Investigations of leakgas by current density measurements

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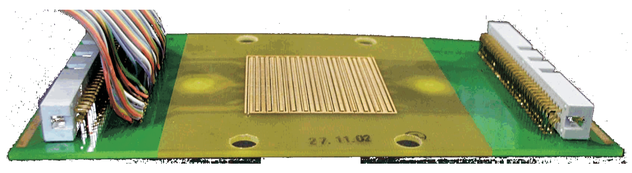
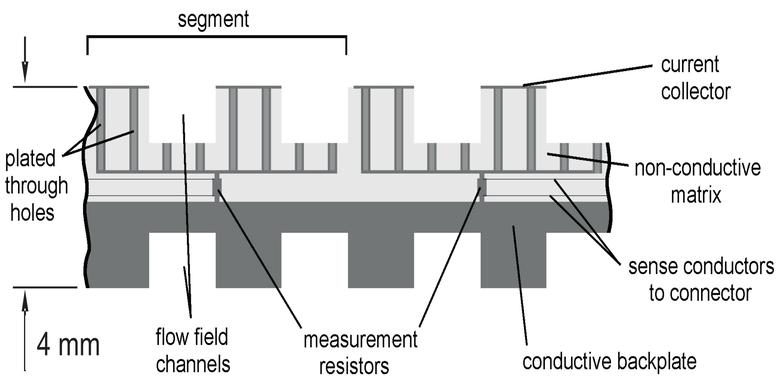
Introduction

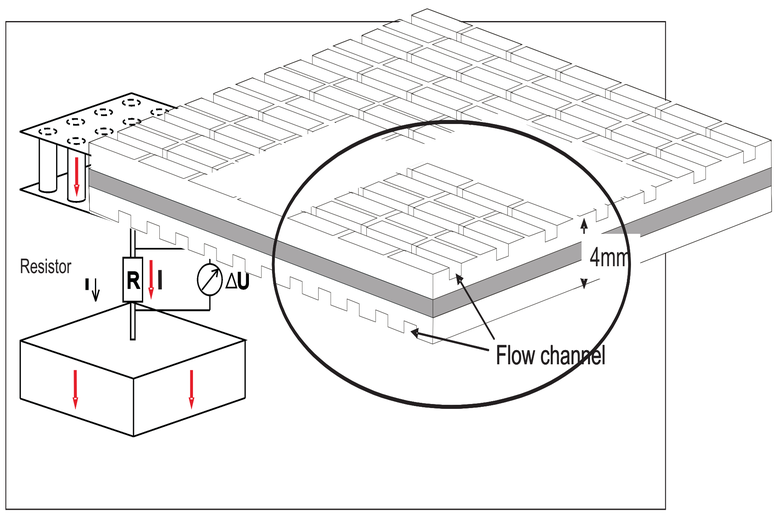
The reliability of the operations is important for commercializing polymer electrolyte membrane fuel cells (PEFC). Beside the degradation of membranes and the resulting losses of the electrochemical performance, leakages in membranes and sealings may lead to complete breakdowns of fuel cell operations. The decay of performance is in addition accompanied by the formation of mixed potentials and losses of fuel. Furthermore, leakages can cause hazardous working conditions like the emergernce of explosive gas mixtures (hydrogen in air and vice versa). For that reason, an early detection of leakages is of great interest. Therefore, a better understanding of the conditions inside and arround a damage of a membrane can help to evaluate the effect of leakages on the cell system. At DLR, a setup for current density distribution measurements was developed as a tool for the in-situ diagnostic of fuel cells. The measurement of current densities is a promising technique for the detection of leakages. The passage of the reactant gases through a damage causes dramatic changes in the local potential and consequently in the local current densities. In the area that is affected by a leakage, a current with reversed polarity can be observed. This can be explained by the formation of mixed potentials around the hole in the membrane from the intrusion of oxygen from the cathode side. The local potential differs from those of the non-influenced areas. Caused by the in-plane conductivity inside the membrane-electrode assembly this potential difference will be equalized by a current with reversed polarity. Consequently local currents crossing the cell can be detected.

Current density measurement

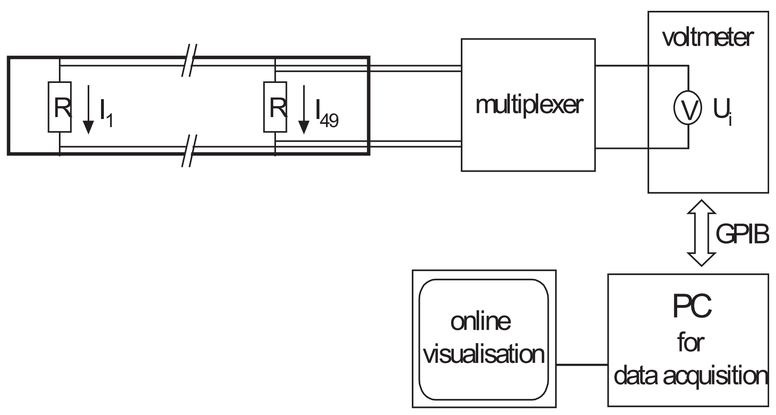




Photography of a segmented bipolar plate and scheme of the printed circuit technology for current density measurements

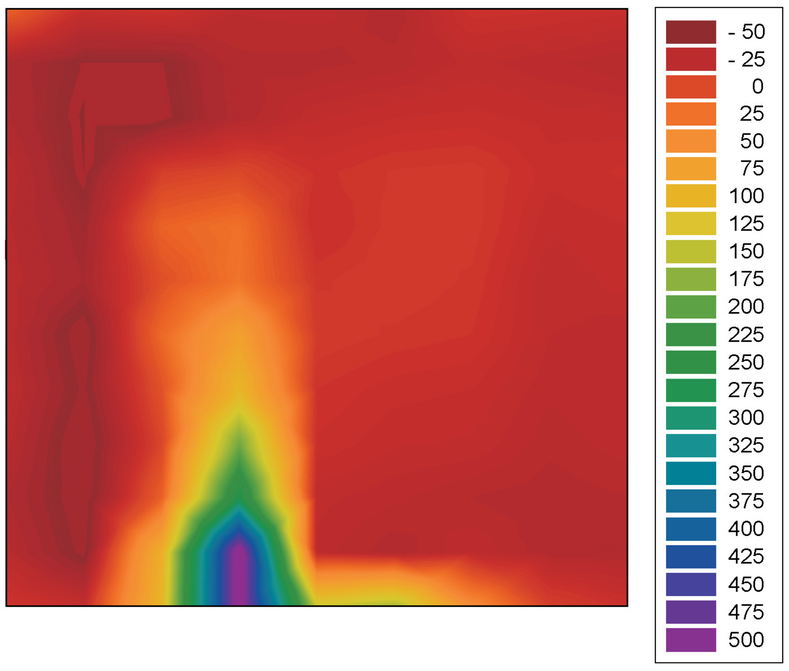


Scheme of the segmented bipolar plates for current density measurements

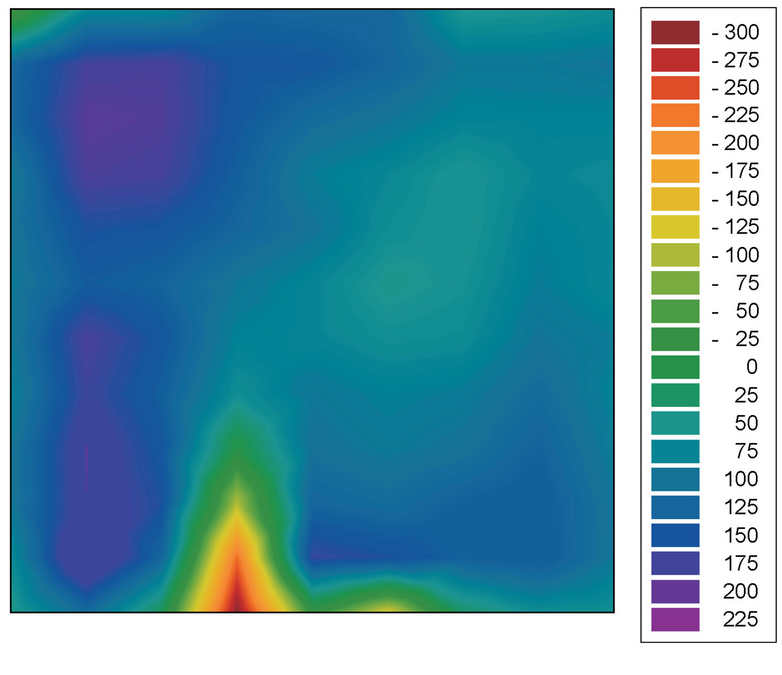


Measuring system used for the segmented bipolar plate. Only the resistors for segment 1 and 49 are shown for clarity.

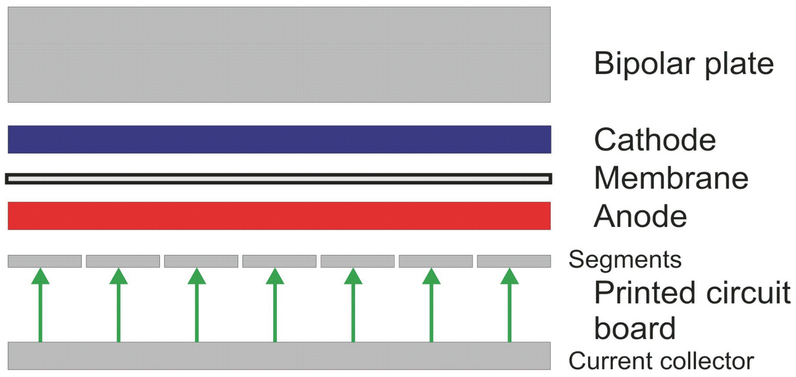
Investigation of leakage



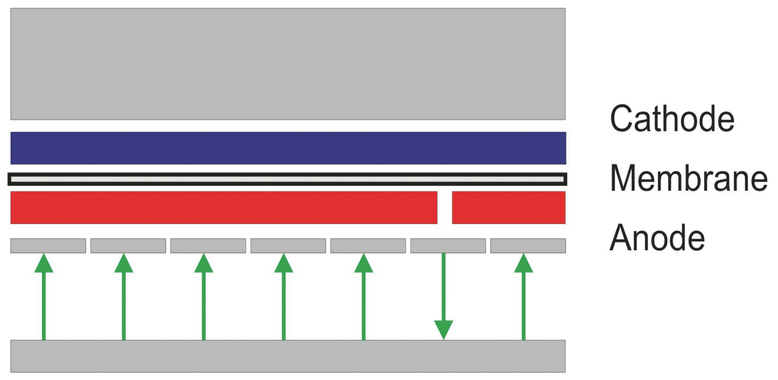
Current density measured at open circuit conditions on a MEA with a leakage



Current density measured under load (approx. 100 mA/cm2) on a MEA with a leakage



Scheme of current density measurement configuration with the printed circuit board under normal conditions



Scheme of current density measurement under open circuit conditions with a leakage in the membrane

Conclusions

The current density measurements allow to detect leakages in the cell. Especially at open circuit conditions areas operating in “electrolysis mode” as well as areas operating in the “fuel cell mode” coexist under stationary conditions. Under load the current density distribution is also reflecting the existence of the leakage, whereas the effect is being complex and depending on the applied load.
The relevant reactions in the fuel cell which influence the current density distribution of a cell with a leakage is presently not understood sufficiently. However, it is clear that the current density measurements are a suitable tool for the detection of leakages independent whether the reaction is understood in detail or not. Future investigations using the PCB method for current density measurement on both electrodes will be performed in order to clarify the effect. In particular it is necessary to ascertain that the current density on anode and cathode are symmetrical and to estimate the influence of the GDL.

Acknowledgment
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