High power fuel cells with direct membrane deposition via ionomer spray-coating

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Introduction

In the recent work of Klingele et al.[1] direct membrane deposition (DMD) was introduced. Nafion® ionomer dispersion was inkjet-printed onto gas diffusion electrodes to fabricate proton exchange membranes for high power polymer electrolyte fuel cells (PEMFC). A schematic of a DMD fuel cell is shown in figure 1. DMD results in thin membrane layers (9-14 µm). This enables an overall membrane proton resistance as low as 12.7 mΩ*cm² leading to power densities exceeding 4 W/cm² with H_2/O_2 gas feed and 300/300 kPa_{abs}.

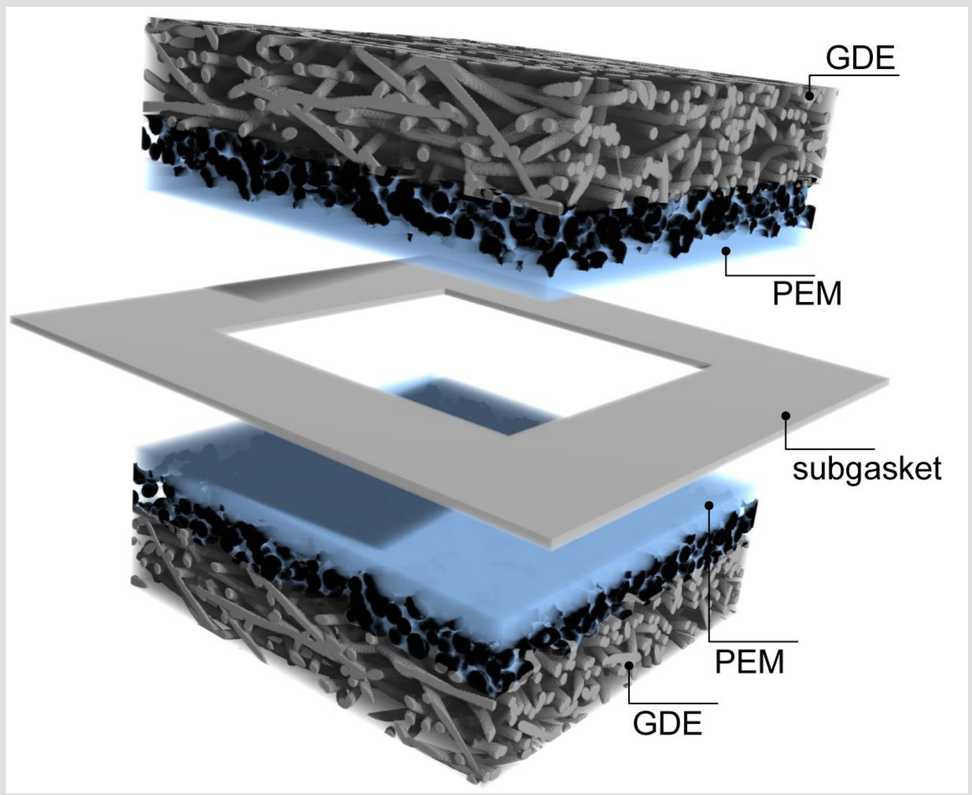

Figure 1: The polymer electrolyte membrane (PEM) is directly deposited on the gas diffusion electrodes (GDE). Anode and cathode side are isolated by a PTFE sub-gasket [1].

Results & Discussion

In this work the comparably slow deposition process inkjet-printing was substituted by spray-coating. A Sono-Tek spray-coating device with sonicated syringe pump was used to fabricate MEAs with directly deposited membrane (DDM).

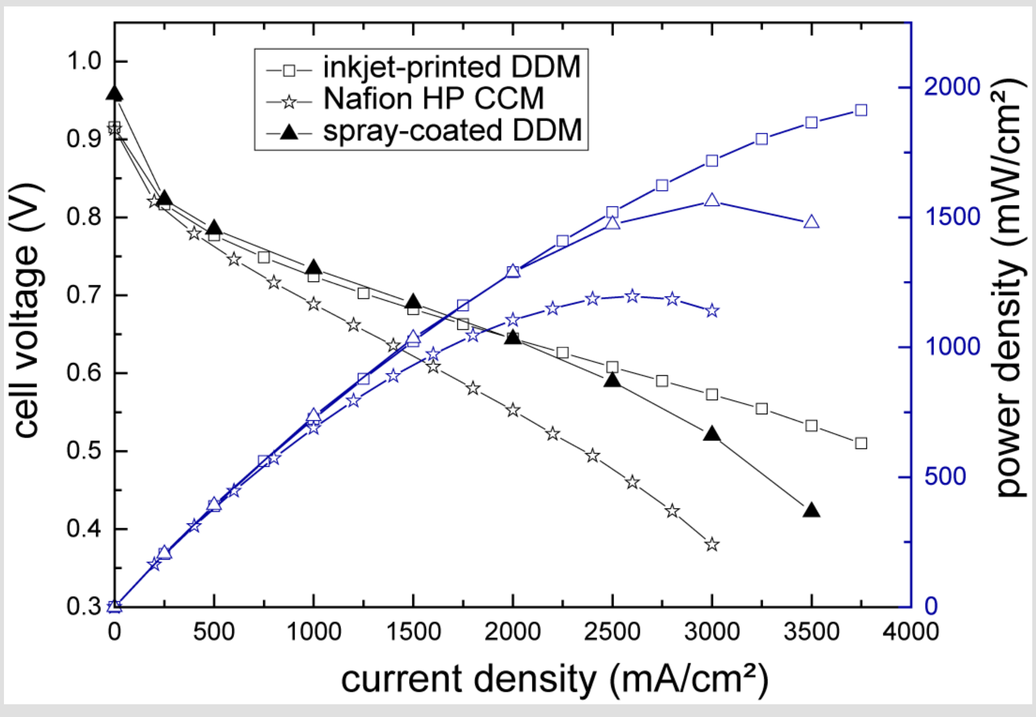

Figure 2: Spray-coated and inkjet-printed directly deposited membranes (DDM) show higher performance than a conventionally catalyst coated Nafion® HP membrane (CCM) with identical Pt-loading of 0.5 mg/cm² on anode and cathode side. The operation conditions were: 0.25/0.5 l/min H_2/O_2, 95 % RH, atmospheric pressure.

With DMD we obtain significantly higher cell performances compared to a reference fuel cell with a 20 µm thin Nafion® HP CCM as shown in figure 2. All cells were assembled using electrodes with identical Pt-loading (0.5 mg/cm²). Even though the power density is still inferior to an inkjet-printed cell, this gives a promising perspective to this MEA fabrication technique to produce MEAs cheaper, faster and with higher performance. As depicted in figure 3 one could imagine a strongly facilitated workflow compared to state of the art MEA production lines. Micro porous layer, catalyst layer and PEM could be deposited subsequently within one single spray coating device. Finally the two “half cells” could be assembled with the sealing sub-gasket to obtain an entire PEMFC. Since spray-coating of porous carbon layers is an established technique with high deposition rates this strongly facilitates an MEA mass fabrication line.

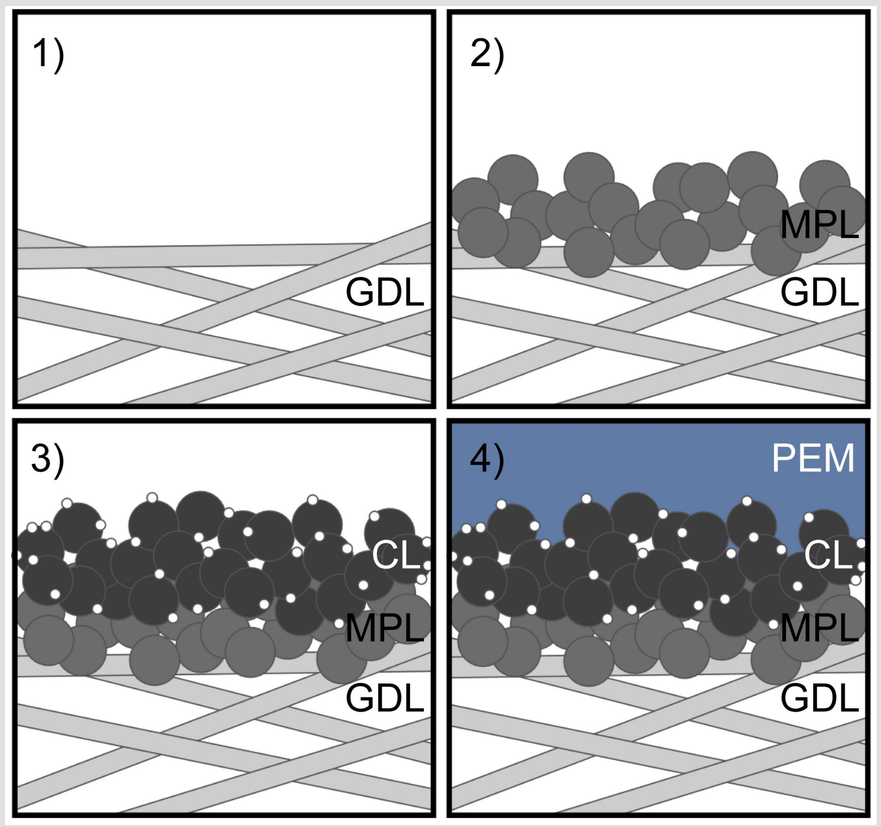

Figure 3: possible workflow for a fully spray-coated MEA: 1) GDL-substrate, 2) MPL deposition, 3) CL deposition, 4) direct membrane deposition.

Conclusion

The concept of direct membrane deposition is successfully transferred to spray coating which is a high throughput manufacturing approach. This may open up the way for a cheap and fast MEA production line, where micro porous layer, catalyst layer and PEM can be produced subsequently within one single device.

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References

[1] Klingele, M., Breitwieser, M., Zengerle, R., & Thiele, S. (2015), *Journal of Materials Chemistry A*, *3*(21), 11239-11245.