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Combined Local Current Distribution Measurements and High Resolution Neutron Radiography of Operating Direct Methanol Fuel Cells

Alexander Schröder, Klaus Wippermann

Institute of Energy Research (IEF-3)
Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

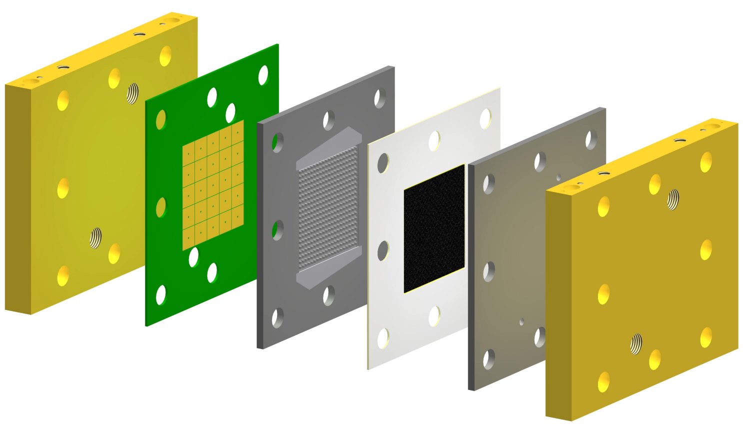
Outline

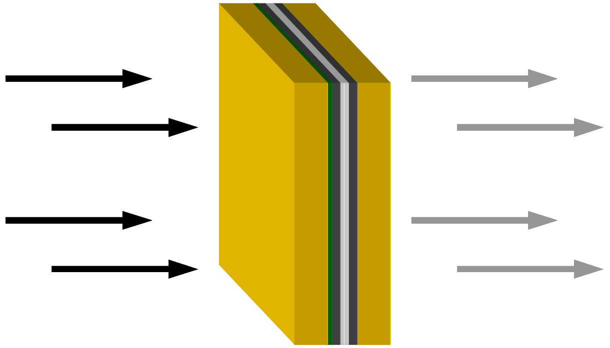
- Introduction
- Influence of Current Density
- Bi-functional Operation
- Hydrophobicity of GDL
- Conclusion

Strategy

Diagnostics of
local fluid and current distribution by

Segmented Cell Technology and **Neutron Radiography**

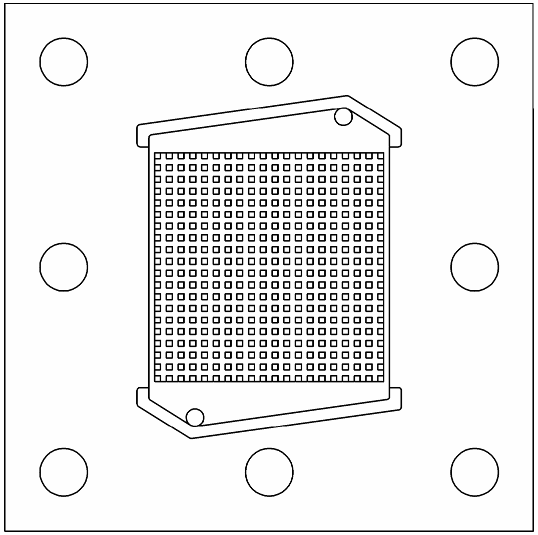




Target:
Systematic optimization of cell components and operating conditions

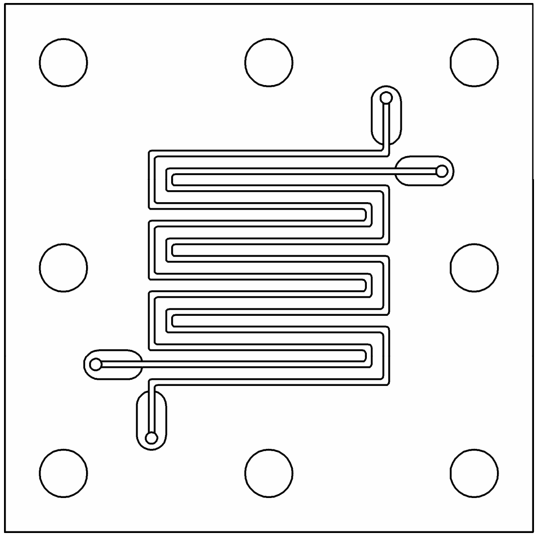
Flow Field Geometries

Anode and cathode axially symmetrical



Grid structure

Anode and cathode axially symmetrical



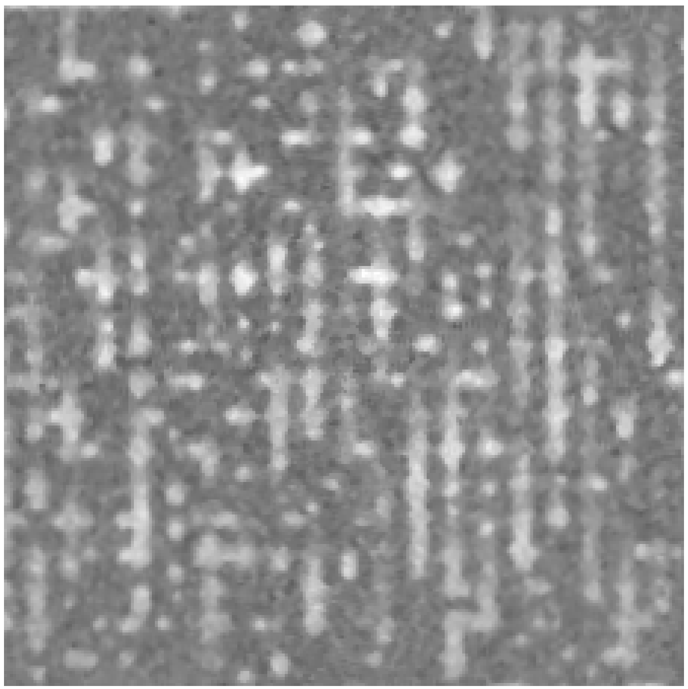
Twofold meander

Dimensions:	Graphite plate:	90 mm × 90 mm × 3 mm
	Channel width:	1.0 mm
	Active area:	4.2 cm × 4.2 cm

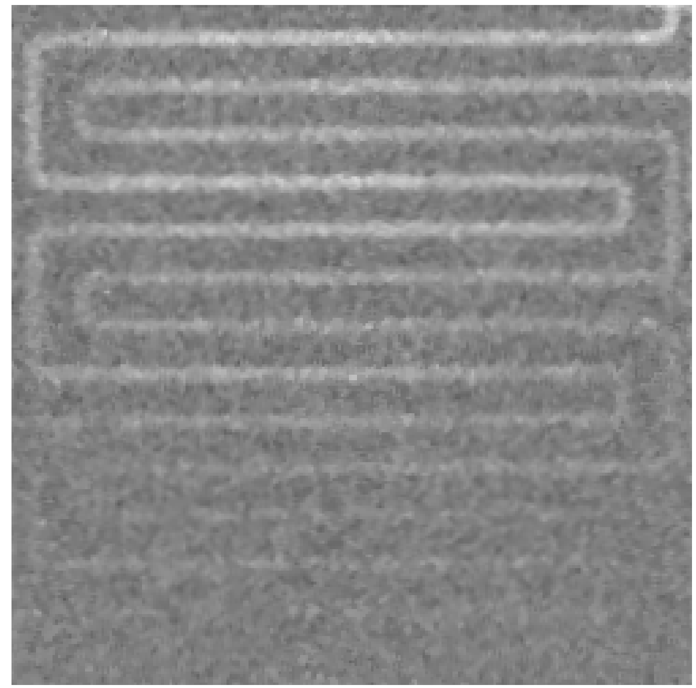
Variation of Current Density

Average current density: 50 mA/cm^2

Grid structure flow field



Twofold meander flow field

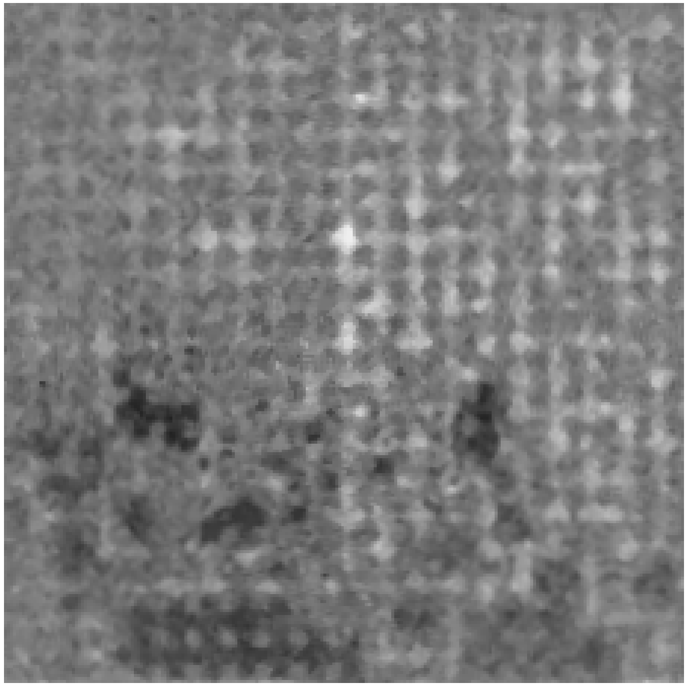


Temperature: 70 °C λ_{Air}: 24 $\lambda_{Methanol}$: 24

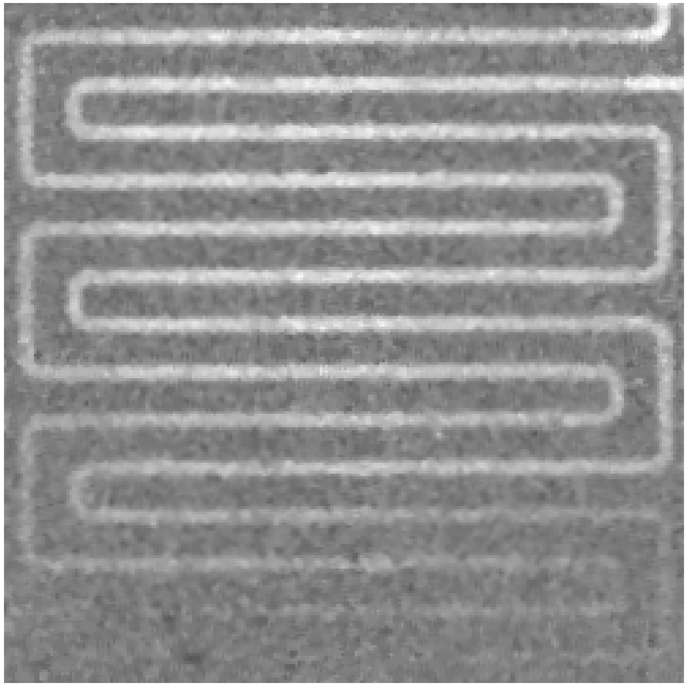
Variation of Current Density

Average current density: 150 mA/cm^2

Grid structure flow field



Twofold meander flow field

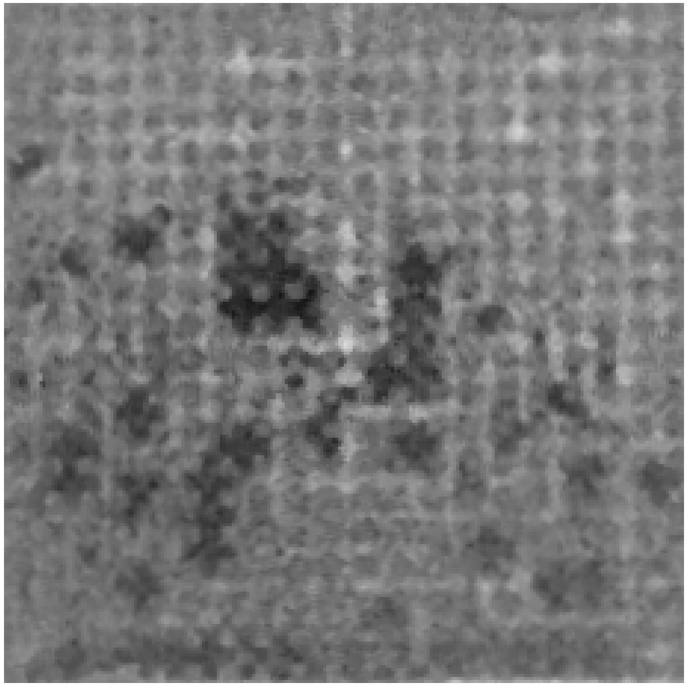


Temperature: 70 ℃ λ_{Air}: 8 $\lambda_{Methanol}$: 8

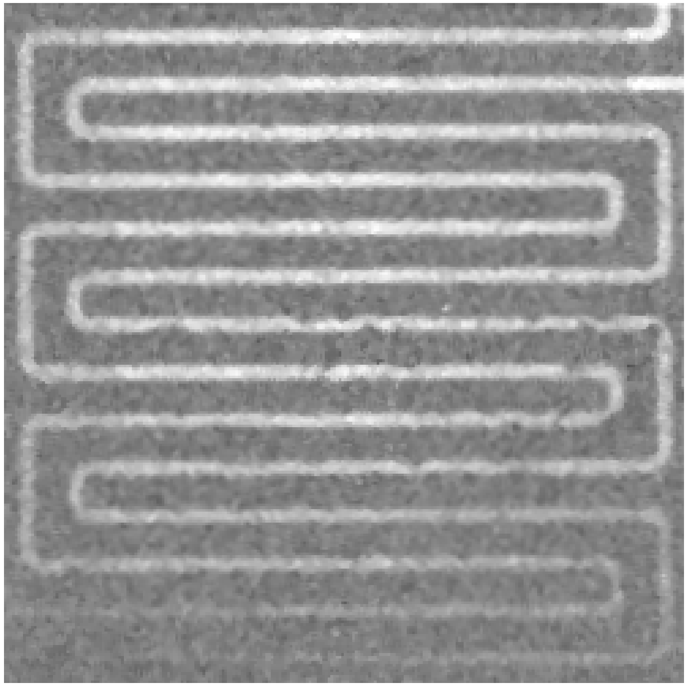
Variation of Current Density

Average current density: 300 mA/cm²

Grid structure flow field



Twofold meander flow field

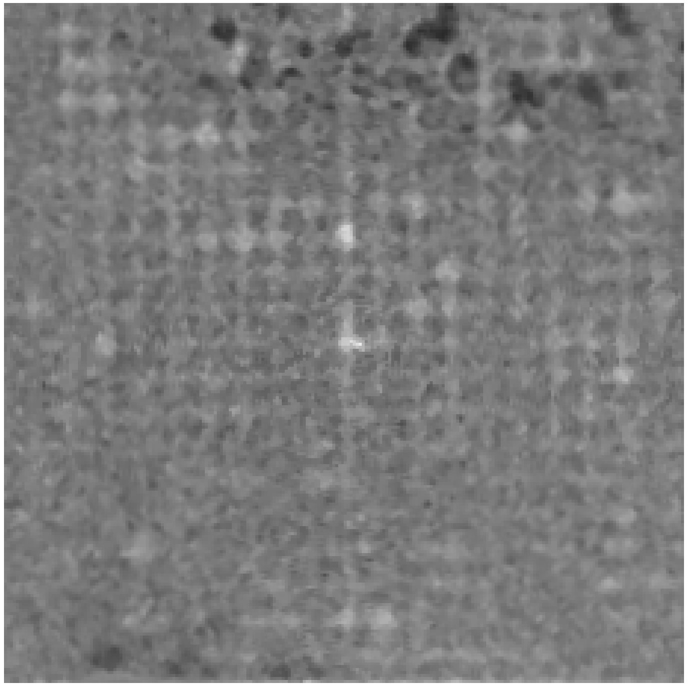


Temperature: 70 ℃ λ_{Air}: 4 $\lambda_{Methanol}$: 4

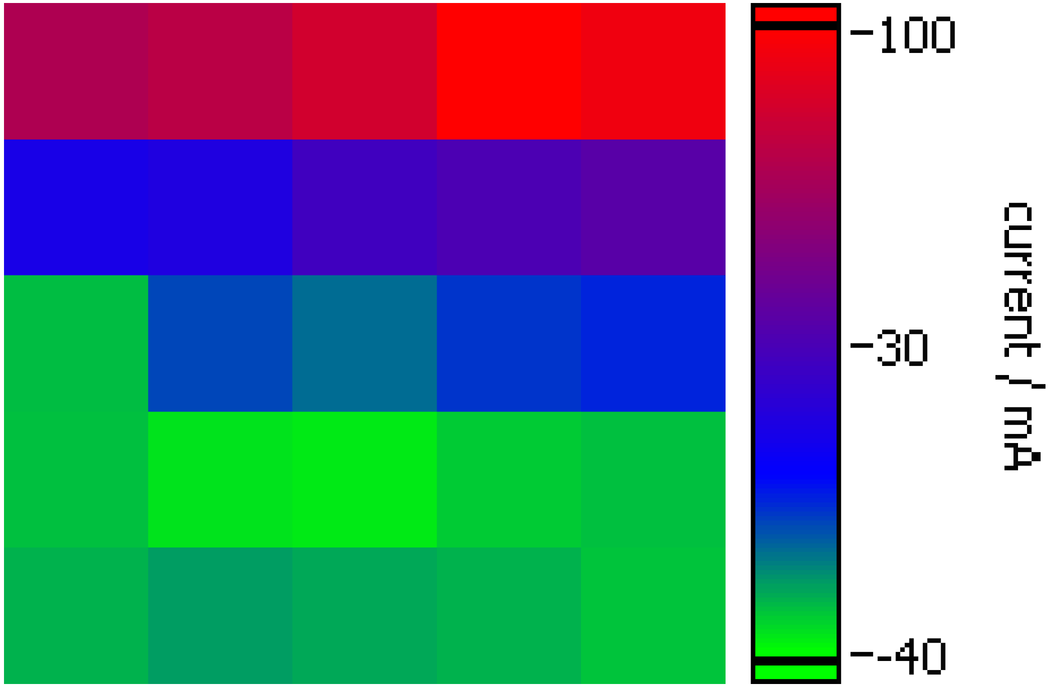
Bi-functional Operation

Average current density: 10 mA/cm²

Grid structure flow field



Corresponding current distribution

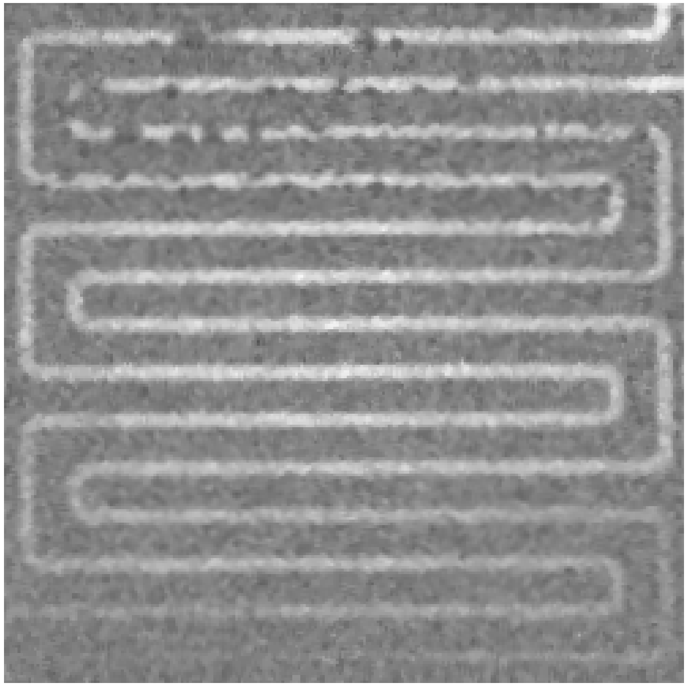


Temperature: 70 ℃ λ_{Air}: 6 $\lambda_{Methanol}$: 140

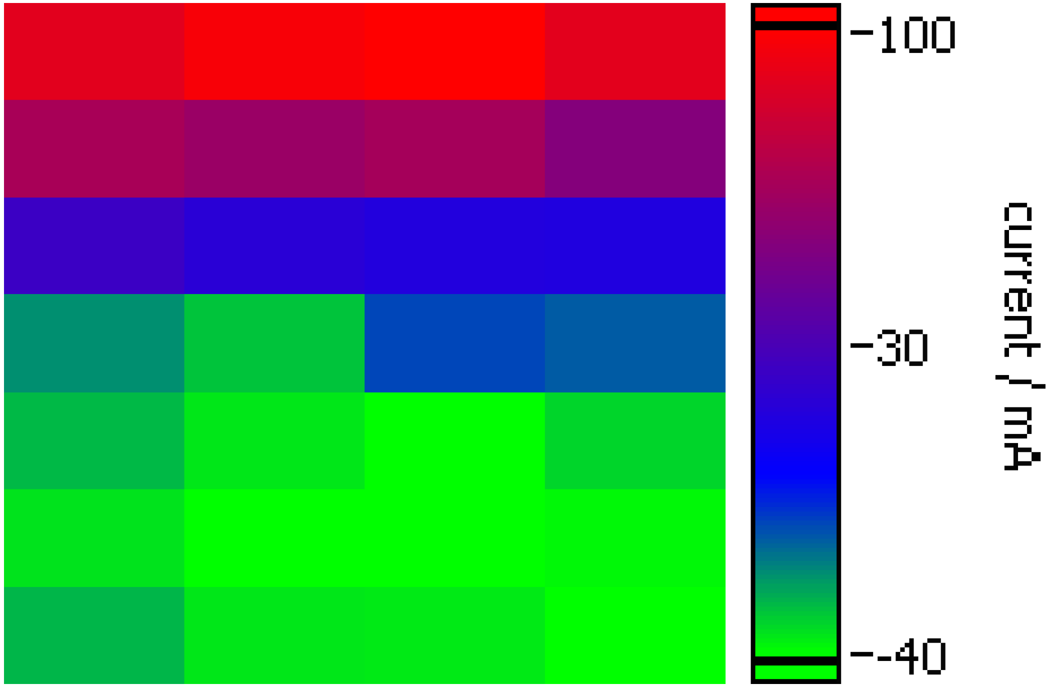
Bi-functional Operation

Average current density: 10 mA/cm²

Twofold meander flow field



Corresponding current distribution

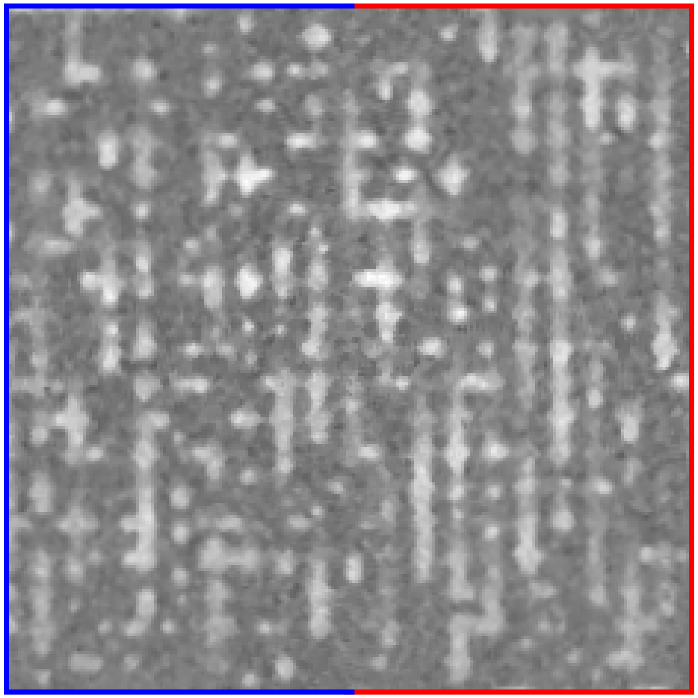


Temperature: 70 °C λ_{Air}: 6 $\lambda_{Methanol}$: 140

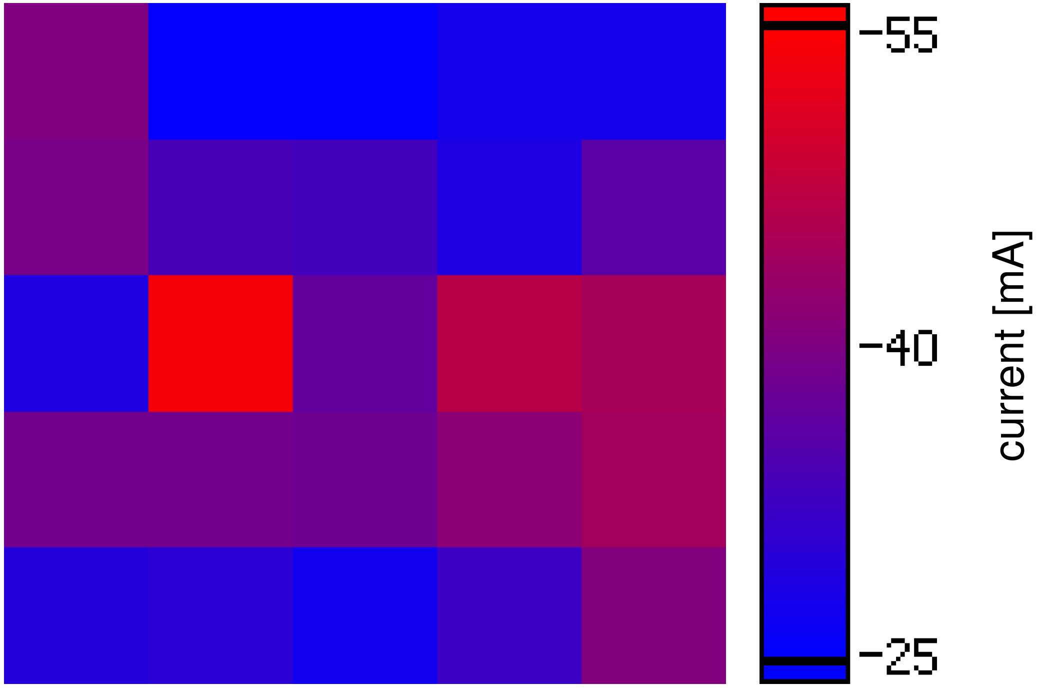
Hydrophobicity of Anode GDL

Operating Conditions: 70 °C, 50 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 24$

Neutron radiograph



Current distribution



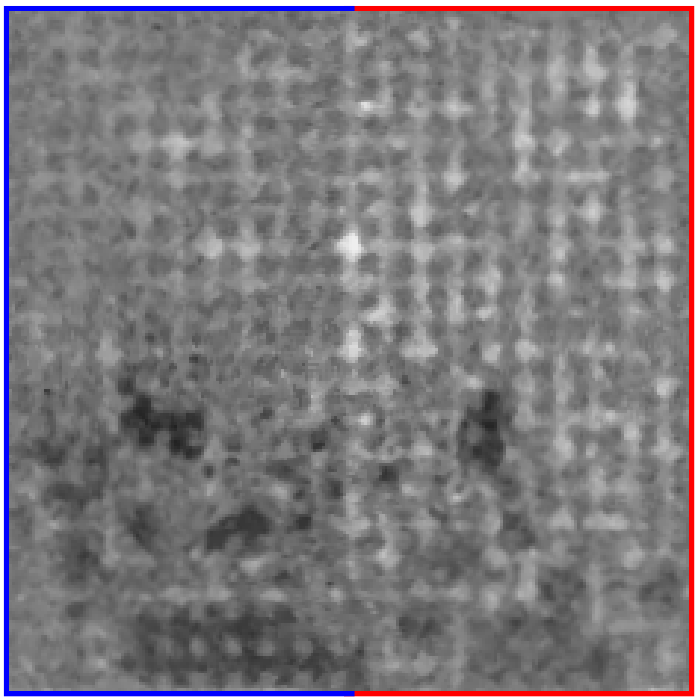
Negligible effect of anode cloth hydrophobicity

(Power generation: **49 %** left partition, **51 %** right partition)

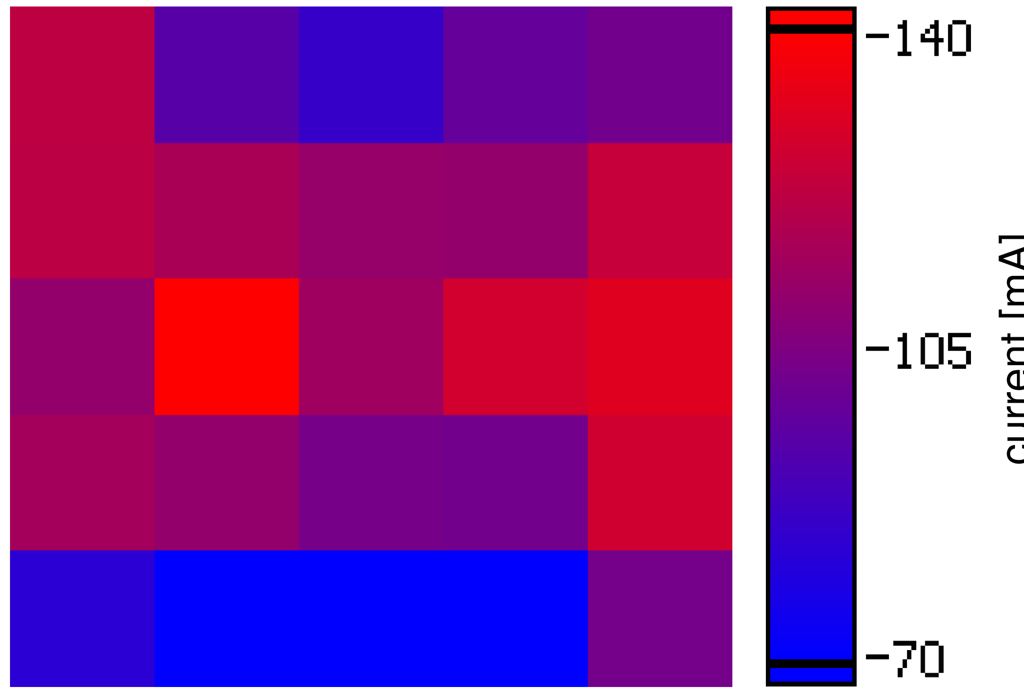
Hydrophobicity of Anode GDL

Operating Conditions : 70 ℃, 150 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 8$

Neutron radiograph



Current distribution



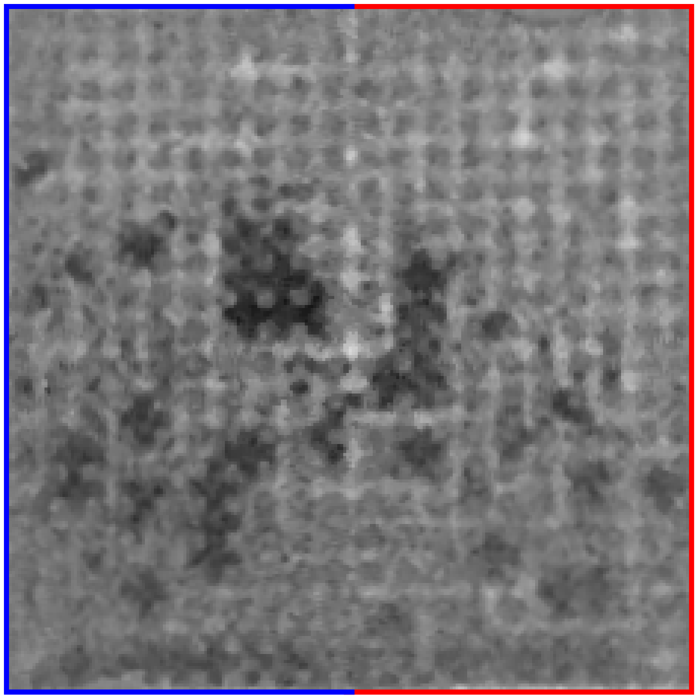
Negligible effect of anode cloth hydrophobicity

(Power generation: **49 %** left partition, **51 %** right partition)

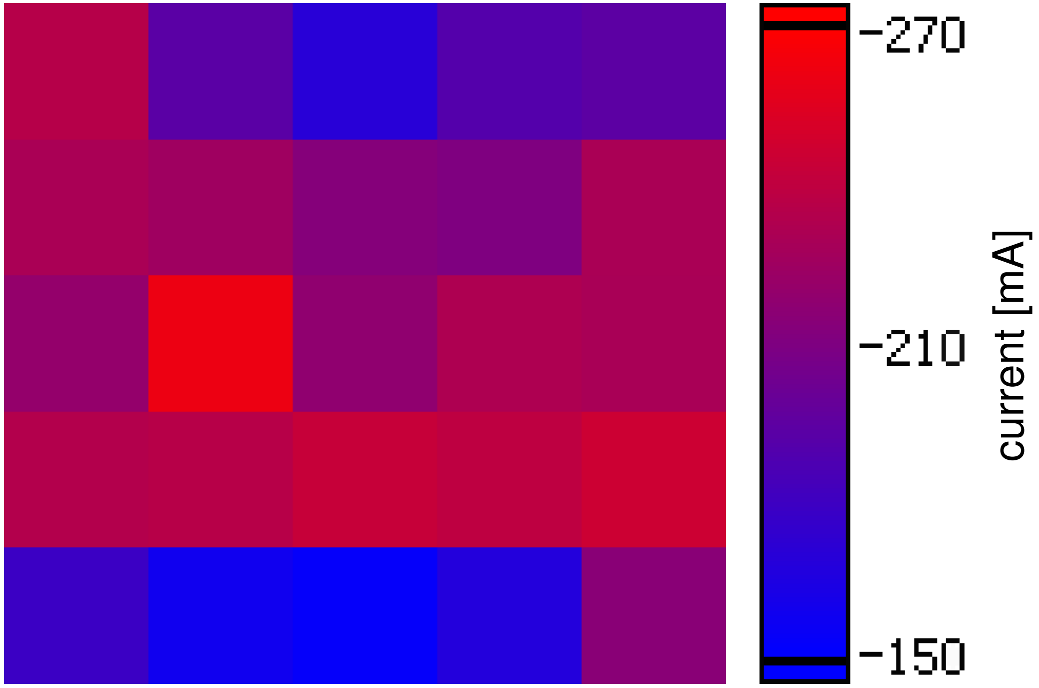
Hydrophobicity of Anode GDL

Operating Conditions : 70 °C, 300 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 4$

Neutron radiograph



Current distribution



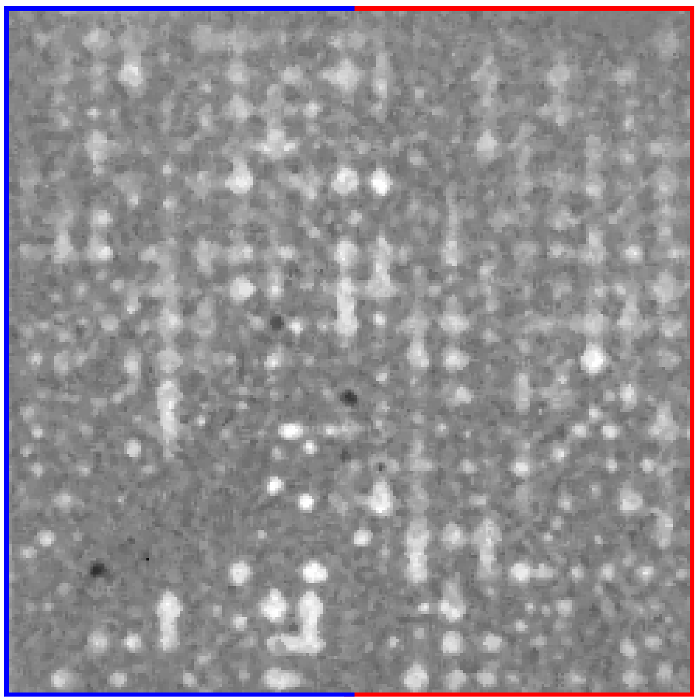
Negligible effect of anode cloth hydrophobicity

(Power generation: **50 %** left partition, **50 %** right partition)

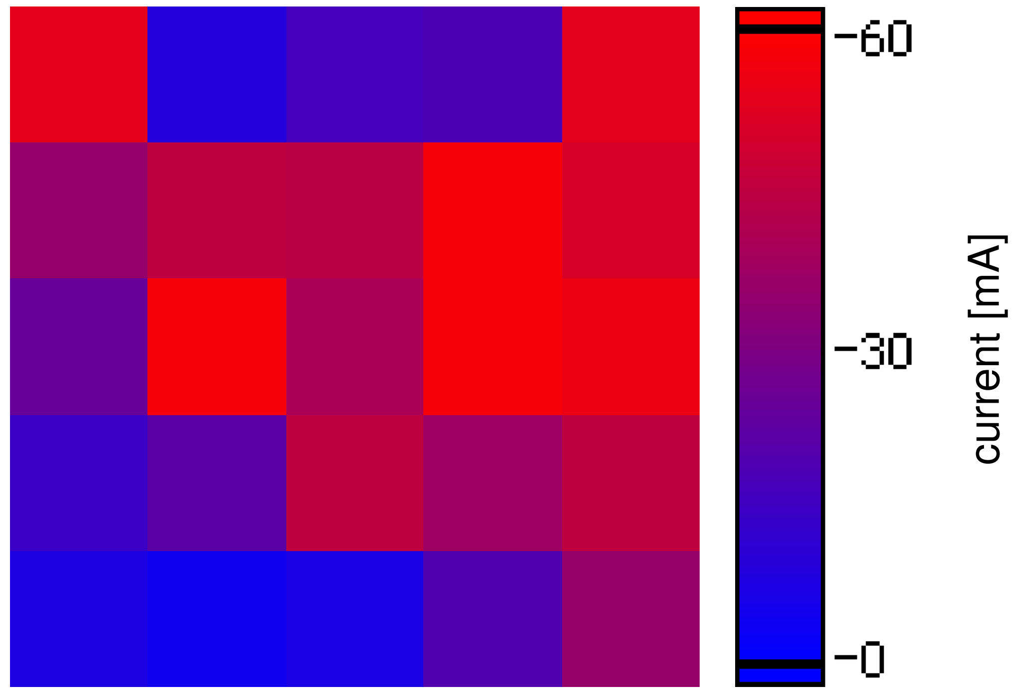
Hydrophobicity of Cathode GDL

Operating Conditions : 70 ℃, 50 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 24$

Neutron radiograph



Current distribution



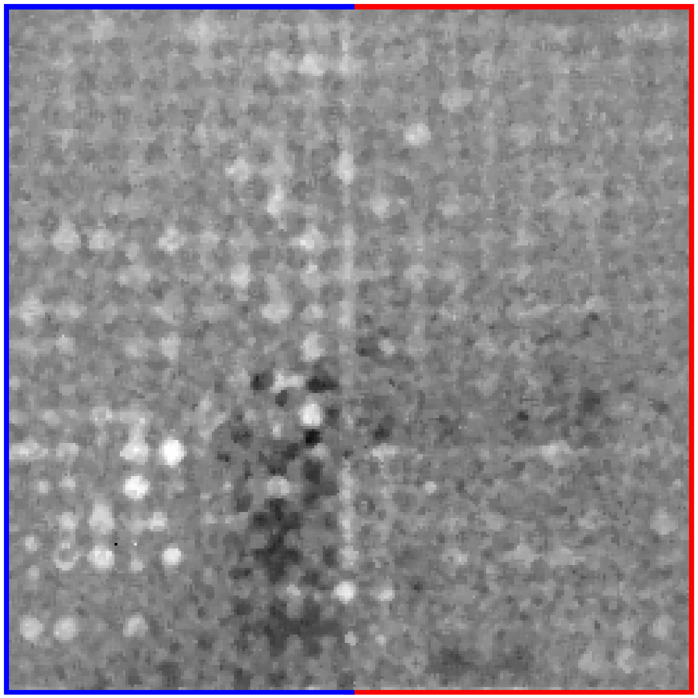
Significant effect of cathode cloth hydrophobicity

(Power generation: **41 %** left partition, **59 %** right partition)

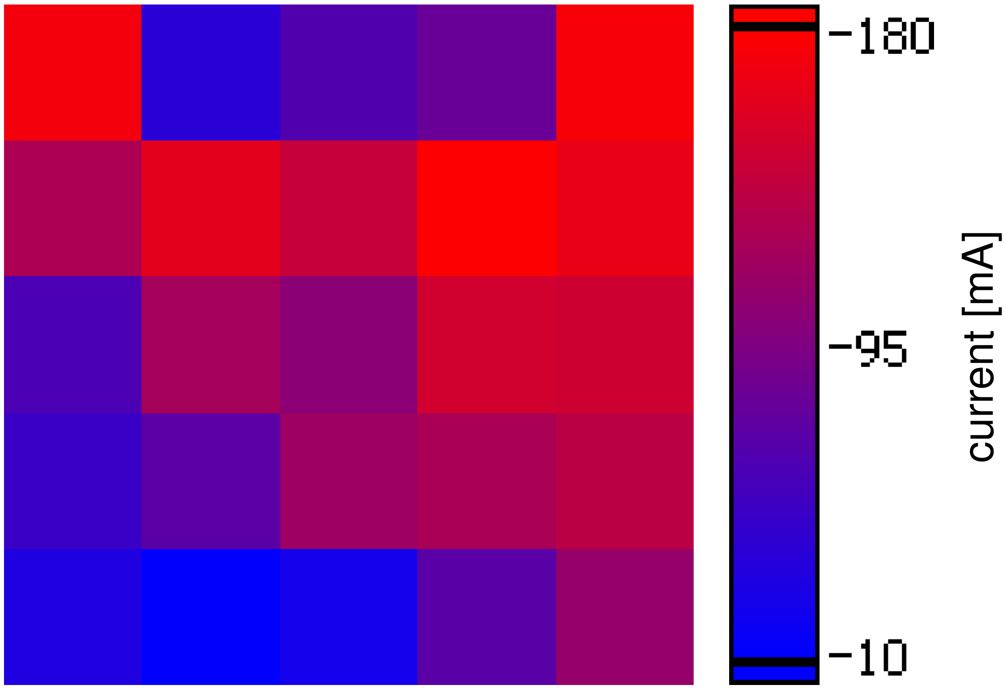
Hydrophobicity of Cathode GDL

Operating Conditions : 70 ℃, 150 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 8$

Neutron radiograph



Current distribution



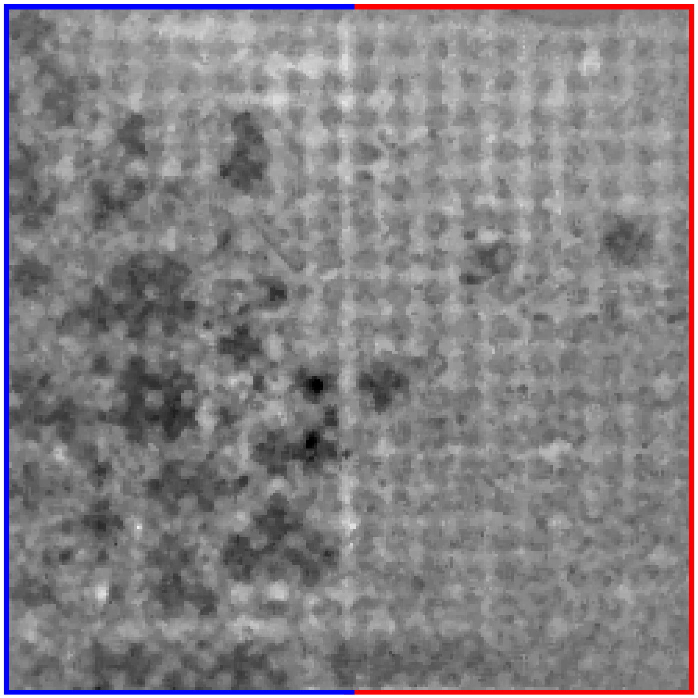
Significant effect of cathode cloth hydrophobicity

(Power generation: **41 %** left partition, **59 %** right partition)

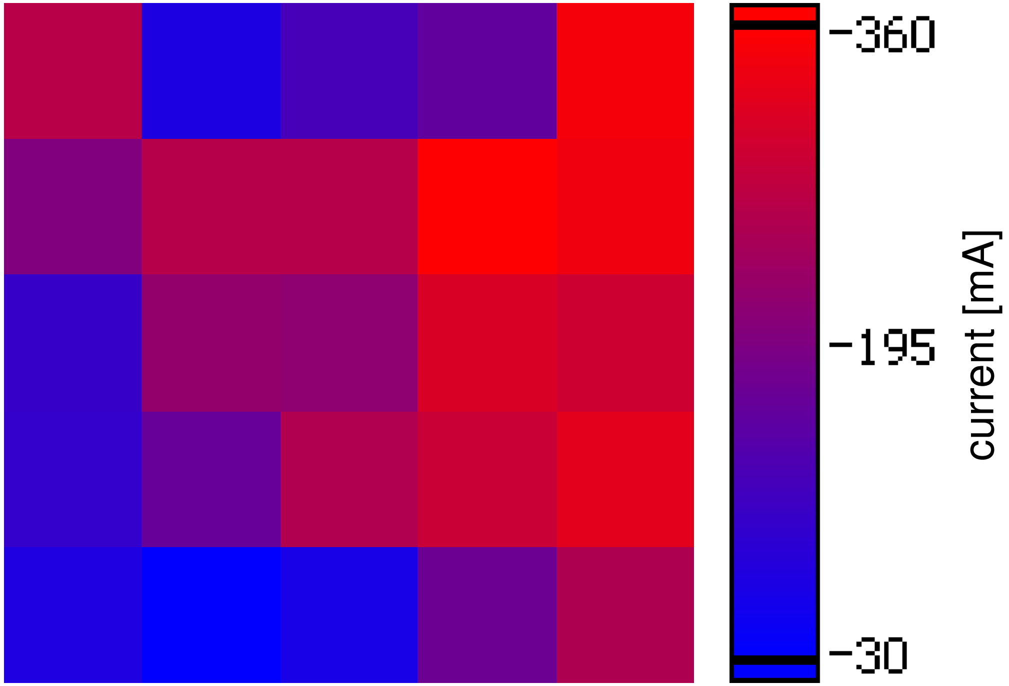
Hydrophobicity of Cathode GDL

Operating Conditions : 70 °C, 300 mA/cm², $\lambda_{Air} = \lambda_{Methanol} = 4$

Neutron radiograph



Current distribution



Significant effect of cathode cloth hydrophobicity

(Power generation: **38 %** left partition, **62 %** right partition)

Conclusion

Combined current distribution measurements and neutron radiography

- suitable tool to study different operating conditions
- useful hints for DMFC development and operation

Influence of Current Density

- correlation of water content in cathode channels and current density

Bi-functional Operation

- visual verification

Hydrophobicity of GDL

- anode cloth hydrophobicity negligible
- cathode cloth hydrophobicity significant

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Forschungszentrum Jülich GmbH, Institute of Energy Research,
IEF-3: Fuel Cells, 52425 Jülich, Germany

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Institute for Power Electronics and Electrical Drives (ISEA),
RWTH Aachen University, 52066 Aachen, Germany

I. Manke, N. Kardjilov, A. Hilger, J. Schloesser, S. Petrov

Helmholtz Centre Berlin (Hahn-Meitner-Institute), SF3,
Glienicker Str. 100, 14109 Berlin, Germany

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Diagnostic Tools for Fuel Cell Technologies – Future issues

Nuclear technologies:

- Enhanced use of test cell designs close to reality (e.g. stack operation), including scale-up of cell & PCB design
- Special focus on water/gas management in gas diffusion layers (enhanced use of high resolution techniques)
- Further improvement of test cell & components regarding spatial & temporal resolution

General

- Broad approach concerning analytical tools and dimension of system (from nm to m)
- Enhanced use of locally resolved techniques
- Enhanced use of combined *in situ* techniques
- Adaptation of existing analytical tools for fuel cell diagnostics

Thank You for Your Attention