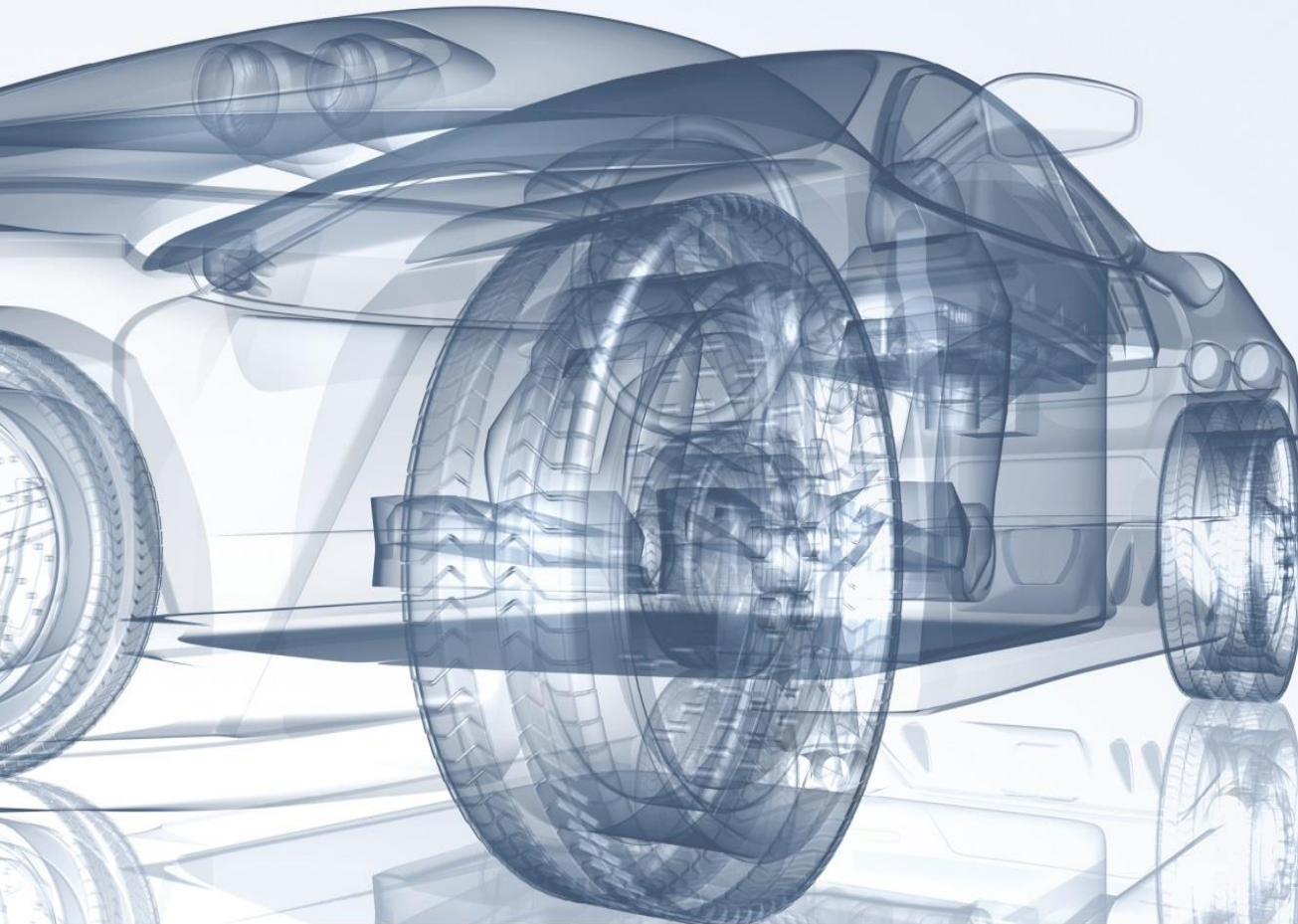


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# Sealing, coating and quality control of bipolar plates: Scaling up for mass production

Dr.-Ing. Jörg Karstedt,  
Coordinator Emobility

WES 2017, Stuttgart, 11.10.2017





# Fuel cell plug-in hybrids: Long-distance emobility with batteries and fuel cells

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- ZBT – A brief introduction
- Development of cost efficient, scalable production technologies for fuel cells
  - Sealing
  - Coating
  - Bonding
  - Optical quality control



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- Research and development:  
fuel cells, hydrogen and battery technology
- Focus on industry demand
- Independent service provider and R&D partner
- Share holder: University of Duisburg-Essen
- 100 full time employees

### Infrastructure:

- 1200 m<sup>2</sup> laboratory
  - Flexible test benches
  - Advanced measurement and analytics
  - Chemical laboratories
- Modern CAE & Simulation tools
- 500 m<sup>2</sup> technical center / production technologies
  - Injection molding/compound laboratory
  - Gasket production site
  - Mechanical workshop



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# Development of a fuel cell plug-in hybrid: Project BREEZE: Development of a 300cm<sup>2</sup> automotive fuel cell stack

## BREEZE: Development of a fuel cell plug-in hybrid

- Battery electric operation for short distances
- 30 kW fuel cell system enables emission free long-distance mobility and short refuelling times
  
- Automotive stack development by ZBT and Gräbener Maschinentchnik
  - Component benchmarking
  - Flowfield design/CFD simulation/
  - Development sealing technology
  - Testing and qualification
  
- System development by FEV and VKA

Vehicle integration,  
„Proof of Concept“



source: FEV



System developed and tested

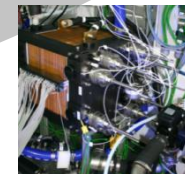


source: FEV

Lab-stack qualified



Development  
Automotive BPP Design



Fullstack: power density > 1 W/cm<sup>2</sup>



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# Cost efficient production technologies for fuel cells

## Bipolar plate production



### Substrate

- Stainless steel
- Ferritic steel
- Uncoated
- Coated

### Forming & Cutting

- Stamping
- Hydro-forming
- Diecutting
- Laser-cutting

### Joining

- Laser-welding
- Bonding

### Coating

- Batch-coating

### Sealing

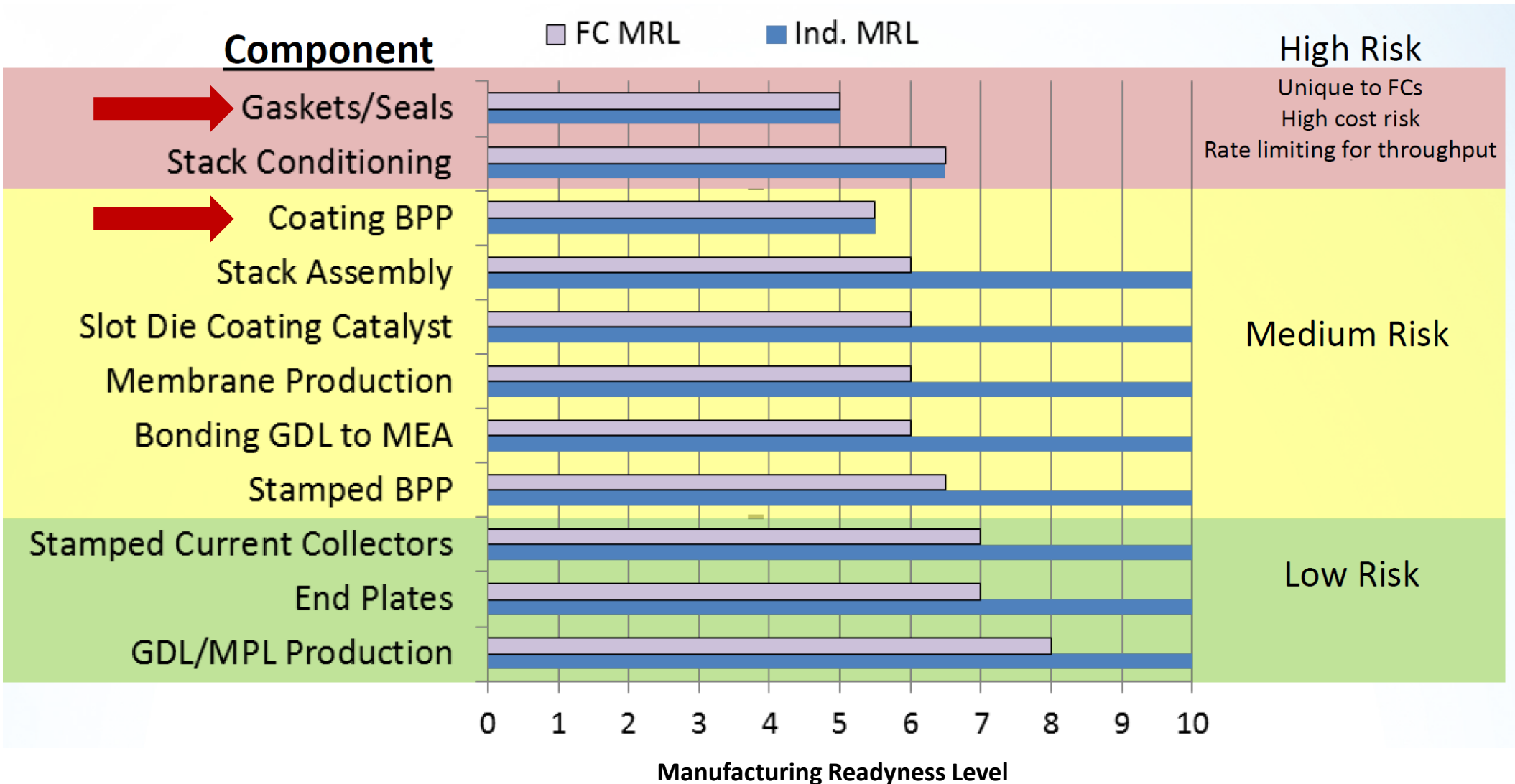
- Injection molding
- Screen printing
- Dispensing

### QS

- Leakage testing (seal + weld)
- Deformation
- Mechanical damage

# Cost efficient production technologies for fuel cells

## Manufacturing Readiness Level (MRL) of fuel cell stack components



### Injection molding

- Fine geometries and low sealing loads possible
- Slower process
- High investment cost (injection molding machine + tooling)



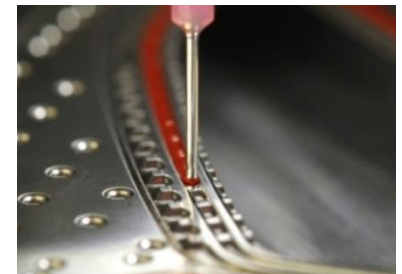
### Screen printing

- Fast process
- Risk of gas bubbles enclosed in sealing
- Wear of screens during printing
- Increased operating cost



### Dispensing

- Fast process (4 plates in parallel with 4 dispensing heads on one machine)
- No gas bubbles in sealing
- No changes in sealing quality during production
- Low investment cost
- Low operating cost (robust dosing pump, dosing needles)





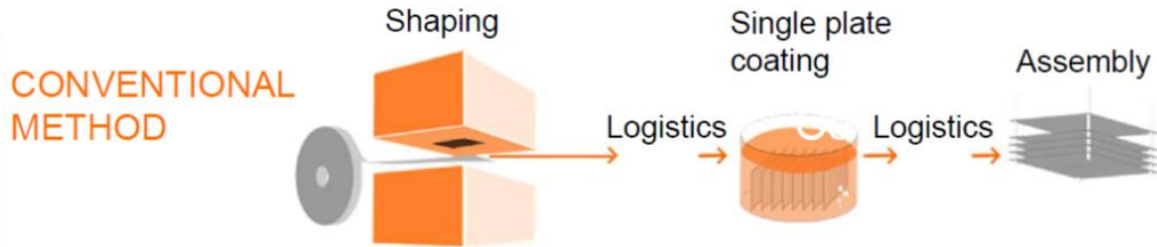
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# Cost efficient production technologies for fuel cells

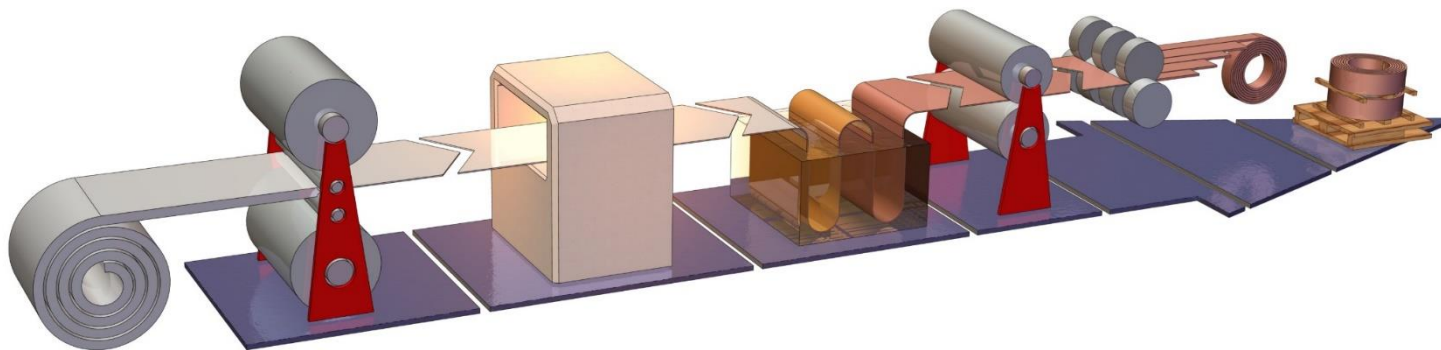
## Coating of metallic bipolar plates – Precoating vs. Postcoating



Source: BPP Workshop 20.5.2015: SANDVIK SURFACE TECHNOLOGY - COMMERCIALIZING FUEL CELL TECHNOLOGY

### Project PRECOAT:

- Partners: Hille&Müller, Gräbener Maschinenteknik, ZBT
- Objective: Cost efficient continuous precoating of metallic bipolar plates



Source: Hille&Müller



Source: Hille&Müller


Gefördert durch:

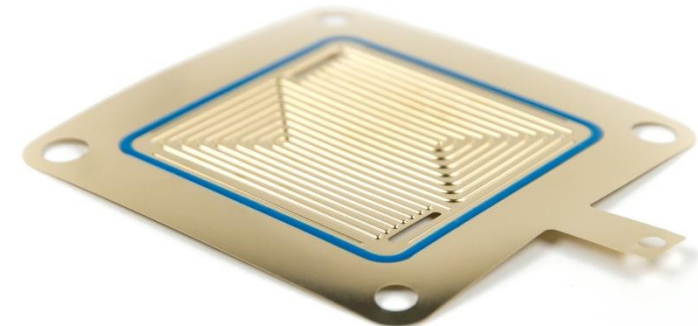
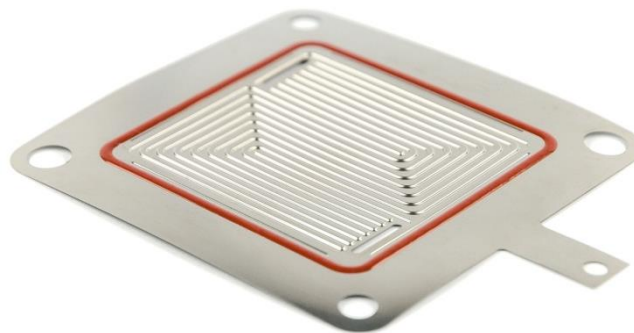
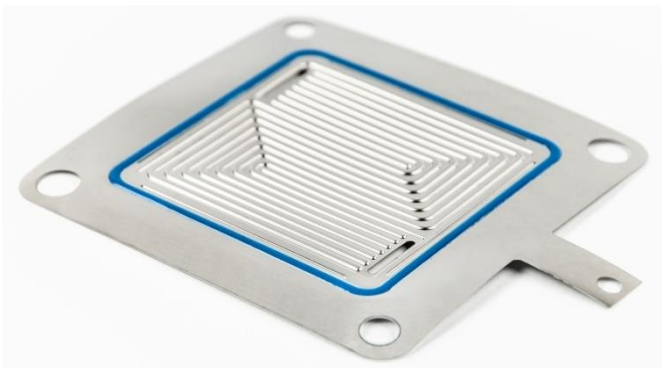
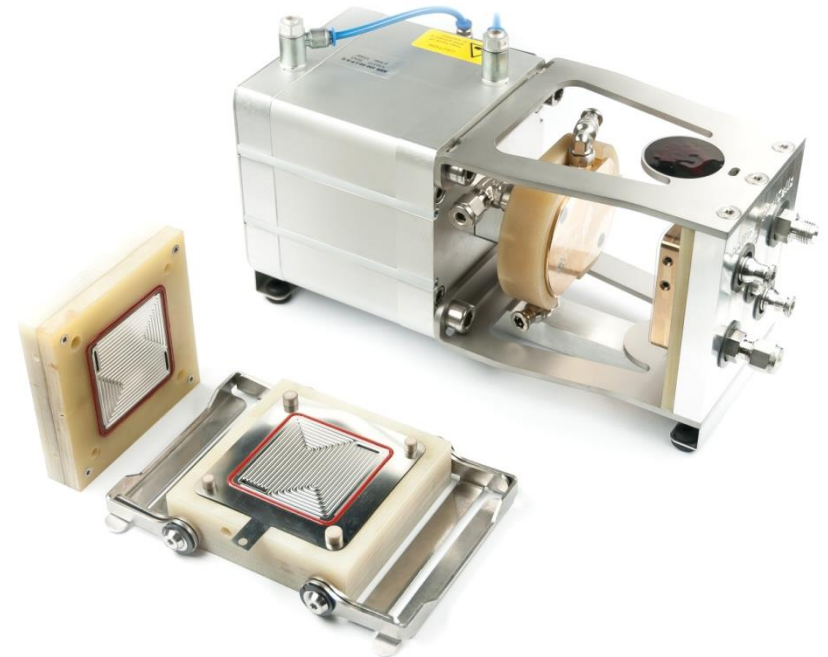


aufgrund eines Beschlusses  
des Deutschen Bundestages

# Cost efficient production technologies for fuel cells

## In-situ testing of stack components

- Metallic sheet metal bipolar plates
- Active area: 25 cm<sup>2</sup>
- Power density > 1,2 W/cm<sup>2</sup>
- Compaction: max. 2.5 MPa on active area
- Sealable by o-rings or FIP gaskets
- Inserted in commercial available test hardware Baltic qCF
- Temperature range: RT...180°C
- Voltage monitoring directly contacted to the bipolar plates
- Test cell developed in cooperation with 





# Fuel cell plug-in hybrids: Long-distance emobility with batteries and fuel cells

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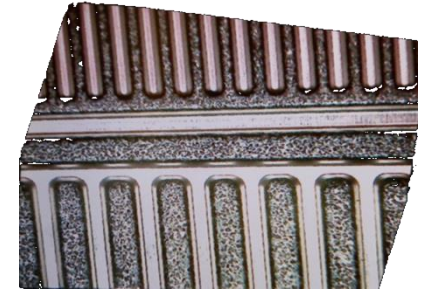


# Cost efficient production technologies for fuel cells

## Project Low Cost Bip: Bonding of metallic bipolar plates

### Bonding of metallic bipolar plates requires:

- Minimum hydrogen diffusion
- High electric conductivity
- Media compatibility
- Minimization of contact area and bonding height
- Application suitable for high-volume production
- No effects on fuel cell degradation



### Project partners:



**VOLKSWAGEN**  
AKTIENGESELLSCHAFT

**GRAEBENER**  
MASCHINENTECHNIK  
www.graebener-maschinentech.de



**Jowat**  
Klebstoffe



*ifs*

Gefördert durch:



aufgrund eines Beschlusses  
des Deutschen Bundestages



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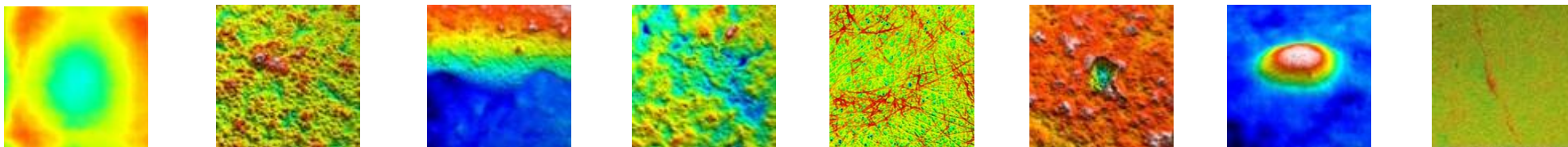
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# Cost efficient production technologies for fuel cells

## Fast combined 2D and 3D surface measurement

Develop very fast combined 2-D and 3-D surface measurement systems that will be used to identify optical quality / defects and define failure criteria in order to improve fuel cell performance and lifetime as well as to reduce manufacturing and QC costs



### Measuring examples:

- Membrane electrode assembly: Evenness and waviness / Porosity / Layer thickness / particle distribution and electrode microstructure
- Gas diffusion layer: Roughness
- General defect detection: Holes / Catalyst accumulation / Folds and cracks



Project Management:



Project Partners:



Project Lead Partner:





- Technical performance of fuel cell vehicles meets customer expectations
- Cost targets for series production not yet reached
- Development is currently focusing on low-cost manufacturing technologies that are scalable to high volume production
- ZBT supports the industry in the development of fuel cell stacks and systems, manufactures low cost sealing solutions for fuel cells and provides independent testing and qualification services

# Thank you for your attention!

**Interested?**

**Visit us in hall 1 booth 1A33!**

Contact:

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[www.zbt-duisburg.de](http://www.zbt-duisburg.de)

