Polymer Electrolyte Fuel Cells Fabricated with Direct Membrane Deposition (DMD)

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In the "Direct Membrane Deposition" (DMD) approach for polymer electrolyte fuel cells the conventional catalyst coated membrane (CCM) is replaced by two gas diffusion electrodes (GDE) coated with ionomer. Assembling the ionomer-coated GDEs creates a fuel cell with a very thin membrane (12 µm) and improved ionic contact of membrane and electrodes. Fuel cells fabricated with DMD therefore showed peak power densities of 4 W/cm² at 70°C, 300 kPa and with oxygen as fuel exceeding the peak power density of the Nafion HP reference fuel cell by a factor of 2 [1]. Despite the thin membrane DMD fuel cells showed no increased hydrogen crossover (< 2 mA/cm²). Furthermore, DMD fuel cells reached a power density of more than 1 W/cm² even under very dry conditions (zero gas humidification) and with air at the cathode. This is possible due to the strong back diffusion of water through the thin membrane, visualized with in-situ neutron radiographies [2].
In a second work we demonstrated a record Pt-utilization efficiency of 88 kW/g_{Pt} of a DMD fuel cell with low Pt-loaded electrodes (anode/cathode 0.029 mg_{Pt}/cm^2) at 80°C, 300 kPa and with oxygen as fuel [3]. The DMD approach also proved its suitability for medium temperature fuel cells: by incorporating TiO_2 nanoparticles into the directly deposited membrane the fuel cell showed stable operation at 120°C with a power density of 2 W/cm² (300 kPa and oxygen at the cathode) [4]. Extensive electrochemical characterization showed that fuel cells fabricated with DMD have an ionic resistance and a mass transport resistance half that of reference fuel cells with CCMs at high current densities. Impedance spectroscopy revealed that the reduction of mass transport losses is responsible for the major part of the improvement in power density. Besides the increased power density, DMD bears the potential to simplify the fabrication process of fuel cells by successively spray-coating all layers including the membrane onto a gas-diffusion-layer [5].
This talk provides an overview of the DMD activities, its future potential and gives detailed insight into the underlying reasons for the increased power density of DMD fuel cells.

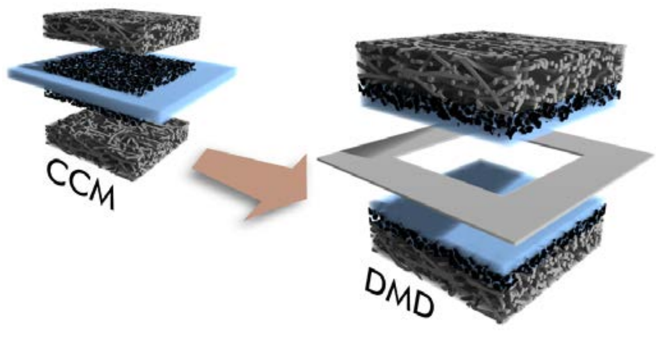

Fig. 1 Conventional catalyst coated membranes (CCM) with gas diffusion layers are replaced by gas diffusion electrodes with direct membrane deposition (DMD) assembled with a subgasket. Taken from [1] - Published by The Royal Society of Chemistry.