Durable MEAs for PEM electrolyser systems operating at high current densities

P. Lettenmeier[a], R. Wang[b], R. Abouatallah[b], A. S. Gago[a], K. A. Friedrich[a]

[a]*Institute of Engineering Thermodynamics, German Aerospace Center*
Pfaffenwaldring 38-40, 70569 Stuttgart, Germany
[b]*Hydrogenics Corporation, 220 Admiral Boulevard, Mississauga, ON L5T 2N6, Canada*

philipp.lettenmeier@dlr.de

Hydrogen can be used as an energy vector for renewable energies such as solar or wind by using water electrolysis systems [1]. Commercially, it can be electrochemically produced by alkaline and proton exchange membrane (PEM) electrolysis, at which the investment cost of the later is presently almost three times higher than the alkaline technology [2]. However, the main advantage of PEM electrolysers is the possibility to operate at much higher current densities with a significant potential for cost reduction owing to the compact design [3]. An open question is still the life time of the membrane electrode assembly (MEA) of the PEM electrolyser operating at high performance. In this work rainbow stacks with MEAs from different suppliers are tested in a 20 kW PEM electrolyser (2.5 N m^3 H_2 h^{-1}) operating constantly and dynamically up to 5 A cm^{-2}. The 120 cm^2 active area MEAs have membranes with the same thickness but different Ir-based catalyst loadings. The cell voltage (E_{cell}) increases ca. 50 mV at 1.25 A cm^{-2} when reducing the anode loading by 30% (Figure 1a), although this parameter does not influence the degradation rate. It is possible to reduce the cell voltage by 150 mV at 3.3 A cm^{-2} by increasing the temperature from 28° to 48° C. At the maximum current density the stack temperature and E_{cell} reach almost 65 °C and 2.5 V, respectively. Operating the electrolyser at low current densities has an impact in the H_2 crossover. The most durable MEAs do not experience any lost in performance after more than 3000 h of operation under stationary and dynamic regimes. Post-mortem characterisation and water analysis are carried out to determine the degradation mechanism of the rest of the MEAs.

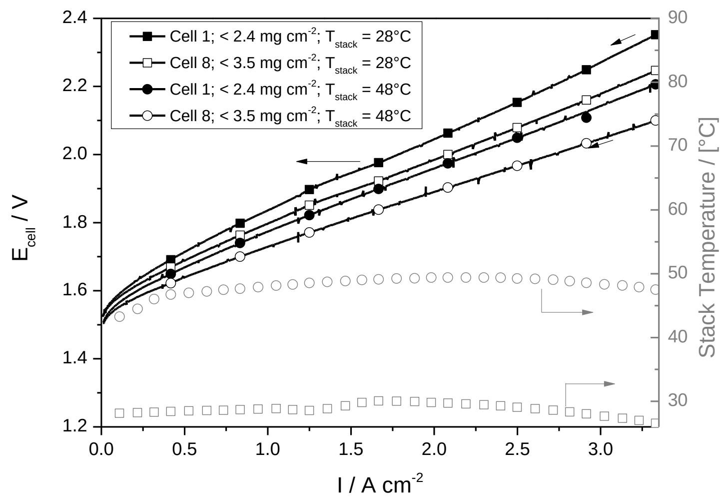

Fig. 1. Cell voltage and current density characteristics of a 120 cm^2 stack with half of the cells having anode catalyst loadings of 2.4 g cm^{-2} and the other half with 3.5 g cm^{-2}. The measurements are performed at 7 bar and two different stack temperatures. The step rate of the rectifier is 4.2 mA cm^{-2} s^{-1}.

References

[1] A. Sternberg, A. Bardow, Energy Environ. Sci. (2015) 389.
[2] Fuel Cells and Hydrogen Joint Undertaking, Report: Commercialisation of Energy Storage in Europe, 2015.
[3] M. Carmo, D.L. Fritz, J. Mergel, D. Stolten, Int. J. Hydrogen Energy 38 (2013) 4901.