Project Report

Application No. 2015
Short title Degradation effects of PEMFC in the edge region of the active cell area

Objectives: short, medium and long term (<250 words)

In this work, water and gas transport phenomena in PEM fuel cells were investigated by means of neutron radiography. Experiments were carried out with regard to the outer edge region of the active cell area, where a sealing gasket is situated and an edge channel is formed between sealing gasket and the flowfield. In the next few month the main objective is to analyse the obtained data and to investigate and describe the general water and gas transport mechanisms in the edge region of a cell. The effects of different cell configurations in the edge region on water transport properties will be compared. Results will be published soon in a peer reviewed journal. On a mid-term view, the results of the measurements will be helpful to evaluate suitable methods for the fuel cell development, as neutron imaging is one. On a long-term time scale the results will also be considered in the development of next generation sealing solutions for PEM fuel cells. Also the results will be analysed in respect to the active cell area with the objective, to support the development of improved flowfield designs.

Brief summary of work carried out:

In this work liquid cooled test cells with an active area of 50cm² were operated, which were especially designed for neutron imaging. 5 different cell setups were deployed, in which different cell configurations for the edge region of the active area were realized. MEAs with and without sub-gasket frames were employed, the edge channel width was varied in two steps and single flat sealing gaskets were used as well as Seal-on-GDL setups (sealing directly attached to the GDL). Also flowfield designs were varied in the way, that the outer land, which surrounds the flowfield, was either continuous or locally interrupted as it is the case in many technical cells with welded metallic bipolar plates. Sequentially purging the anode and cathode compartment of the cell by releasing the gas pressure shortly allowed the differentiation of water between both sides. Purge protocols were evaluated to optimize the water removal, especially from the edge channels. Different operation protocols were applied to the cells. RH-maps were performed, where anode and cathode humidification was varied over a wide range, in which each configuration was hold for 30min. For 3 of the cells also temperature, stoichiometry, load and gas inlet pressure were varied over a wide range. Each steady state point was terminated by sequentially purging the anode and cathode to assign water quantities to both sides. Furthermore steady state operations with different humidification levels were conducted sequentially without purging in between, so that dynamic changes in water distribution could be made visible. As a method to make gas movements visible, hydrogen was temporarily replaced by deuterium as a fuel gas. In presence of a catalyst and water, hydrogen and deuterium atoms can change places and heavy water is generated, which is almost invisible for neutron imaging. So particularly gas transport into the edge channel could be made visible in an appropriate way.

Main achievements intended for publication <250 words

In a subsequent publication, the influence of different cell structures and configurations of cell components in the edge region of the cell on the water distribution and gas movement will be discussed. Also the impact of cell design parameters on fluid transport properties and consequently on cell performance will be treated. Furthermore the variation of operation parameters, as load, stoichiometry, temperature and pressure, should be regarded, for an enhanced description of the transport mechanisms in the edge region of the cell.

Difficulties encountered <250 words

Phenomena, to be investigated are taking place in through-plane as well as in in-plane dimensions. The viewing direction of neutron imaging is perpendicular to the cell plane so through-plane transport processes can only be made visible by sequential purging, hence no continuous differentiation is possible. In cell setups with fluidic isolated edge channels, water can hardly be removed from the edge region, even multiple purges are not a suitable method therefor. Raising the gas inlet pressure before purging could not improve the efficiency of water removal. In general, time scales for water transport between active cell area and the edge channel were quite high, so that in some experiments steady states could hardly be reached.

Further comments:

I would like to send special thanks to the supporting team at the Paul Scherrer Institute, Pierre Boillat (Electrochemistry Laboratory and Neutron Imaging and Activation Group) and Johannes Biesdorf (Electrochemistry Laboratory) for the energetic support during the measurements round-the-clock. And I would like to acknowledge the H2FC Project for the great unbureaucratic and fast support in getting access to highly interesting scientific facilities. I can emphatically recommend the program to any other user from the fuel cell sector.