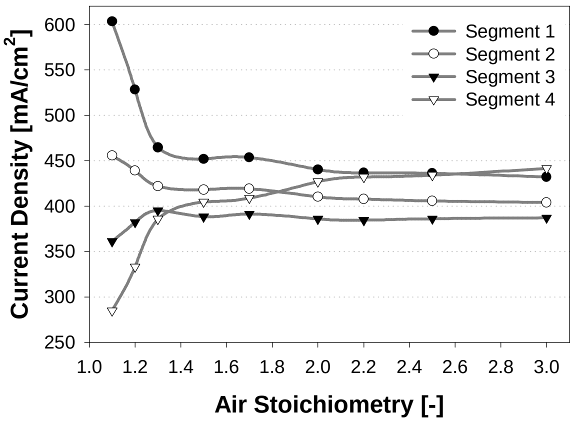

Fig. 2: Current density in the segments 1-4 as function of air stoichiometry. Avg. current density 400 mA/cm^2. Dew point of air 70 °C.

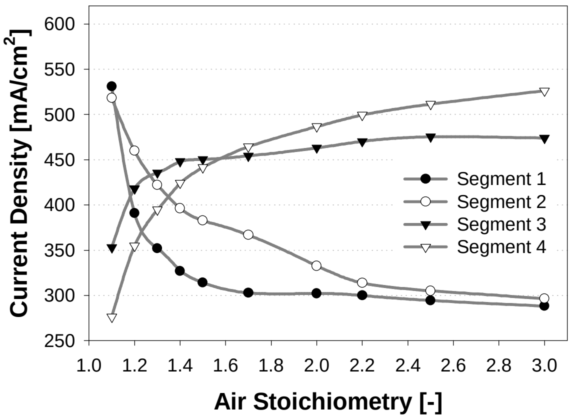

Fig. 3: Current density in the segments 1-4 as function of air stoichiometry. Avg. current density 400 mA/cm^2. Dew point of air 70 °C.