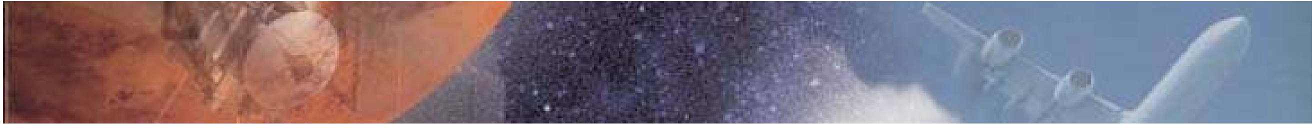

Polymer electrolyte fuel cells with extended operating temperature range of -30°C to 120°C

Abstract

Standard PEM fuel cells systems operate at temperatures up to 80 °C. This temperature level restricts their application because of cooling requirements. However, the present PSA membranes exhibit high performance and capability to start up from -30 °C. The goal for the next-generation cells is a higher temperature stability which allows for a limited time (e.g. about one hour) a transient operation up to 120 °C.

At the DLR institute of Technical Thermodynamics MEA structures with optimized materials and cells with adapted flow fields are investigated in laboratory scale cells and short stacks with technical relevant flow field areas. For optimization of the cells investigation by electrochemical impedance spectroscopy and current density distribution measurements are carried out to identify critical operating conditions and shortcomings of MEA components.

Introduction

Performance and application of PEM fuel cell systems are limited by cooling requirements due to the low operating temperature (< 80°C) of standard PEM fuel cells. However, the present PSA membranes (e.g. Nafion®) exhibit high performance and capability to start up from -30°C. The goal for the next-generation cells is a higher temperature stability to withstand transient operations up to 120 °C for about one hour. DLR will take advantage of novel membranes materials and modified structures to develop a concept for an extended-temperature fuel cell operation involving adapted electrode structures, gas diffusion electrodes, stack design and system operation to achieve and ascertain reliability and durability.

For the realization of an extended operation regime, a good understanding of the relationship between electrode / gas diffusion layer / membrane and performance is required.

The following tasks will be started in the future:

- Identification of advanced membranes
- Characterization of individual components
- Development of appropriate hydrophobic and hydrophilic electrode and gas diffusion structures
- Identification of methods and system signals to diagnose and to avoid malfunctions
- Simulation of the relevant processes

Experimental

At the German Aerospace Center (DLR) test facilities for various operation temperatures (up to 200°C) of fuel cells have been built-up. In a first investigation of MEAs with a PSA membrane for operating conditions up to 120 °C a small standard cell with an active area of 5 x 5 cm² and a single serpentine flow field was used.

In order to yield a detailed understanding of the problems of high (120°C) temperature fuel cell operation a segmented cell is in use with 49 segments.

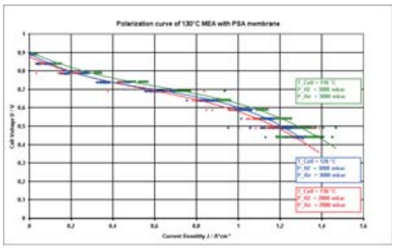

Fig. 1: Polarization curve of MEA with PSA membrane for operating temperatures up to 130 °C

Fig. 2: DLR test bench for PEM fuel cells with integrated DLR current density measurement system

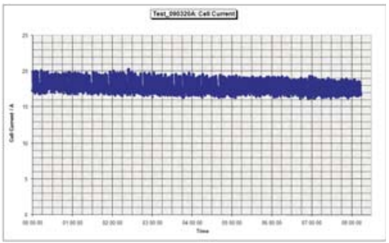

Fig. 3: Current fluctuations at constant operating conditions - Current measurement during first 5 hours of 13 hours test

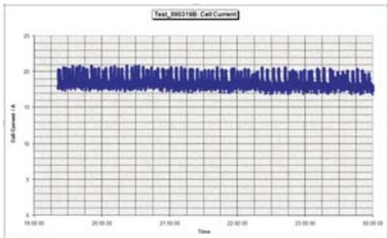

Fig. 4: Current fluctuations at constant operating conditions - Current measurement during last 8 hours of 13 hours test

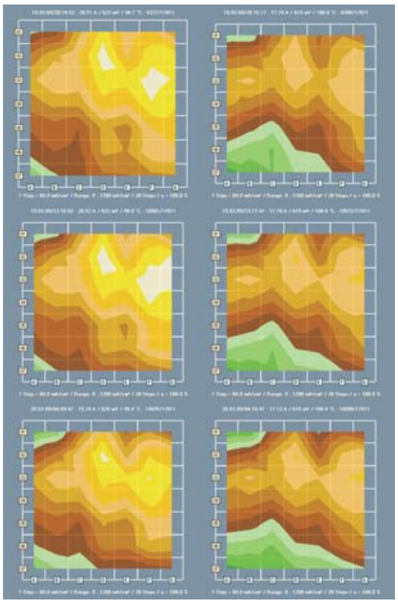

Fig.5: Current fluctuations at constant operating conditions Current density distribution at high current level of 20 A (left) and current density distribution at low current level of 17.5 A (right) at 3 different times A

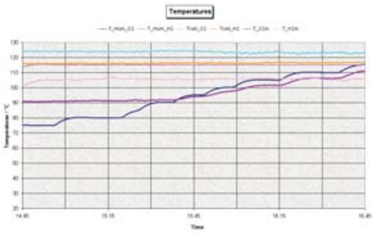

Fig. 6: Diminishing of current fluctuations Temperature measurements during increase of cathode humidification temperature T_Hum_O2 = 75 °C to 115°C

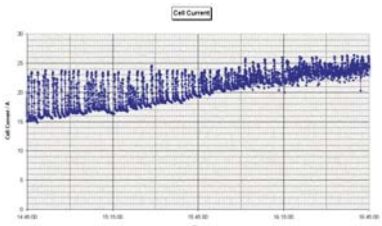

Fig. 7: Diminishing of current fluctuations Current measurements during increase of cathode humidification from RH = 20% (75 °C) to RH = 85% (115 °C)