The MultiSingleCell in PEFC Durability Research

International Symposium on
DIAGNOSTIC TOOLS FOR FUEL CELL TECHNOLOGIES
23rd-24th June 2009 Trondheim, Norway

Thomas Tingelöf, Sonja Auvinen and Jari Ihonen
thomas.tingelof@vtt.fi

Contents

Key ideas of the MultiSingleCell (MSC) and cooling cascade

Design principal

- Flow splitting

Unit cell designs

Design for MEA testing

- Selected results from the MSC in MEA testing

Design for stainless steel and coating

- Selected results from the MSC in stainless steel and coating testing

Future development of the MSC concept

What is a Multisinglecell?

- A multisinglecell consists of number of stacked single fuel cells
- Isn’t this a fuel cell stack? Yes, but…
  - The gas and cooling flows can be separated
  - Thermal insulation between cells →The cells can be individually disconnected from gas/water flows and electric load

Figure 1 Multisinglecell with 8 unit cells

The key ideas in Multisinglecell measurement setup

- One common test station and splitting of gases before cells
- Gases are dried after fuel cell using an array of heat exchangers
- “Precision flow resistances” (3-10 higher than flow resistance in the cells) splits the flows evenly
- Individual sampling of exhaust water (fluoride, corrosion products)
- The experiment history will be the same for all the samples
- The use of common thermostating liquid circuit and one load box with in fuel cell stacks
- The clamping pressure is the same in all cells

⇒ Capacity of a conventional measurement station is multiplied!

A principal setup for Multisinglecell measurements

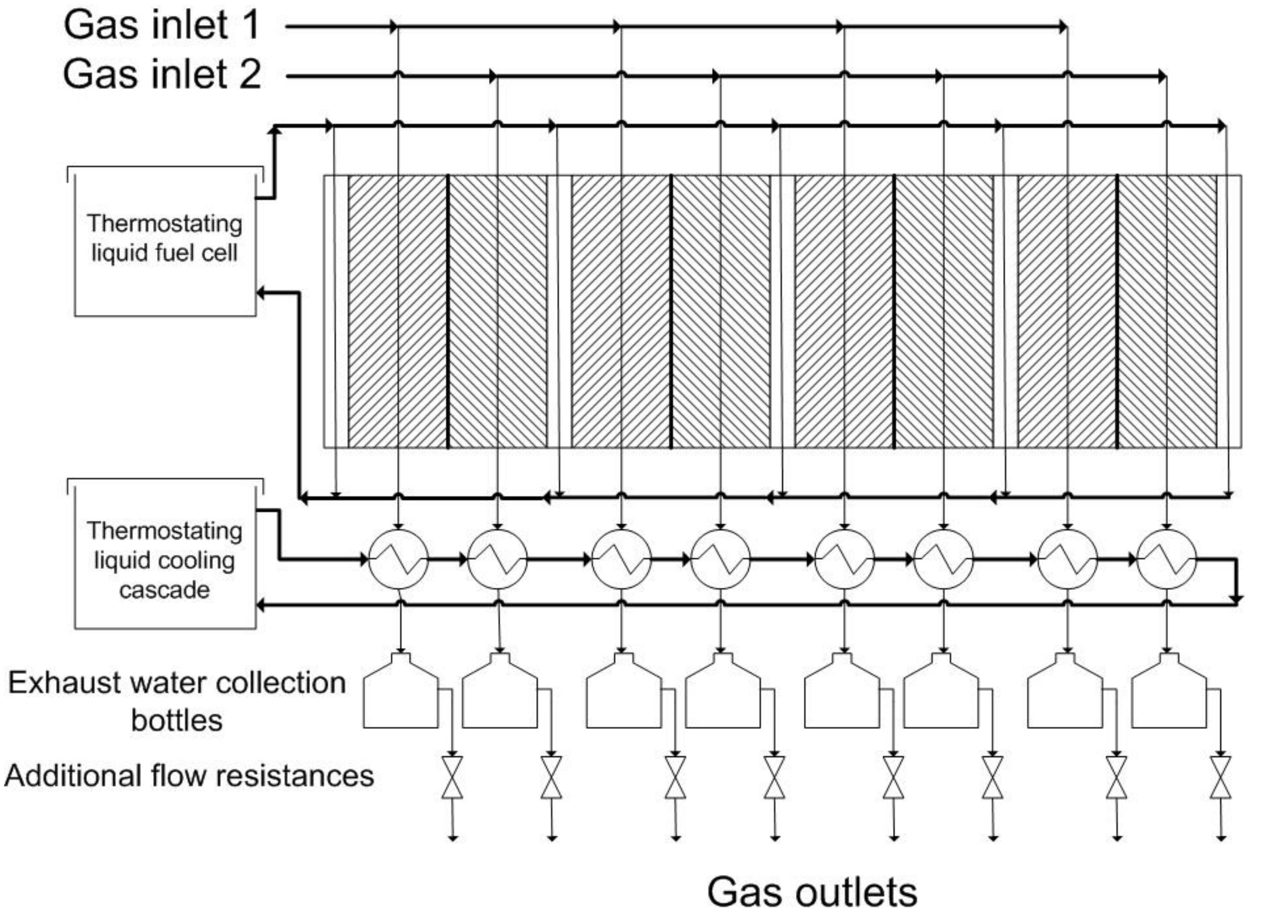

Figure 2 Principal setup of a multisinglecell and cooling cascade

- Water must be condensed before "precision flow resistances“!!

Flow splitting

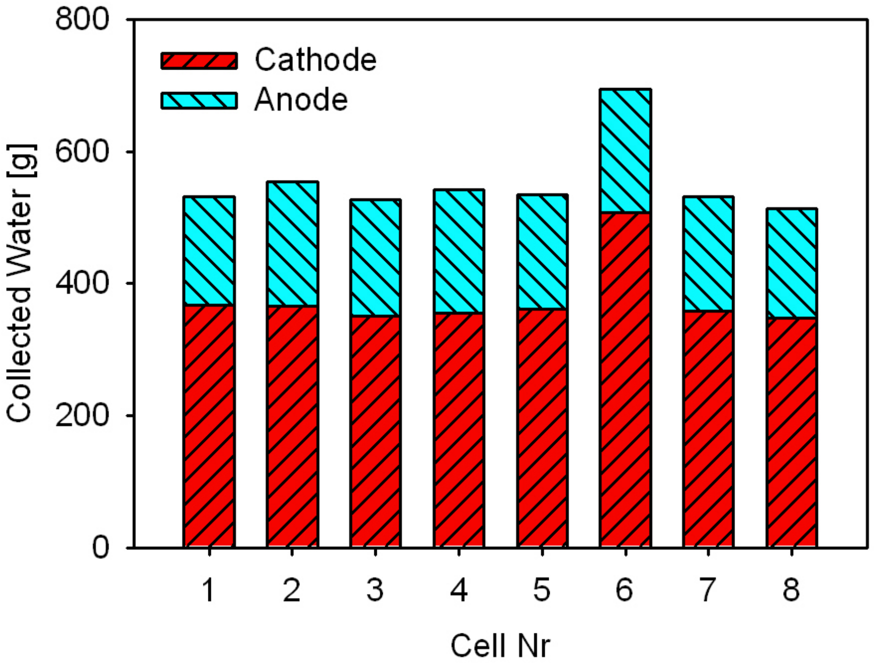

Figure 3 Flow splitting at 140 h with leak after cell 6

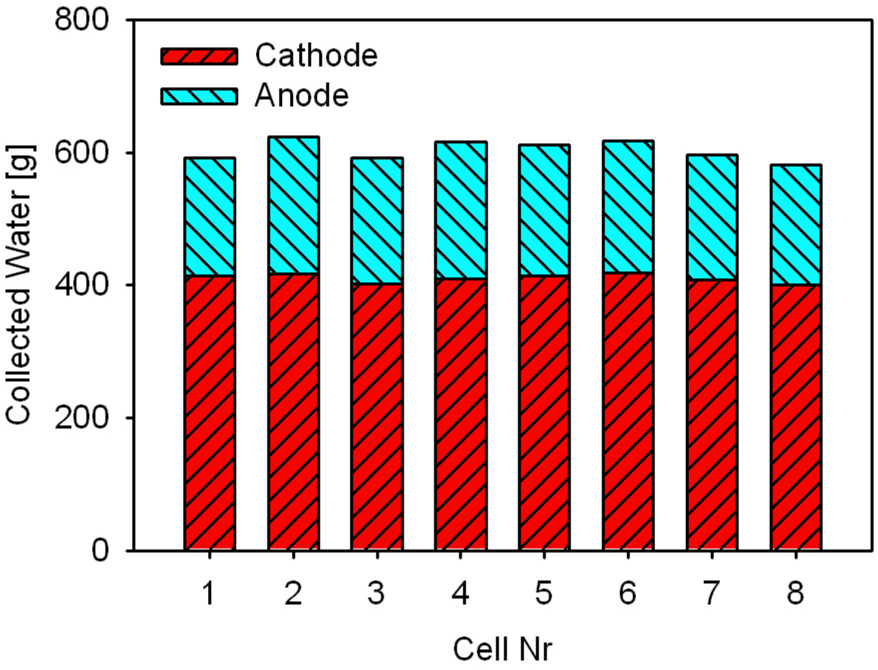

Figure 4 Flow splitting at 280 h

Cell design for MEA research

- A 25 cm^2 MSC has been designed for testing of screener MEAs
  - Single serpentine flow channels for gas and cooling water
  - Internal, or external, manifolding of inlet gases
  - Internal manifolding of cooling liquid
  - Viton rubber sheets between each cell

Figure 5 Cell design for screener MEAs

Example of MSC in MEA research – Potential cycling

Table 1 Experimental parameters potential cycling

MEA	Paxitech S25-3L (0.6/0.6 mg Pt cm-2)		
GDL	Carbel® CL (compressed to 200 µm)		
Cell hardware	8 x In-House 25 cm^2 single serpentine		
T_{cell}	75 °C	Air flow rate	5.2 (n)lpm
RH	100%	H_2 flow rate	2.6 (n)lpm

Table 2 Load box set-up

Cell nr	Potential level A [V]	Potential Level B [V]	
Cell 1	0.875	0.700	*Slew rate [V/s] 20* *Frequency [Hz] 0.2* *Duty [%] 50*
Cell 2			
Cell 3	0.850	0.700	
Cell 4			
Cell 5	0.825	0.700	
Cell 6			
Cell 7	0.750	-	
Cell 8			

Table 3 Evaluated parameters

Polarization curves	Galvanostatic
Fluoride Emissions	Orion ionplus® fluoride electrode
Post-mortem SEM	*Not yet completed!*

Performance decrease during potential cycling with Paxitech MEAs

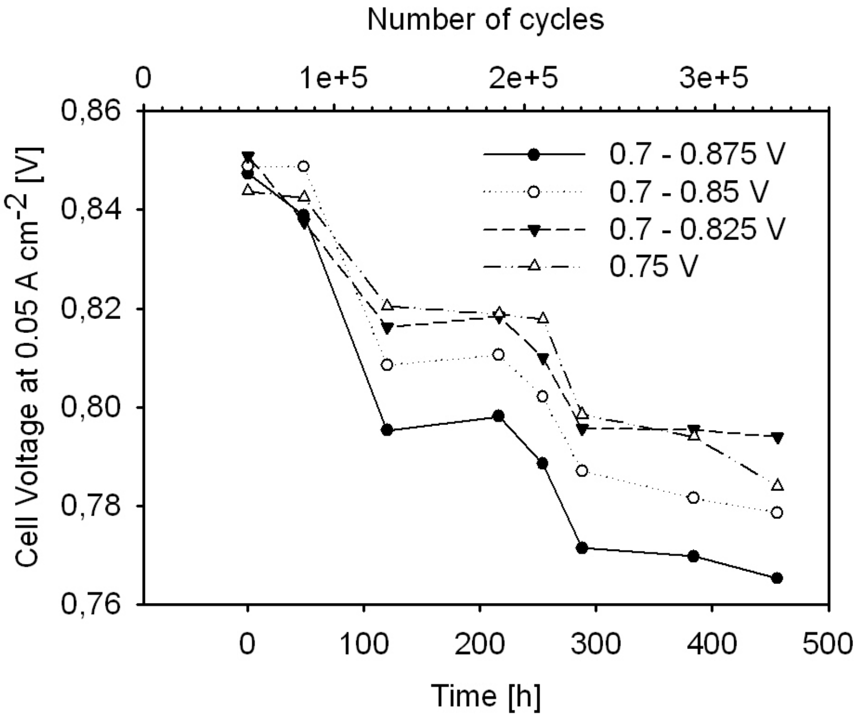

Figure 6 Cell voltage at 0.05 A cm-2 during potential cycling experiment

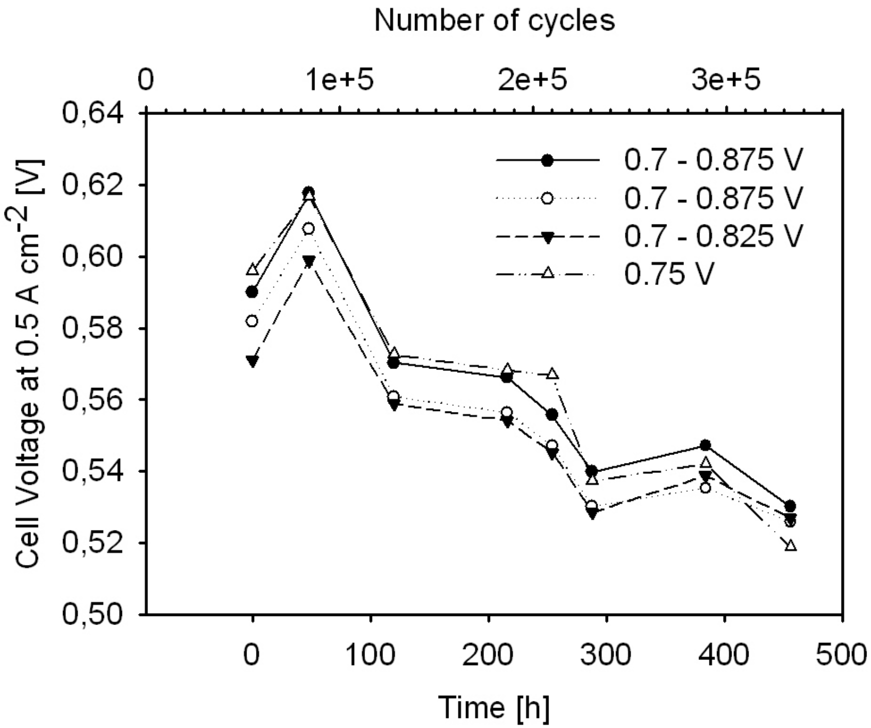

Figure 7 Cell voltage at 0.5 A cm-2 during potential cycling experiment

A clear performance decrease at *low currents* as a function of upper potential cycling limit and time, indicates lower catalytic activity!

Fluoride emission rates during potential cycling with Paxitech MEAs

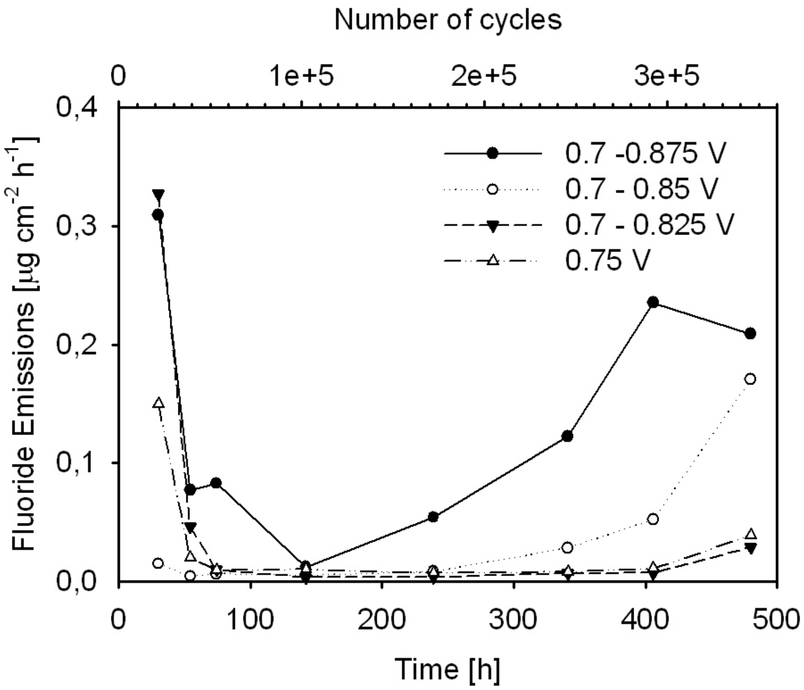

Figure 8 FER at anode during potential cycling experiment

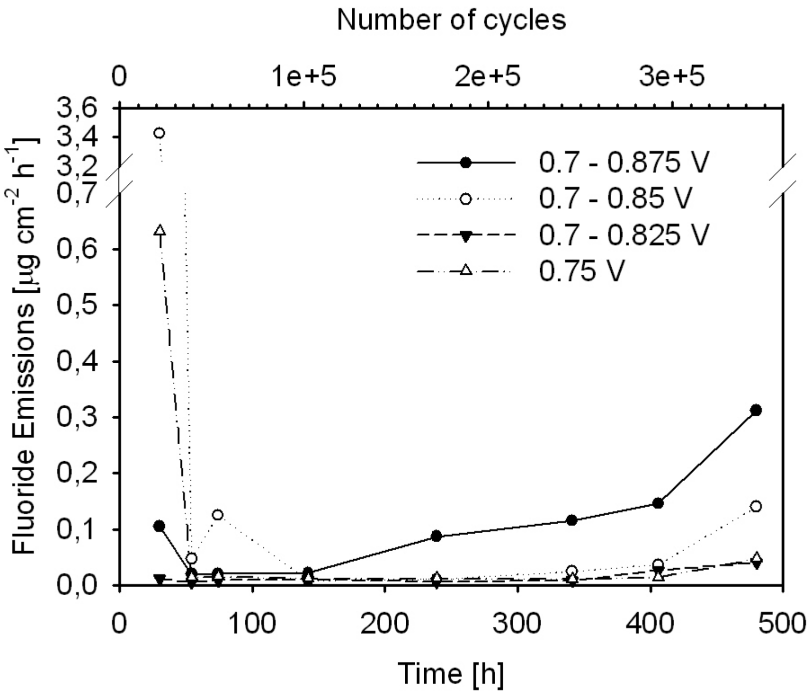

Figure 9 FER at cathode during potential cycling experiment

Fluoride emission rates follow same trend as cell voltage. Also here the cells cycled to 0.825 V are in the same range as the reference cell.

Cell design for stainless steel and coating research

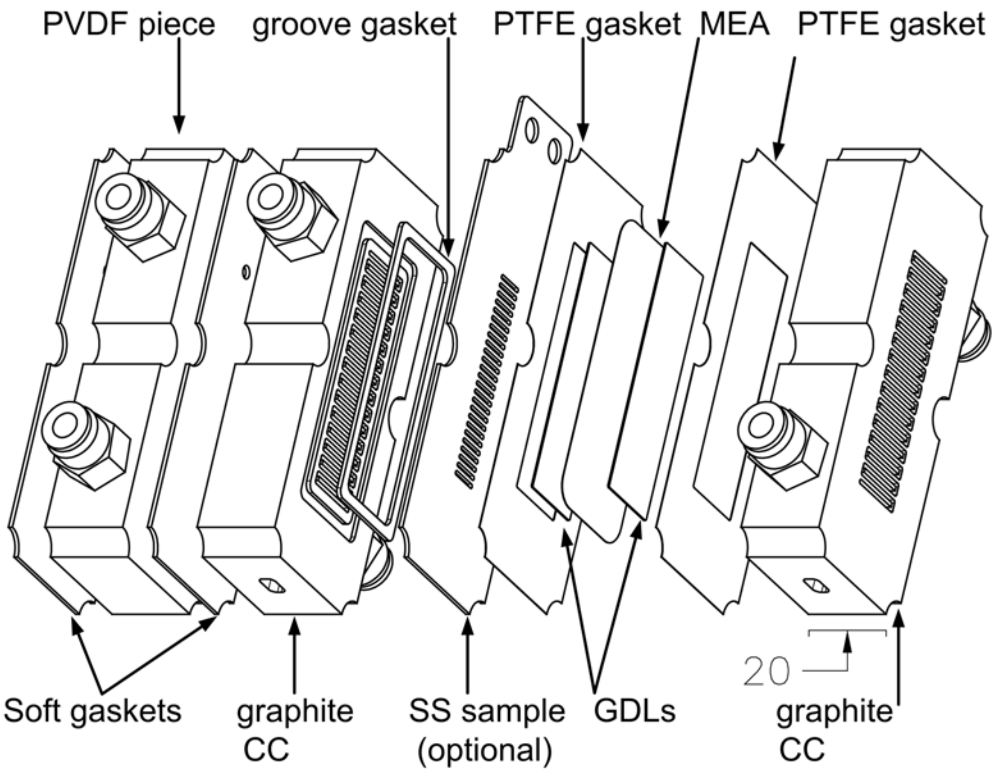

Figure 10 Principal setup of multisinglecell for stainless steel and coating testing

Figure 11 Cell design for stainless steel and coating testing

Example of MSC in stainless steel and coating research

Table 4 Experimental parameters			
MEA	Gore PRIMEA® 5640 (0.6/0.1 mg Pt cm^{-2})		
GDL	Carbel® CL (Compressed to 200 μm)		
Cell hardware	8 x In-House 10 cm^2 single serpentine		
Test duration	650 h	Current density	0.05 A cm^{-2}
T_{cell}	80 °C	Air flow rate	0.6 (n)lpm
RH	100%	H_2 flow rate	0.3 (n)lpm

Table 5 Evaluated parameters	
Interfacial Contact Resistance	Before and after corrosion measurements
Fluoride Emissions	Orion ionplus® fluoride electrode
Iron ion contents of exhaust water and MEA	GF-AAS, F-AAS and ICP-AES (TKK analysis centre)

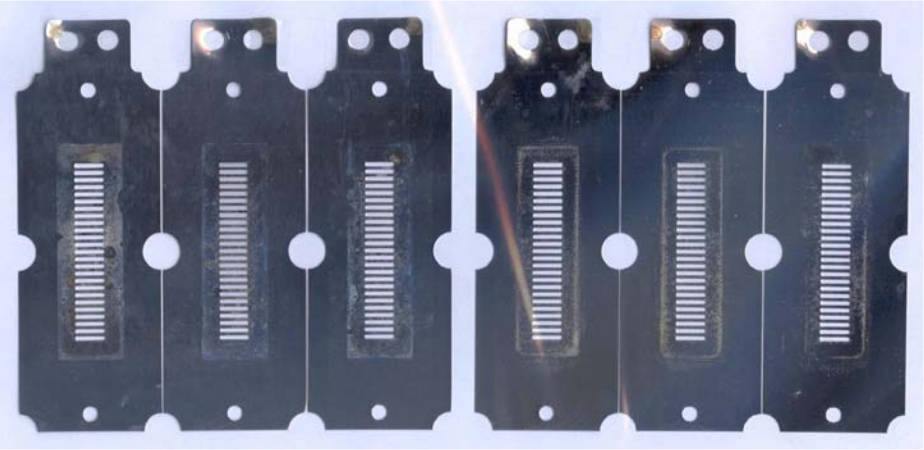

Figure 12 904L samples after the corrosion test. On the left: the anode samples, on the right: the cathode samples.

Fluoride emissions

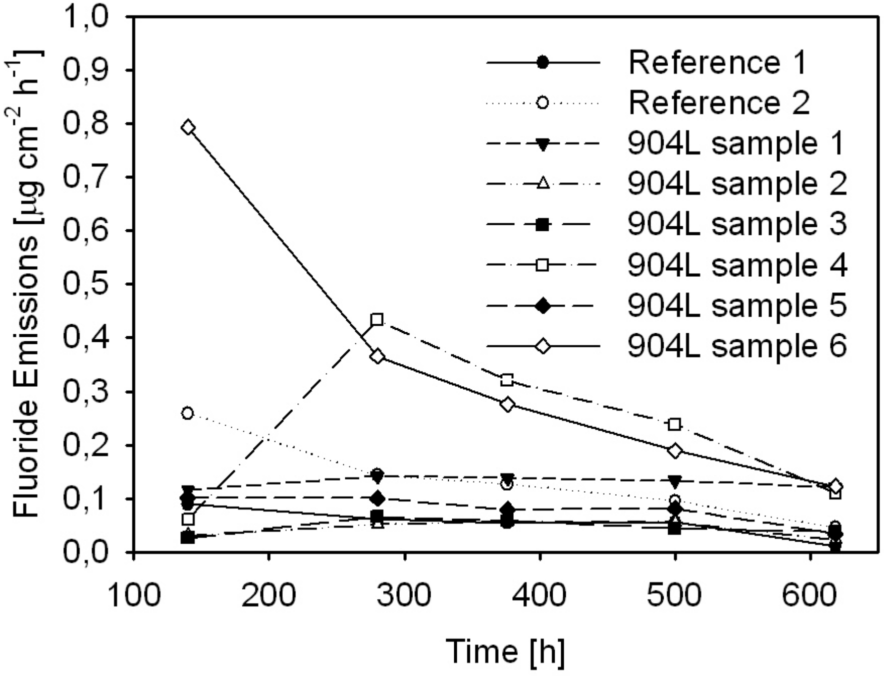

Figure 13 FER at anode during experiment with 904L samples

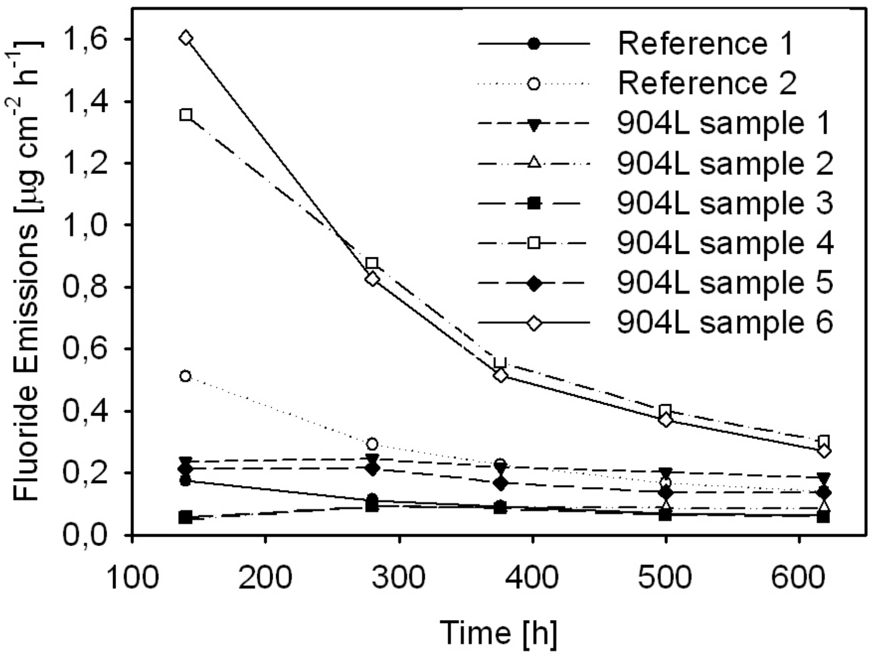

Figure 14 FER at cathode during experiment with 904L samples

Flush out of fluoride at beginning of experiment. Otherwise, no clear trend in fluoride emission rates.

Post-mortem analysis of MEAs and steel samples

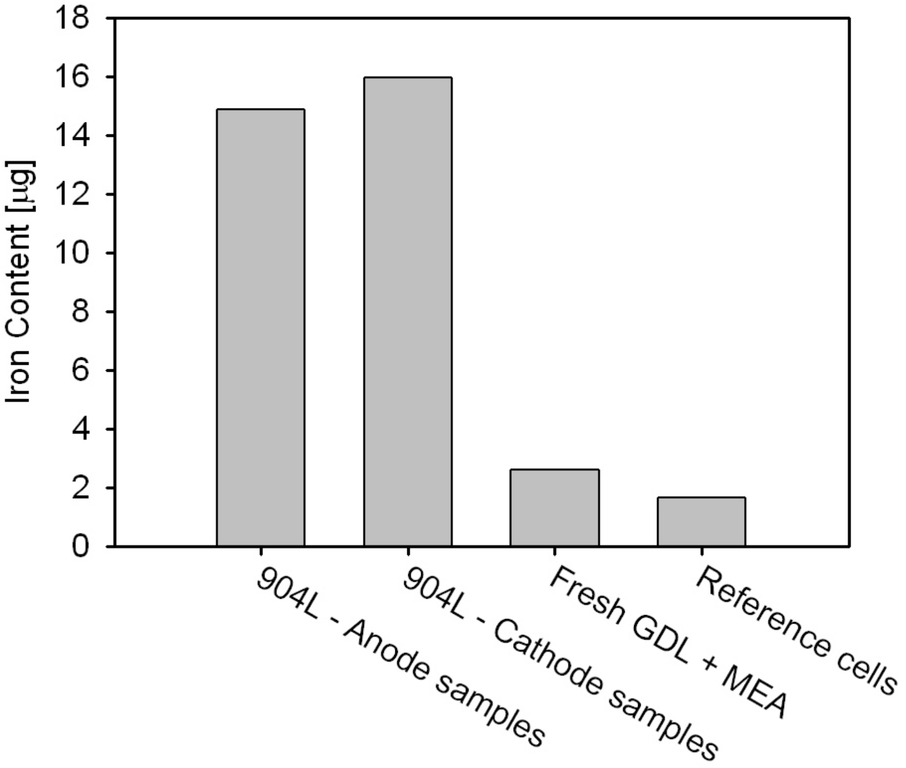

Figure 15 Iron contents from MEAs and GDLs

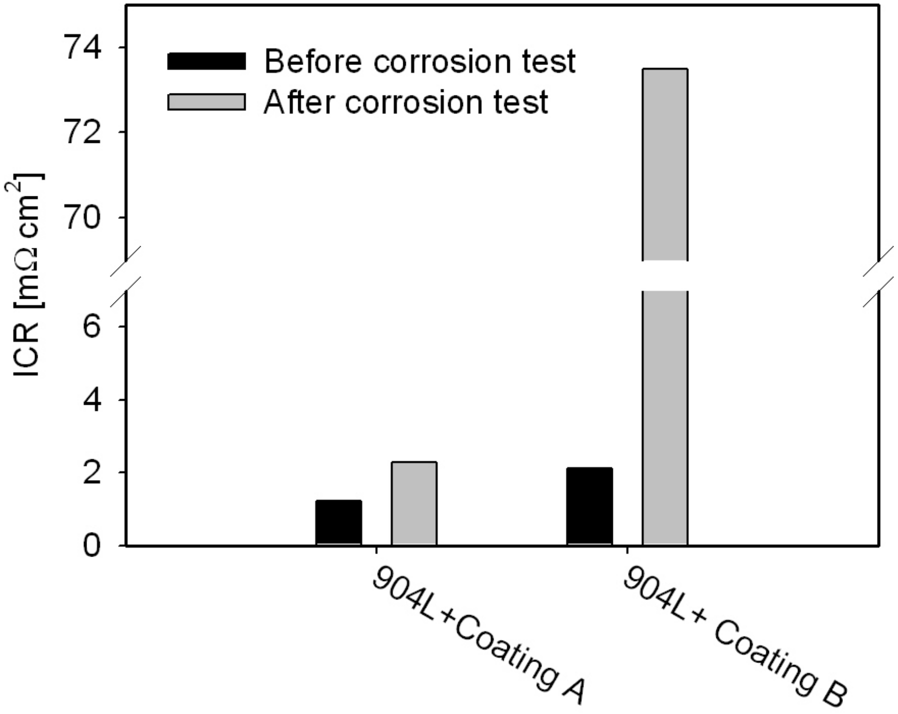

Figure 16 Contact resistance before and after testing of two different coatings

Future development of the MSC concept

- Continuous measurement of flow splitting by small mass flow sensors
    - Smaller stoichiometric ratios possible
    - Accurate water management studies

- Cell design for catalyst development
    - Adapted to small amounts of available catalyst