Properties of a direct deposited membrane (DDM) Investigating the reasons for its high performance

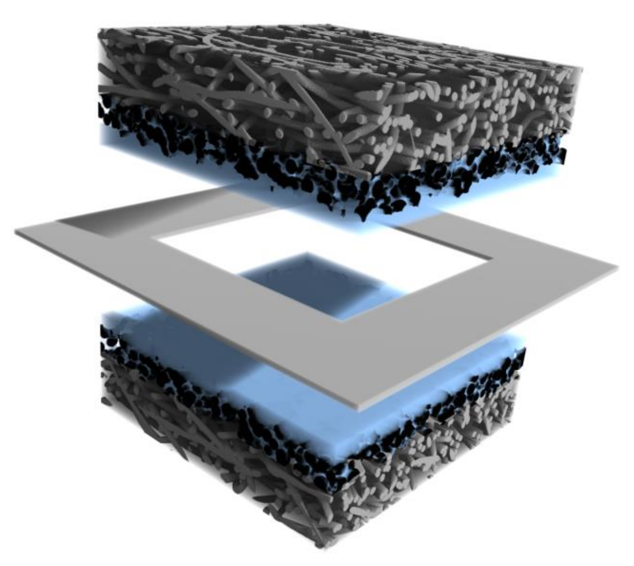
S. Vierrath[1], Matthias Breitwieser[1], Matthias Klingele[1], Roland Zengerle[1], Simon Thiele[1,2]

[1]Laboratory for MEMS Applications, Department of Microsystems Engineering - IMTEK, University of Freiburg, Germany

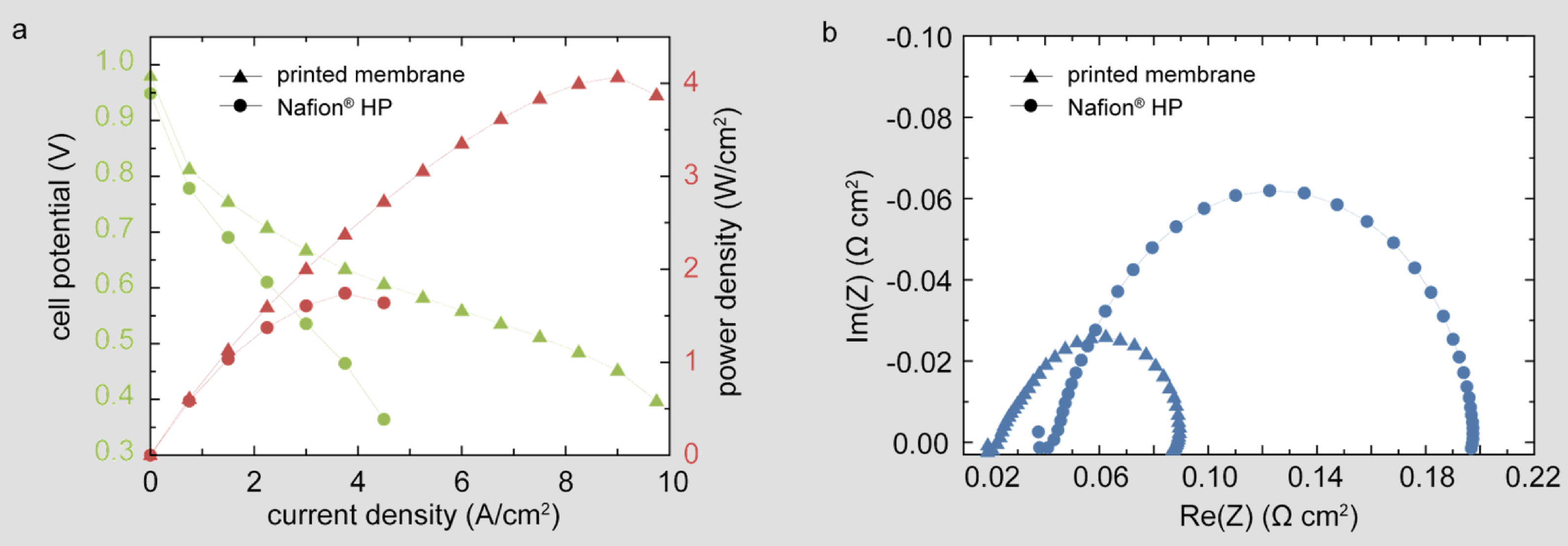
[2]FIT, University of Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg, Germany

Introduction

Previous work[1] has shown, that fuel cells with Direct Deposited Membranes (DDM) outperform conventional catalyst coated membranes (CCM) in terms of power density (see below). In this work we investigate two potential reasons for this: low thickness and good contact of the DDM ionomer and the electrode ionomer.

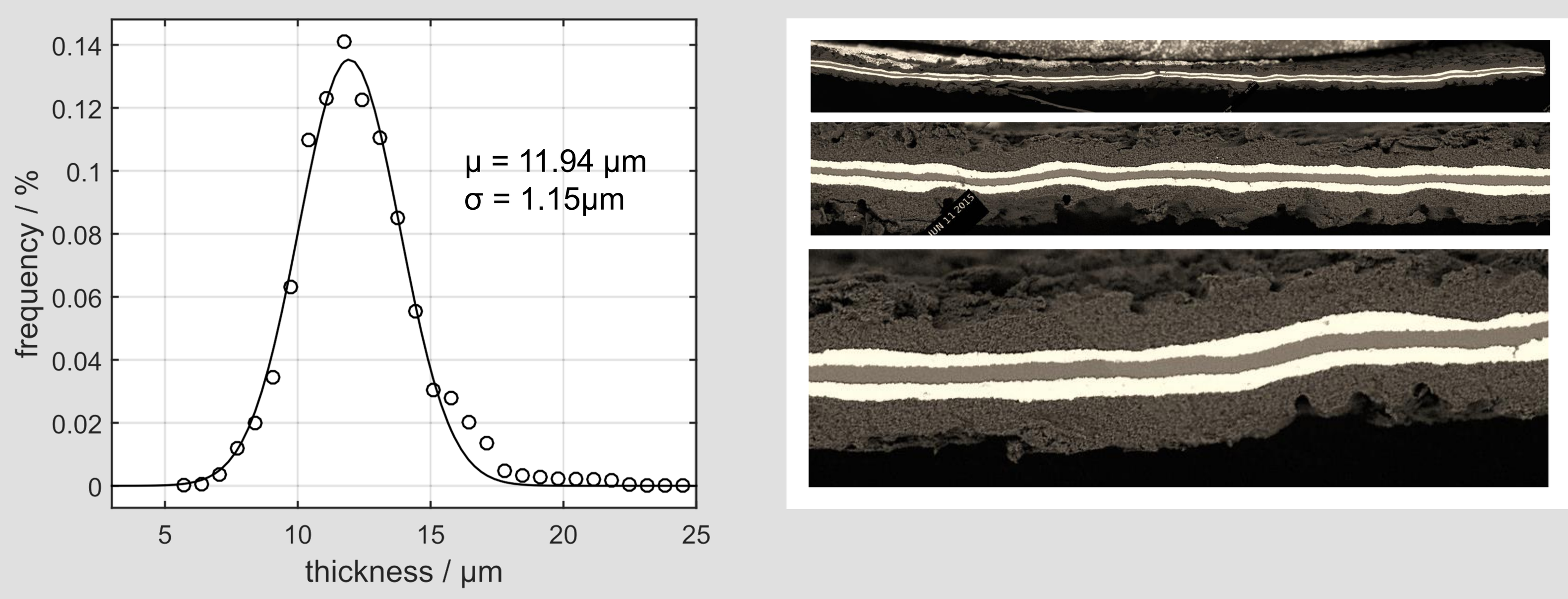


Schematic of a DDM: two GDEs coated with Nafion assembled with subgasket.



The **polarization curves** (a) and electrochemical **impedance spectroscopy** (EIS)-data (b) for the direct deposited membrane MEA and a commercial Nafion®HP based MEA (as reference) under optimized operation conditions (H_2/O_2; 0.5/0.5 L min1;70 C, 100% RH, 300/300 kPa). The loading of the catalyst layers of anode and cathode is 0.5 mg cm2 at 70% Pt/C. Both EIS measurements were conducted at a cell voltage of 0.75 V.

Membrane thickness: 12 µm



Thickness distribution and sample **stitched SEM images** of a DDM obtained by N_2-freeze fracturing.

Acknowledgements

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References

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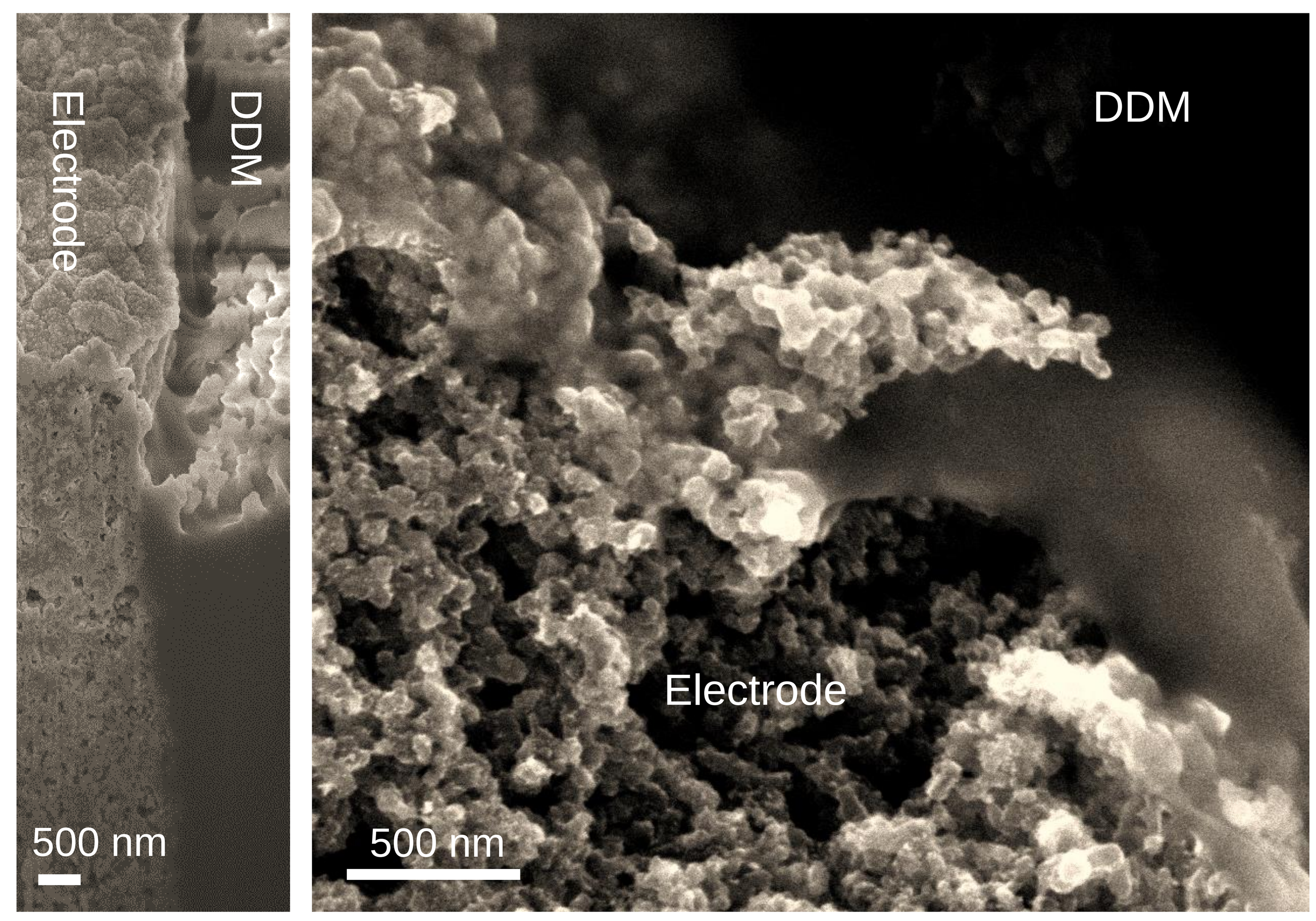
Membrane Electrode Interface

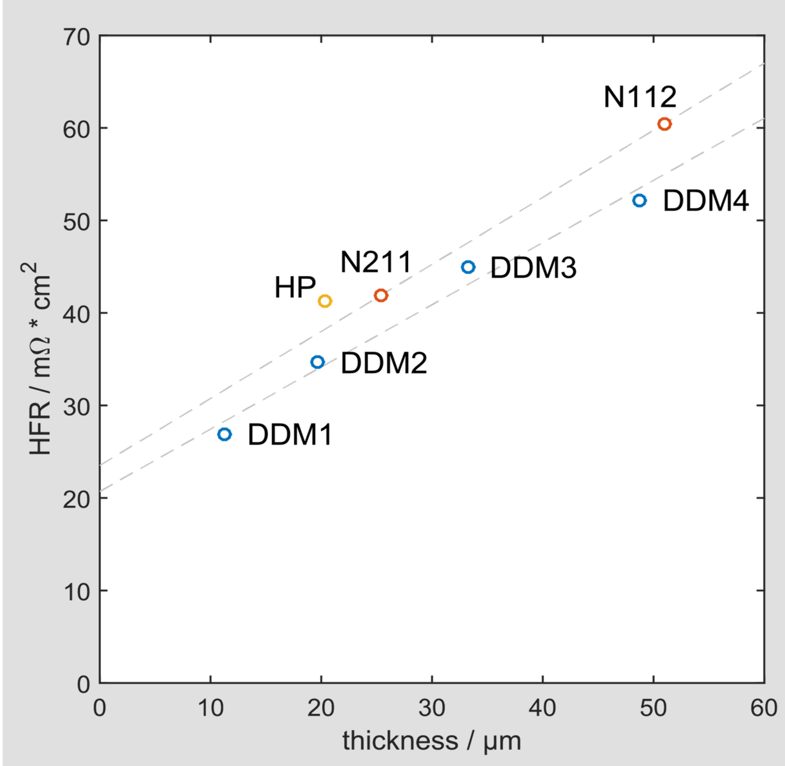


SEM images of membrane electrode interface obtained by ion milling (left) and N_2-freeze fracturing (right). Images indicate an intrusion depth of the DDM of 200nm (left) and show the good contact of the DDM ionomer and the CL ionomer (right).

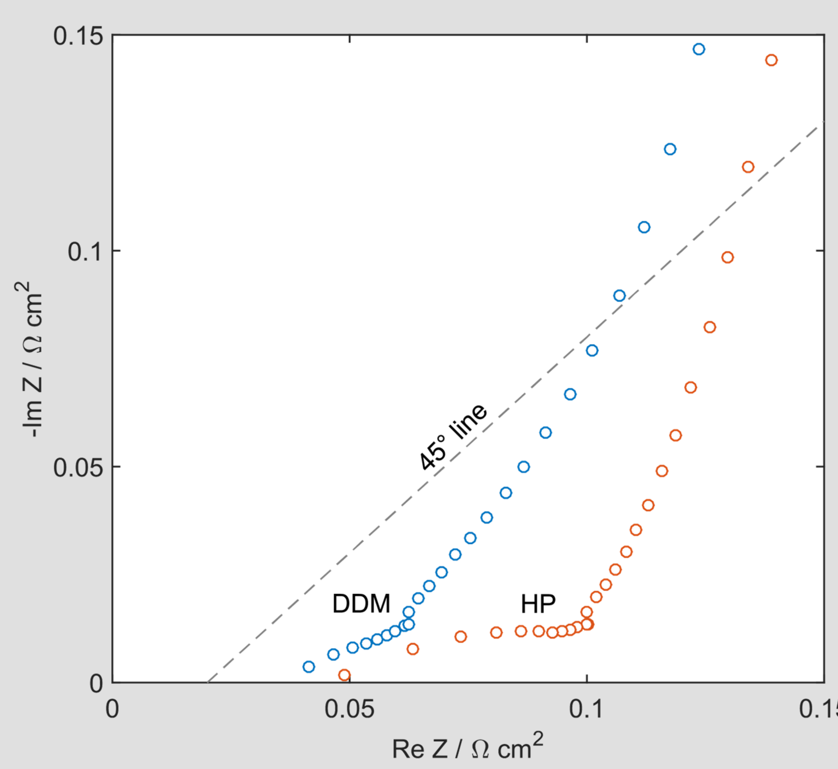
To measure the **High Frequency Resistance over membrane thickness**, GDEs (0.5mg Pt/cm²) were coated with 1-4 layers of Nafion D2020, DDM1-4 respectively, and assembled as depicted in the schematic resulting in membranes of 2-8 layers (11 – 48µm) thickness. CCMs (Nafion 112, 211 and HP) served as reference.

The slope of the DDMs and the references[a] correspond to the intrinsic Nafion conductivity (0.14 S/cm) as reported in the literature[2]. When extrapolated to zero thickness the DDMs exhibit a lower HFR than the references **indicating a better contact of the DDMs' ionomer** to the electrode ionomer.

[a] The Nafion HP was omitted due to its reinforcement and therefore lower conductivity.



High Frequency Resistance over thickness at 3.2kHz, 500mA cm², 80°C, 90% RH, air and 0 bar, thickness were obtained as described on the left.



H_2/N_2 impedance spectroscopy at 80°C, 100% RH, H_2/N_2, 0 bar. The 45°-line represents the ionic migration through the catalyst layer. [3]

Another way to quantify the ionic resistance of the electrode ionomer and the contact to the membrane ionomer is **H_2/N_2 impedance spectroscopy**[3].

Again the **DDM shows a lower resistance** than the reference, which is represented by the distance on the real axis from the high frequency intercept to the bend in the slope.