Reasons for the high power density of direct membrane deposition fuel cells revealed by impedance spectroscopy

Severin Vierrath*1, Matthias Breitwieser, Matthias Klingele, Roland Zengerle1 and Simon Thiele13

1University of Freiburg, Department of Microsystems Engineering, Laboratory for MEMS Applications, 79110 Freiburg, Germany
2Fraunhofer Institute for Solar Energy ISE, Heidenhofstr. 2, 79110 Freiburg, Germany
3FIT, University of Freiburg, Georges-Koehler-Allee 105, 79104 Freiburg, Germany

* severin.vierrath@imtek.de

Klingele et al. showed never reached high power fuel cells by applying direct membrane deposition (DMD), excelling the peak power of a catalyst coated membrane (CCM) by a factor of 2.3. [1] To understand the underlying reasons for their high power, we identify the reasons and quantify their impact by employing electrochemical impedance spectroscopy.

As a result we show, that the main reasons for the high power of DMD fuel cells are (i) a 50% reduced high frequency resistance (26 mΩcm²) due to a thinner membrane (12 µm) compared to state-of-the-art and (ii) a factor 2.2 reduced mass transport losses (0.12 Ωcm²) due to increased water back diffusion through the thin membrane (Figure 1a). A comparison of DMD vs. CCM fuel cells at the maximum power point of the CCM shows that 91% of the DMD’s improvement can be attributed to reduced mass transport losses and only 9% are caused by the reduction of the ohmic resistances (Figure 1b).

Figure 1 Comparison of a DMD with a CCM and a gas diffusion electrode (GDE) with membrane foil: a) Charge transfer resistance (Rct) over current density. b) Impedance spectra at the maximum power point of the CCM, 2.2 A/cm², showing improved mass transport of DMD.

Keywords: direct deposited membranes, electrochemical impedance spectroscopy, charge transfer resistance, mass transport loss