A novel microfluidic PEM water electrolyzer cell for the study of counter-current two-phase flow at the anode side

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Abstract

Driven by the aims to drastically reduce CO_2 emissions in several different sectors within the next decades, such as in the transport or the industrial production sectors, the substitution of fossil fuels by "green" hydrogen is widely considered. The hydrogen is "green" when it is produced emission-free and based on the use of renewable energy sources. Electrochemical splitting of water inside polymer electrolyte membrane water electrolyzers (PEMWEs) is one possibility for efficient and sustained production of "green" hydrogen. However, its efficiency is still limited by the coupled kinetics of flow and reaction that occur at the anodic side of the PEMWEs. Especially the microstructure inside the anodic porous transport layer (PTL) plays a major role for the counter-current transport of the feedstock water and the product oxygen.

In this work, a prototype model of a microfluidic PEMWE cell was tested with the purpose to experimentally examine the two-phase flow in the anodic PTL (**Fig. 1**). The cell is made of transparent PMMA (Poly-Methyl-Methacrylate) in order to allow monitoring of the fluid flow. The anodic PTL is represented by a quasi 2D pore network with distributed pore sizes, similarly as in previous work [1, 2]. However, in contrast to previous works, the microfluidic device is realized as a full electrochemical cell. Thus, the gas phase is not injected at a discrete point, but generated at an electrically activated catalyst coated membrane with iridium oxide on the anode side and carbon supported platinum on the cathode side. Platinum meshes were used as current collectors on both sides.

The microfluidic electrochemical cell is used to study the correlation of gas-liquid invasion patterns in dependence of the pore network structure as well as of the applied current densities and stoichiometry of flow rates. In contrast to more advanced measurements like operando neutron imaging [3], the simplified quasi 2D structure allows to study the invasion profiles directly. In addition to that, very good comparison of the experimentally recorded profiles to simulation results, e.g. from Lattice Boltzmann simulation [4], is given.

Keywords: PEMWE; microfluidic cell; anodic porous transport layer (PTL); counter-current transport; invasion regimes; current density; pore-scale physics.

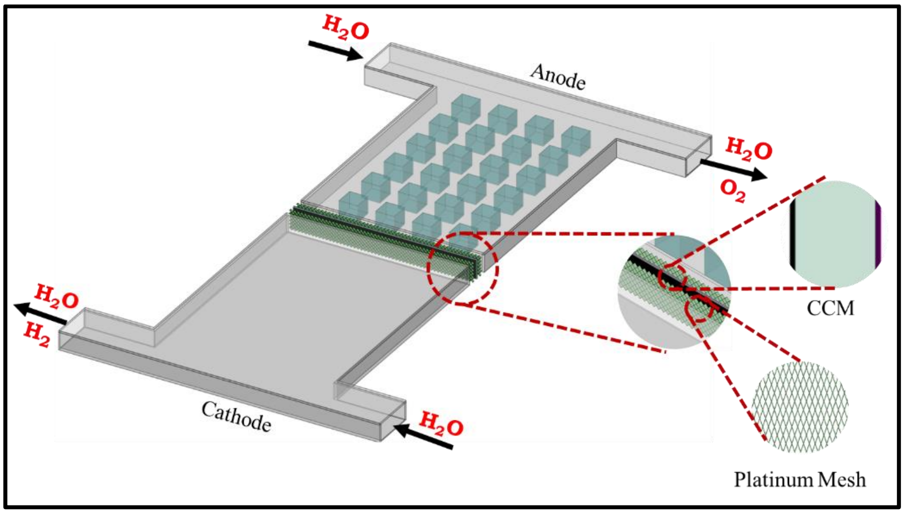

Figure 1: Schematic representation of PEMWE cell

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