Magnetic tomography as a new non-invasive method for current density distribution measurements in PEFC

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Many factors such as temperature, reactant humidity, partial pressures of feed gases and flow field structure in combination with the membrane electrode assembly (MEA) affect the performance of a PEFC. The current density distribution measurement is a well-known method for understanding the influences of these factors on PEFC performance[1,2,3]. From the results of these measurements an optimization of design criteria and operating conditions can be deduced.

The common technique for measuring the current density distribution uses segmented cells. In this study, a measurement method is introduced for mapping the current density distribution in fuel cells, which is very simple, cost-effective and easy to integrate in the fuel cells. Whereas the common approaches need to segment bipolar plates or MEAs, the cell in this study stays unsegmented. A passive resistor network is manufactured from a single expanded graphite plate. The corresponding potential difference across the resistor network due to the current flowing through it is measured to map the current density distribution. The measuring plate is placed between two unmodified bipolar plates. This method can be used to measure the current density distribution in single cells as well as in fuel cell stacks. Fig.1 shows the change of the current density distribution with an increase of the stoichiometry ratio from λ_{Air}=2 to λ_{Air}=4. In both measurements with different stoichiometry ratios the total current is constant. The results indicate that for the lower stoichiometry ratio the current density distribution is more inhomogeneous.

These conventional measuring methods have some disadvantages. The stack has to be disassembled to insert the measuring device. Thus the measuring location inside the stack is fixed. Due to this modification, the conditions inside the stack are changed, for example the temperature distribution.

Magnetic tomography (MT) is a new technique for overcoming these problems in the analysis of fuel cells [4]. MT is a noninvasive, nondestructive method for imaging the current distribution in fuel cells. It can be applied to fuel cell stacks as well as to single cells. In this method, the magnetic field of the sample fuel cell is scanned by rotating two sensors around the stack. The external magnetic flux generated by the current inside the fuel cell is recorded at predetermined sensor positions. It is a fingerprint of the current density distribution inside the stack. Mathematical software converts the resulting data of the magnetic field into the corresponding three-dimensional current density distributions.
Measured by magnetic tomography, Fig. 2 shows the change of the current density distribution under the same conditions as in Fig. 1. Both results show the same trend.

References:
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[4] Patent "Method for determining the current density distribution in a fuel cell stack", PCT 09154

Fig. 1: Standard technique
Influence of the increase in air stoichiometry ratio from λ_{Air}=2 to λ_{Air}=4 on the current density distribution
(blue : decreased current density at the air inlet
red: increased current density at the air outlet)
(operating conditions: 2 bar, 70°C
active area: 244 cm²)

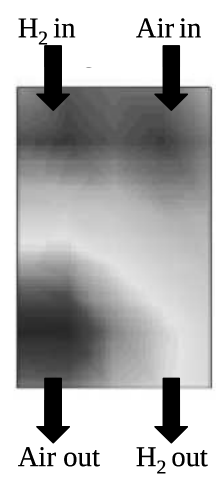

Fig. 2: Magnetic tomography
Influence of the increase in air stoichiometry ratio from λ_{Air}=2 to λ_{Air}=4 on the current density distribution
(blue : decreased current density at the air inlet
red: increased current density at the air outlet)
(operating conditions: 2 bar, 70°C
active area: 244 cm²)