

Effect of Compression Cycling on High-Temperature Polymer Electrolyte Membrane Fuel Cells

F. Javier Pinar, Maren Rastedt, Nadine Bruns, Anja Diedrichs and Peter Wagner

NEXT ENERGY · EWE Research Centre for Energy Technology at Carl von Ossietzky University, Carl-von-Ossietzky Str. 15, 26129 Oldenburg, Germany

Polymer electrolyte membrane fuel cells (PEMFC) are an actual alternative for electricity generation that increases the flexibility in power generation sources. Thus, PEMFCs in combination with renewable energy sources from wind, water and sun may help to reduce our dependence on oil fuels, since fuel cells have higher electrical efficiencies compared to internal combustion engines. The use of pure hydrogen as fuel generates only water as product, so that local poisoning emissions into the atmosphere are disposed of (1).

At the present time, low temperature PEMFC (LT-PEMFC) has been extensively investigated and it is a technology in market scale. Nevertheless, high temperature PEMFC (HT-PEMFC) is attracting researcher's attention in the last years because this fuel cell technology offer desired features that low temperature technology does not have. Thus, the typical operating temperatures of this technology are in the range of 120-200 °C which allows for co-generation of heat and power, improved kinetics for the oxygen reduction reaction (ORR), high tolerance to fuel impurities and simpler system design (2, 3). Phosphoric acid doped polybenzimidazole (PBI) based membrane is the most extended electrolyte material for HT-PEMFC due to the fact that it is one of the most efficient proton conducting materials (4).

In contrast, H₃PO₄ doped PBI based membrane electrolyte technology has some limitations that must be overcome to reach the market scale in the future. They are the increased degradation rates due to the enhanced operation temperature and the acidic environment, the leach of the electrolyte and incompatibility with current materials already developed for LT-PEMFC technology.

A PEMFC is a complex structure set up with different materials. Compression forces have an impact on the physic-chemical properties of these materials which in turn affect the fuel cell performance. Therefore, the control of fuel cell compression is an important requirement to identify some of the degradation effects in HT-PEMFCs and understand their influence on the overall performance (5). There is some literature available that focus on compression studies for HT-PEMFCs but it appears to be incomplete (6, 7). Thus, compression influence needs still further investigation to get a better understanding.

The effect of compression has previously been investigated. In a first study, it was observed that by increasing contact pressure, contact and ionic resistances became lower, hydrogen crossover and internal resistance increased due to membrane thinning and flow field geometry has a big impact on the MEA (membrane-electrode-assembly) compressibility at the same contact pressure (5). In a second study that was focused on giving a further insight, it was detected that hydrogen crossover was more influenced by physical damage of the

membrane than its thinning. The compressive strain of the Gas Diffusion Layer (GDL) was large at low compressive forces due to the strong compressibility of the material. Furthermore, GDL deformation behavior had a big impact on the high-frequency resistance and on mass transport limitation behavior. From the medium to the high contact pressure domain studied, the contribution of the contact resistances to the total high-frequency resistance was low against membrane electrolyte resistance contribution. It was also found that the GDL- Catalyst Layer interface resistance was only a function of contact pressure (8). Thus, this work continues with the aim of studying compression effects on fuel cell behavior but this time it will be focused on the effect of contact pressure cycling, leading to reversible and non-reversible compression effects that can be identified. Therefore, the objective of this work is to increase the knowledge about the compression dependency of a HT-PEM MEA operating in a fuel cell and to enhance the knowledge to its contribution to degradation.

The study has been carried out using MEAs from different suppliers. They have been characterized electrochemically by polarization curve, electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and linear sweep voltammetry (LSV) measurements.

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