Summary

For special applications Direct Methanol Fuel Cells (DMFC) are close to commercial application or already commercialized today. However for the step from laboratory to a broader market of fuel cells, a significant cost reduction, as well as an improvement in life time and power density of the systems is needed. These items were the focus of the project BZ-BattExt, to be reached by new knowledge in alternative materials, operation strategies as also the realisation of enhanced sub systems.

In the project a 100 W DMFC compact system as battery extender is sucessfully developed and operated. The reduction of the number of components and the simplification of the system make possible a high reduction of price, weight and volume. The feasibility of a micro-DMFC system was evaluated which enables a minimised system periphery due to an improved system architecture. For this, alternative materials and functional components were developed and investigated. New membranes with reduced water and methanol permeation allow operation at low air stoichiometry and favourable system efficiency. Gas diffusion layers of various compositions were tested and optimised material was selected. New sealing materials with good methanol stability and optimized processibility in commercial production process were developed. MEA preparation was adapted to the new materials. The use of a simple, cost-effective way of stack production was demonstrated for DMFC use. The investigation and construction of enhanced subsystems and operation strategies, which enable and optimise the use of new components and materials, as also the realisation of the micro-DMFC system is a focus of the project. The technical feasibility of the results is investigated in the application, which means it is tested as battery extender of a solar boat. The DMFC fuel cell system serves as a basis for an efficient, compact and cost

need for research	advantages for application	project targets
• less complexity • less auxiliary power • cost reduction • control algorythm • power density (MEA) • operational reliability • availability	• range extension 20-50% • whole day use (10 h) • no grid dependency (charging batteries) • supply guarantee (partial load) • prevention of total discharge • „emission free“ • marketing tool	• alternative membrane • optimised MEA • optimised stackdesign • less components • simplified electronic • cost reduction • enhanced efficiency

Project Structure

Uni Stuttgart, ICVT
R/D Membrane

DLR - Institute of Technical Thermodynamics
MEA:
• R/D
• test/characterisation
• manufacturing
• flowfield
• test/characterisation
• BoP
• lab-system
• test/characterisation
• demonstrator

membrane-development ↔ **MEA-development** ↔ **stack-development** ↔ **system-development** ↔ **application**

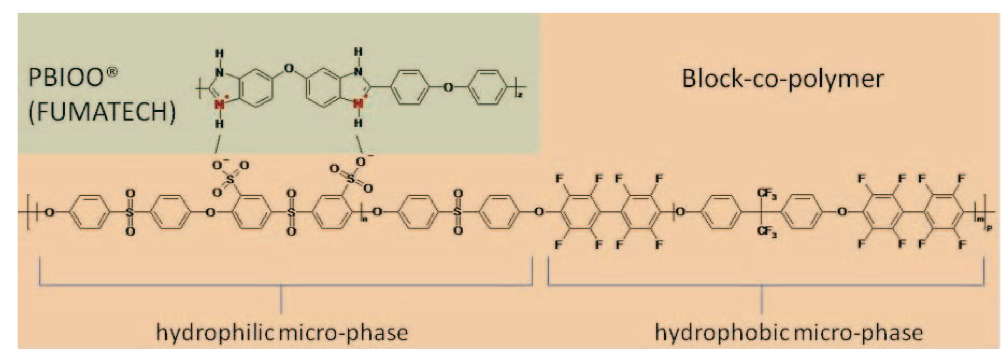
Freudenberg FCCT KG
GDL- development
GDL-supply
integrated sealing

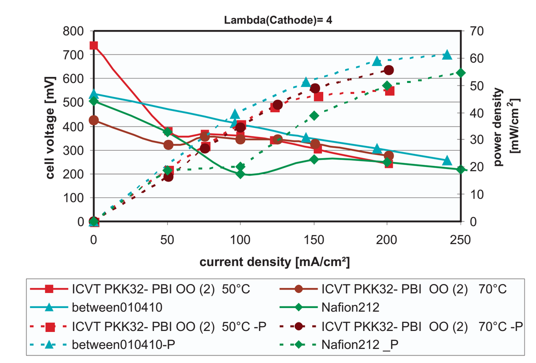
Kopf Solarschiff GmbH
requirements, integration
battery interface, field test,
evaluation

Between Lizenz GmbH
R/D Membrane
membrane
manufacturing

UBzM / Staxon
bipolarplates, short stacks
stack for demonstrator

Membrane Development





Structure of ICVT block co-polymer membrane

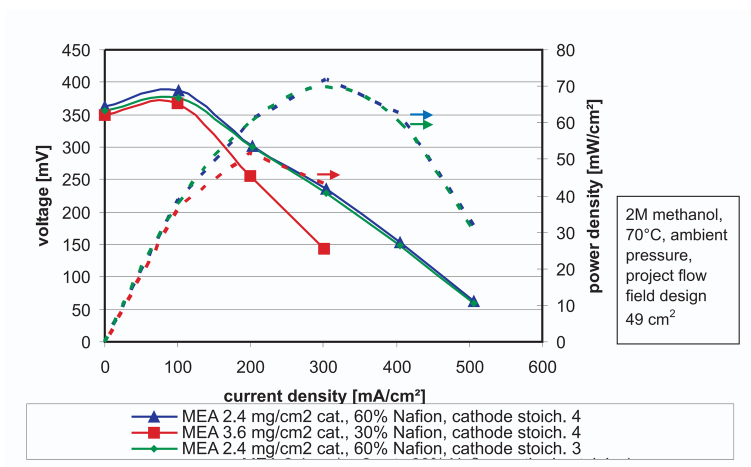
new materials for block-co-polymer blend membranes

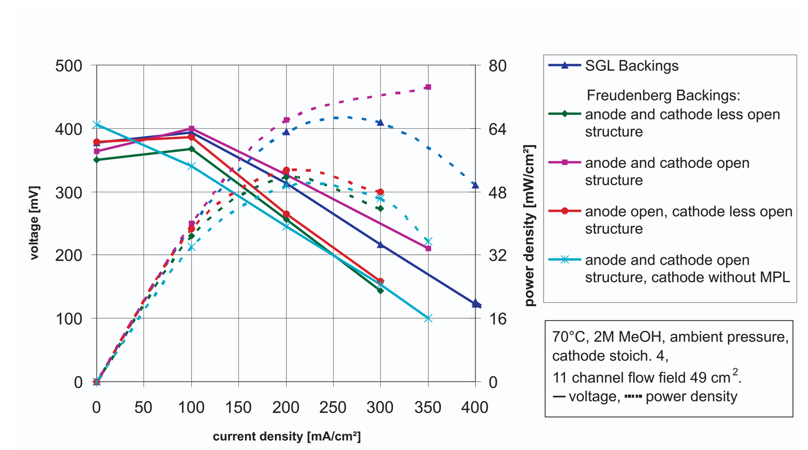
Phase-separation of block-co-polymers into hydrophilic and hydrophobic domains increases proton conductivity and reduces methanol permeability. Ionical-crosslinking of acidic block-co-polymers with basic polybenzimidazole (PBIOO®) stabilizes the phase-separated morphology and ensures a stable membrane performance.

• performance of „ICVT“- and „between“ membranes in U(i)-curves comparable to Nafion
• methanol permeation reduced
• water permeation reduced
• cells can be run at lower air stoichiometry or higher methanol concentration
• cost-efficient alternative to Nafion

MEA Development

• MEA development for 50-70°C, low air stoichiometry, ambient pressure
• DLR dry spraying technology avoiding use of solvents
• selection of optimised GDL
• optimisation of reaction layer composition
• reduction of catalyst loading to 2.4 mg/cm^2 total MEA





U(i)-curves for MEAs of varying composition, prepared at DLR, Nafion membrane.
left: variation Nafion content and catalyst loading in reaction layer; right: variation backings

Stack/Sealing Development

option A

• successful stack development of 120W and 30W stacks demonstrated
• stack with project flow field design
• alternative sealing concept
• „rapid prototyping“
• cost efficient
• commercially available technique
• 40 cell stack with > 100 W demonstrated
• commercial MEAs used
• extension to 50-70 cells is feasible

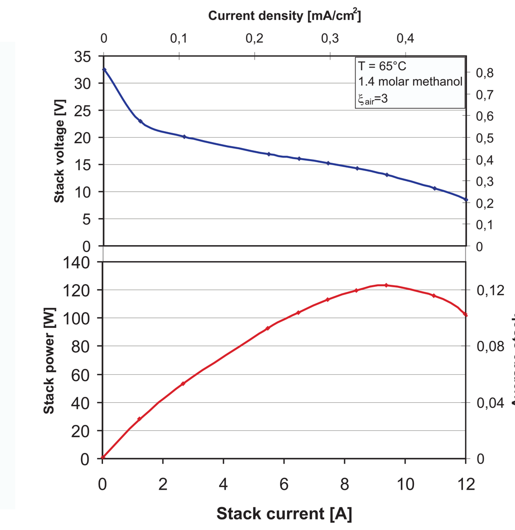
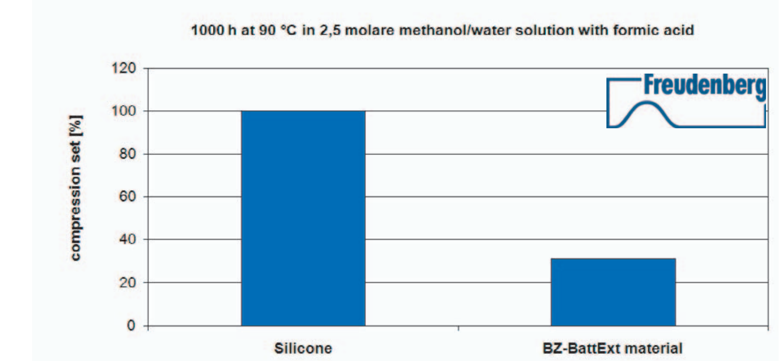
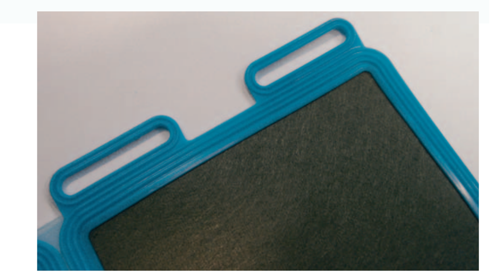


Photo and U(i)-curve of project stack prototype III,
40 cells, active area 1000 cm^2, 1680g, 190x128x52 mm^3

option B

Within the project Freudenberg FCCT has developed a new stack sealing material on a polyolefin basis with improved stability in the DMFC environment (see picture right top). It has been demonstrated that the production of this material is reproducible and that it is processable using an injection moulding process. A stack sealing design for a conventional type stack was developed. An integrated sealing on the gas diffusion layers has been realized using cold runner technology (see picture right bottom). This „Fast GDL“ concept allows a simplified cell assembling.





System Development

• 100 W demonstrator system developed
• compact system: 8 kg without methanol, size 49x21x51 cm
• high power density (430 Wh/kg with 5 l tank), consumption 0.9 l/kWh
• subsystems developed, number of components minimised,
• auxiliary power approx. 20 W, high efficiency total η=25%
• simple operation (on/off)
• integrated micro control
• Sensor-free methanol concentration control
• Water recovery from cathode exit without active cooling

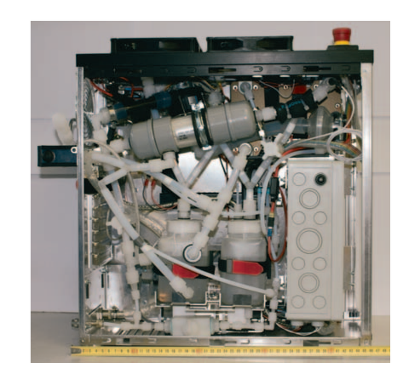
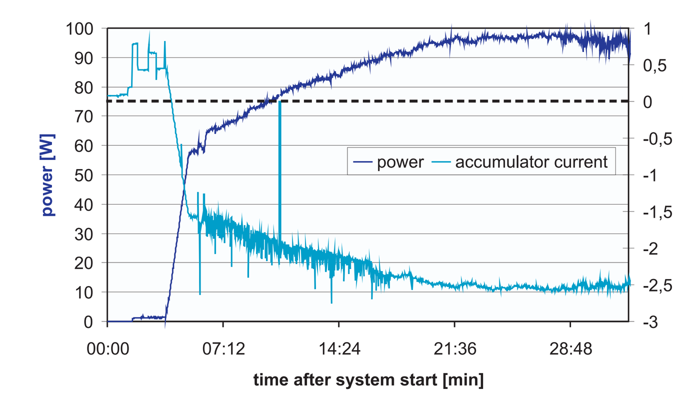


Photo of compact system



Behavior of the compact DMFC system during start-up

Boat Integration

• restyling of boat-hull under hydrodynamic aspects
• modification of boat design
• integration of fuel cell
• hybridization fuel cell/batterie
• stability calculation of boat-hull, verification from accredited laboratory
• increase of cruising range and time of operation by approx. 30 %

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Förderkennzeichen: BMBF Projekt 03X3512