Development of a nitrogen detector to monitor the distribution of gases on the anode side of polymer electrolyte membrane (PEM) fuel cells

The limited lifetime of membranes in PEM fuel cells is one of the key barriers on the way to a rapid commercialization. Lifetimes of membranes are limited by thinning, the formation of pinholes and cracks. These degradations affect the performance of cells and stacks and enable gas crossovers. For instance the nitrogen crossover from the cathode to the anode can lead to an enrichment of this gas at the end of the anodic flow field. The displacement of hydrogen by nitrogen then leads to a local decrease of current density. If a cell in the stack is not provided by sufficient hydrogen to generate the stack current, side reactions takes place, which induces carbon corrosion and causes the complete damage of the system.

In order to prevent local nitrogen accumulation we develop an alternative and low cost gas detector system for detecting nitrogen in the anode exhaust gas stream. We chose the concept of an electric arc emission spectrometer in which the molecules are excited by electron impact. After electronic excitation the molecules undergo an irradiant deactivation that leads to light emission. The relation between signal intensity and nitrogen concentration is linear over a large concentration range (pure gas to three-tenths of a percent). For lower concentrations the relation is non-linear and has the shape of a square-root function. This arc emission spectroscopy is very sensitive. The present limit of detectability is in the range of about 10 ppm

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Gas detector for fuel cell diagnoses

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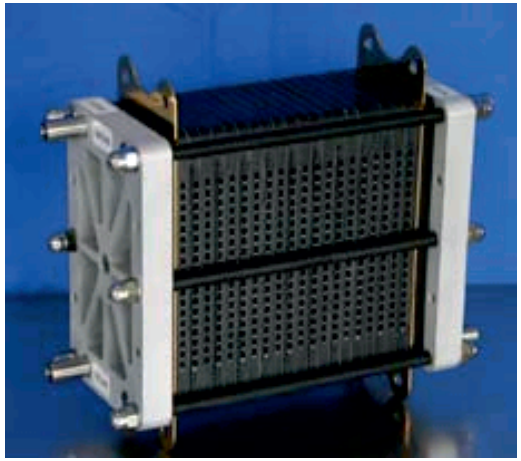
Centre for
Fuel Cell Technology



Prevention of critical stack states
by detecting nitrogen on
the anode side

Initial situation

In PEM fuel cells nitrogen can be enriched on the anode side by diffusion. This effect is most pronounced near the anode outlet when most of the hydrogen is consumed by the fuel cell reaction. Enrichment of nitrogen can lead to corrosion of the electrodes. If Membranes get thinner by ageing, degradation or micro cracks in the membranes are generated, nitrogen crossover increases also. This can be detected with the gas detector and counter measures to prevent the total stack failure can take place in early stages.

Concept of the nitrogen detector

The detection of nitrogen based on arc emission spectroscopy. The exhaust gas is directed to the discharge unit at the end of the anode flow field. The device detects hydrogen, water vapor and nitrogen simultaneously.

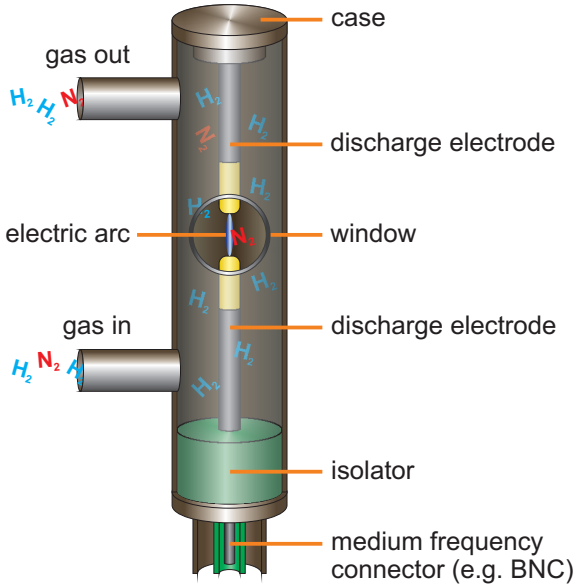


Fig.1: N_2-detector; principle of operation

Arc emission spectrum

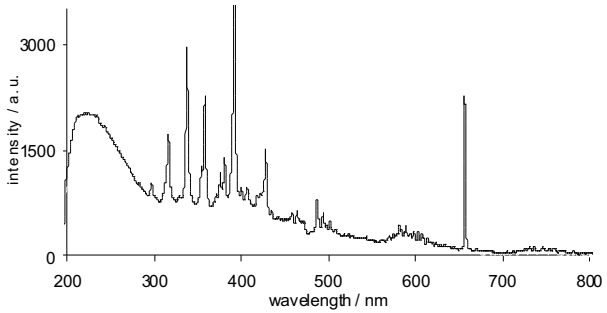


Fig.2: Arc emission spectrum of a gas mixture of hydrogen (95%) and nitrogen (5%); N_2-emission between 300 and 500nm, H-α line at 656.7nm; measuring time: 500ms

Benefits

- increase of durability of stacks by identifying early stages of membrane degradation
- reducing the cost of operation by minimizing the consumption of hydrogen

Specifications

limit of detection: 10 ppm N_2
measuring time: 5 s
dimensions (W/D/H): 10x10x50 mm
operating voltage: 9 V

A prototype is exhibited at

Halle 2, Stand C 38

DIWA Düsseldorfer Innovations- und Wissenschafts-Agentur GmbH

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