Transient Response of a
Proton Exchange Membrane Fuel Cell

Helge Weydahl[1], Steffen Møller-Holst[2], Georg Hagen[1]
[1]Department of Materials Tecnology,
NTNU, NO-7491, Norway
[2]SINTEF Materials and Chemistry, NO-7465, Norway

Fuel cell technology is expected to be implemented in a broad range of applications. For real market penetration the fuel cells will have to comply with the load requirements of these applications. For applications where the load changes rapidly, knowledge of the load variation requirements as well as the response time of the fuel cell is essential for designing suitable buffer systems, if required.

Transient processes in a fuel cell occur on time scales ranging from a few microseconds to several minutes. In this work, we focus on transient processes in a single proton exchange membrane fuel cell (PEMFC) on the sub-minute time scale. Many authors (e.g., [1-4]) have studied the transient response of cell voltage to imposed current steps. Our objective is to observe the relaxation of both cell voltage and current upon a step change in the *outer circuit resistance*.

Step changes in the outer circuit resistance are obtained using a resistance board and a high-speed transistor switch. Due to the short switching time of the transistor, we can observe processes with a relaxation time down to a few microseconds. An equivalent circuit for the PEMFC is established on basis of electrochemical impedance spectroscopy (EIS) at different cell voltages. The response of the PEMFC upon step changes in the outer circuit resistance is compared to the theoretical response of the equivalent circuit.

EIS indicates, as expected, a dominating cathode charge transfer resistance and double layer capacitance that decrease with increasing load (Figure 1). This is reflected in the resistance step measurements, which show a slower response when the cell is operating at low currents (Figure 2). Based on the experimental results, the trajectories followed between points on the steady-state polarisation curve are identified. The response time of the PEMFC at various loads is mapped and will be further discussed and interpreted.

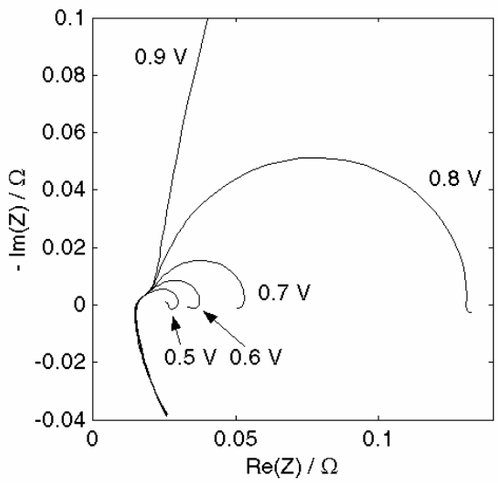

Figure 1: Nyquist diagram of the impedance of the single PEMFC cell at five different cell voltages.

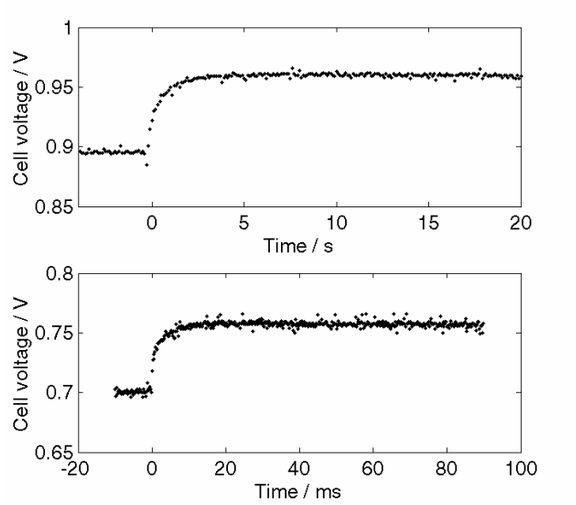

Figure 2: Cell voltage response of a single PEMFC upon step changes in the outer circuit resistance at low load (upper curve) and higher load (lower curve). Note the difference in time scale.

References:

[1] X. Xue, J. Tang, A. Smirnova, R. England, and N. Sammes, *J. Power Sources, In Press, Corrected Proof, Available online 10 May 2004*
[2] M. Ceraolo, C. Miulli, and A. Pozio, *J. Power Sources*, **113**, 131 (2003)
[3] P. Heidebrecht, and K. Sundmacher, *Chem. Eng. Science*, **58**, 1029 (2003)
[4] P. Argyropoulos, K. Scott, and W. M. Taama, *Electrochim. Acta*, **45**, 1983 (2000)