Membrane Electrode Assembly development for High Temperature Polymer Electrolyte Membrane Fuel Cell

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Introduction
Fuel cells offer a high efficient solution for reducing harmful emissions for decentralized small scale electricity and heat generation. High temperature polymer electrolyte membrane fuel cells (HT-PEMFCs) are a suitable technology of clean power production for several applications due to the operating temperature of approximately 160 °C. The advantages of HT-PEMFCs include the inexpensive electrolyte system, the simple system structure and the direct usage of reformed hydrocarbons without the requirement of a new hydrogen infrastructure. To reach successfull commercialization, a significant cost reduction will be achieved by lowering the catalyst loading based on understanding the fundamental electrochemical reactions in fuel cells and by lowering production cost by improving and simplifying the manufacturing process of the membrane electrode assembly (MEA).

Goals of MEA Power project
Development of active platinum transition metal catalysts for an economic (<€ 0.60/cm^2) and long term stable (>80,000 h) MEA:
- Cost reduction by reducing platinum loading
- Functionalization of catalysts
- Enhancement of catalytic activity and stability

a) Precursor 1
b) Precursor 2

Fig. 1: a) Alternative deposition methods established to synthesize active catalyst nanoparticles
b) Laboratory activity and stability analysis of catalysts c) Fabrication of the MEA [TU Graz, Elcore].

COMPUTATIONAL DEVELOPMENT
Optimization of geometry and operating conditions via simulation with regard to minimize degradation:
- Find optimal flow field configuration
- Find suitable operating range
- Special focus on membrane and phosphoric acid transport

More dimensional stack simulation of HT-PEMFC:
- AVL software tools for 3D/10/0D CFD simulation
- Hybrid Analytical Numerical (HAN) simulation
- 1D numerical + 2D analytical = 3D approach (HAN)
- Real time computation
- Coupling of HAN simulation approach with AVL 3D CFD

Fig. 2: 3D-CFD simulation results to identify and localize degradation mechanisms under specific operating conditions [AVL].

Fig. 3: Comparison of HAN (dots) and 3D-CFD (line) results (blue indicates parameters under the channel and orange under the rib) [UL].

HT-PEMFCs application

Fig.4: Elcore 2400 – the most compact and efficient fuel cell µ-CHP (combined heat and power) system for single family homes [elcore].

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