CHARACTERIZATION OF COMPOSITE AND METALLIC BIPOLAR PLATES

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Hydrogen + Fuel Cells 2011
partnerships for global energy solutions

International Conference + Exhibition
Vancouver, British Columbia, Canada
Vancouver Convention + Exhibition Centre
May 15 – 18, 2011

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Project supported by the European Funds for Regional Development and the Region of North Rhine-Westphalia, Germany

ZBT Zentrum für BrennstoffzellenTechnik is

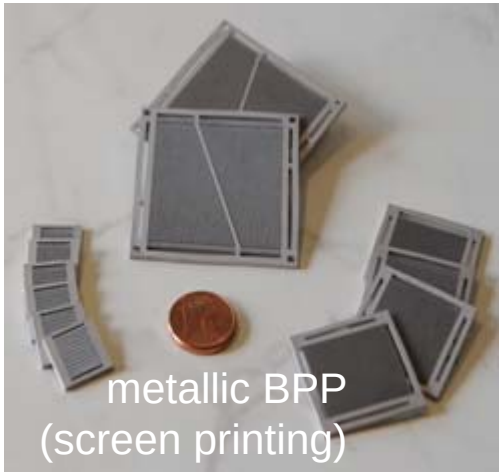
- Independent R&D service provider
- Dedicated to hydrogen and fuel cell technology
- ~ 100 full time employes
- Focussing on applied technologies

Core technologies and services

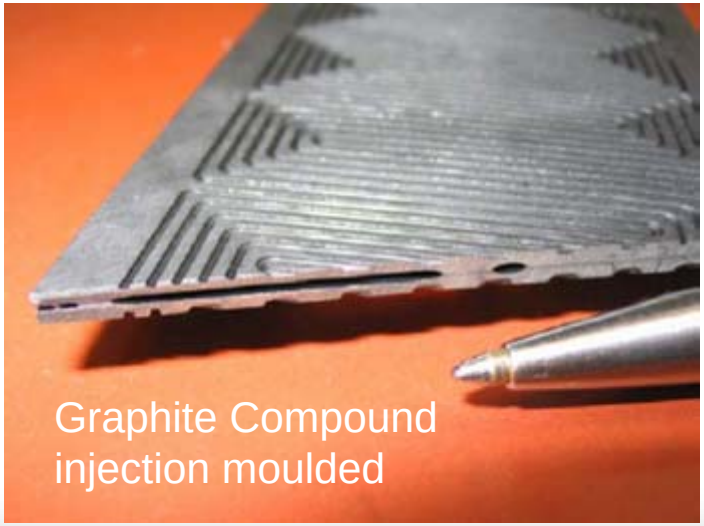
- Bipolar plates
- Fuel cell stacks < 3 kW
- Fuel reforming
- Fuel cell system technologies (H_2, reformate)
- Production technologies
- Testing for certificates
  (accredited testing lab)

Types of bipolar plates – ZBT technologies

Graphite Compound
hot pressed & milled



metallic BPP
(screen printing)



Graphite Compound
injection moulded

metallic BPP
(structured foils)

Gräbener Maschinentechnik GmbH / ZBT

Bipolar plate requirements – US Department of Energy

Table 1 Performance requirements for PEM fuel cell bipolar plates.

Property	Unit	Value	
Tensile strength – ASTM D638	MPa	>41	being established
Flexural strength – ASTM D790	MPa	>59	established
Electrical conductivity	S cm^{-1}	>100	established
Corrosion rate	$\mu A\ cm^{-2}$	<1	being established
Contact resistance	$m\Omega\ cm^2$	<20	established
Hydrogen permeability	$cm^3\ (cm^2\ s)^{-1}$	$<2.10^{-6}$	being established
Mass	kg/kW	<1	established
Density – ASTM D792	g cm^{-3}	<5	established
Thermal conductivity	W $(m\ K)^{-1}$	>10	being established
Impact resistance (unnotched) ASTM D-256	J m^{-1}	>40,5	

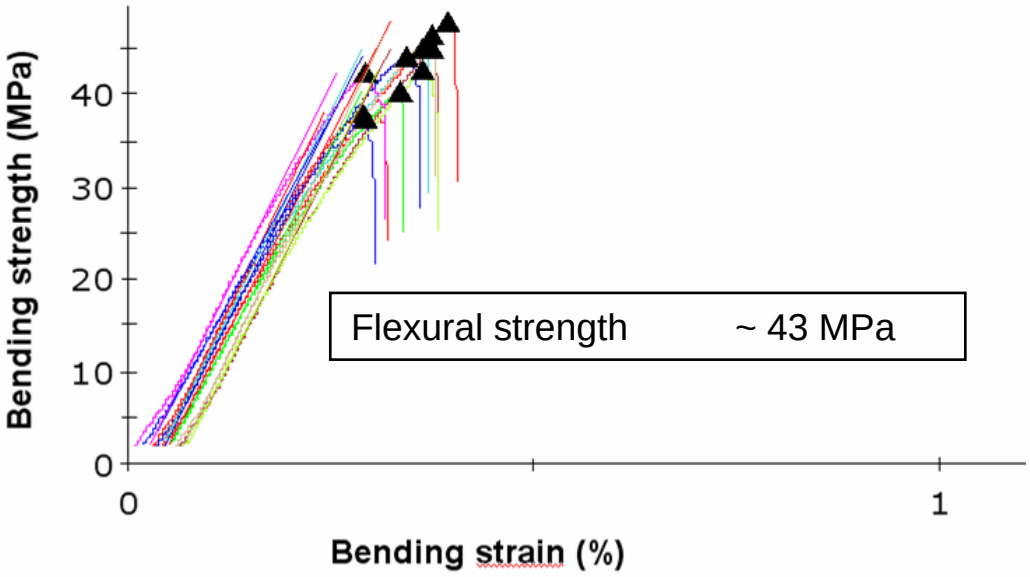
[1] Antunes, R.A., Oliveira, M. C. L., Ett, G. et al. 2010. Corrosion of metal bipolar plates for PEM fuel cells: A review. International Journal of Hydrogen Energy 35 (2010) 3632-3647

Flexural and tensile strength – method of measurement

Determination of mechanical characters:

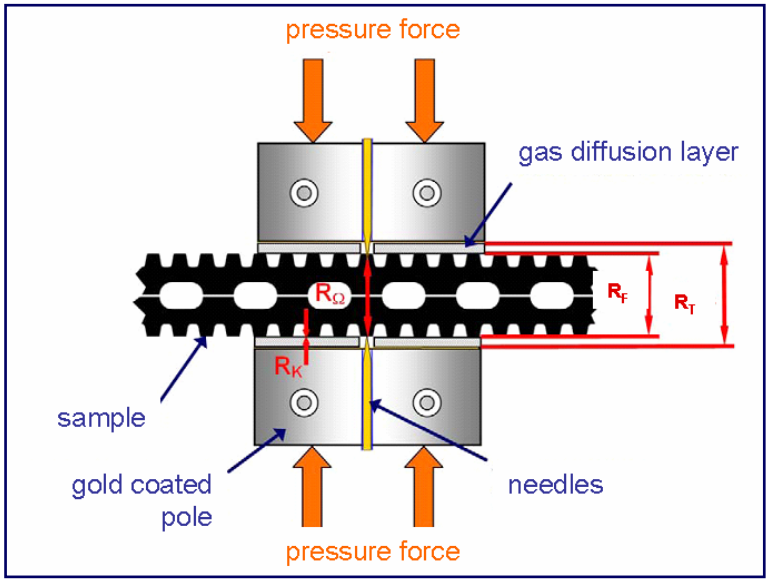
- Three-point bending test for flexural strength
- Tensile test for tensile strength is being established

3-point bending test of ZBT injection molded material for LT application



Injection molded samples for three-point bending test

electrical conductivity / contact resistance – method of measurement



measured resistance:

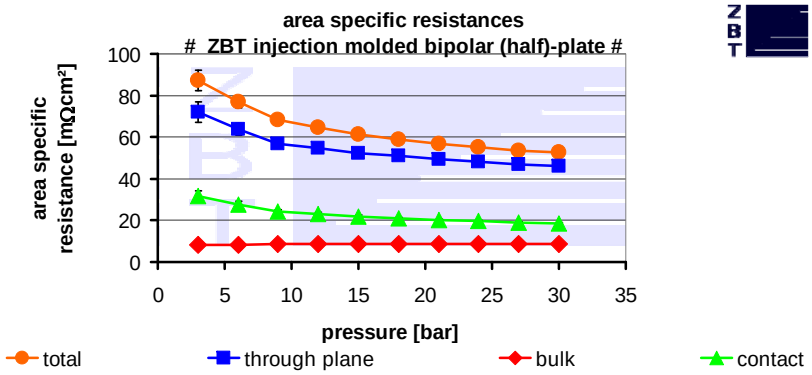
- $R_{total} = 2\ R^{+}_{GDL} + 2\ R_{contact} + R_{bulk}$
- R_{bulk}

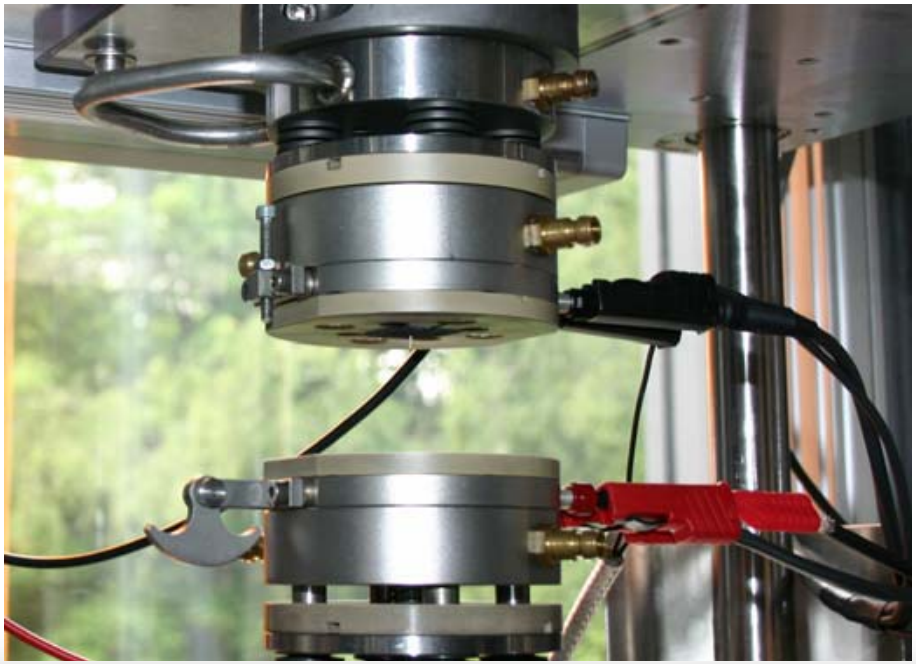
$^{+}(R_{GDL}$ determined prior to measurement)

calculated resistance

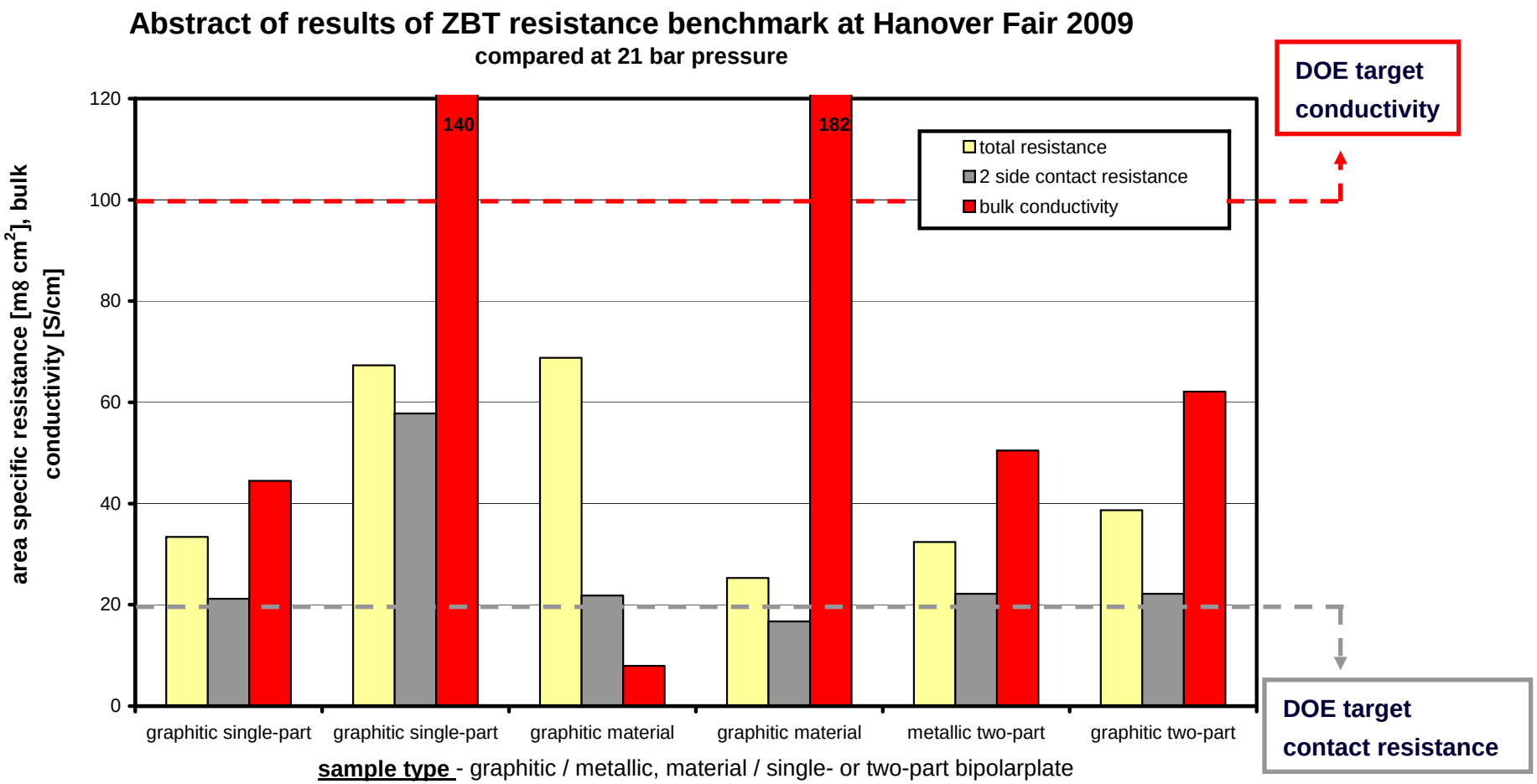
- $R_{forward} = R_{total} - 2\ R_{GDL}$
- $R_{contact} = R_{forward} - R_{bulk}$

„Gaining resistive pressure dependent surface- and bulk-information in the same measurement.“

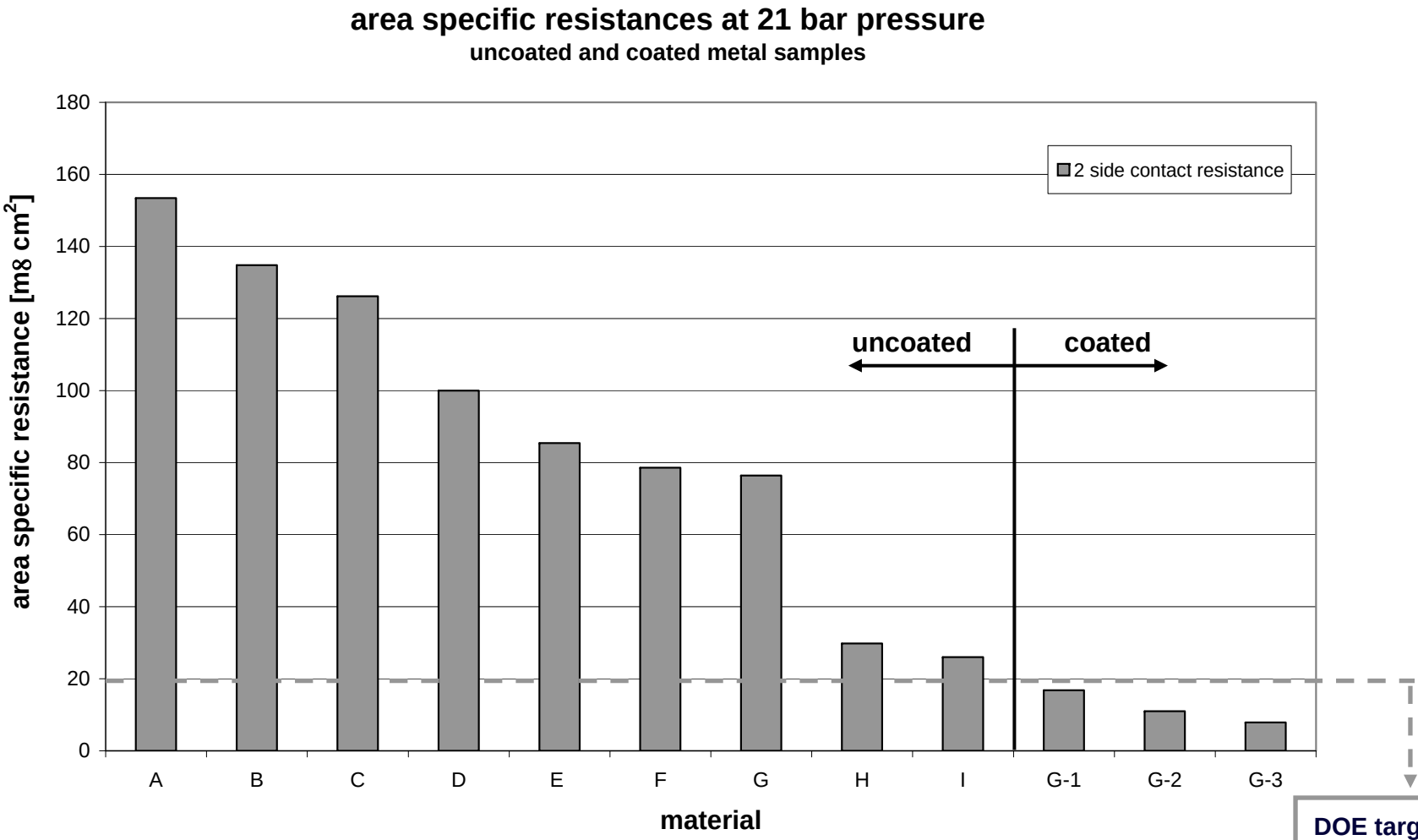




electrical conductivity / contact resistance – results



electrical conductivity / contact resistance – results



Immersion test – method of measurement

Accelerated ageing of PEMFC components (bipolar plates, gaskets) in fuel cell simulating environment.

- dest water / sulphuric acid / phosphoric acid
- temperature 40 – 80°C
- gas purge (air, hydrogen)

Ageing characteristics of samples:

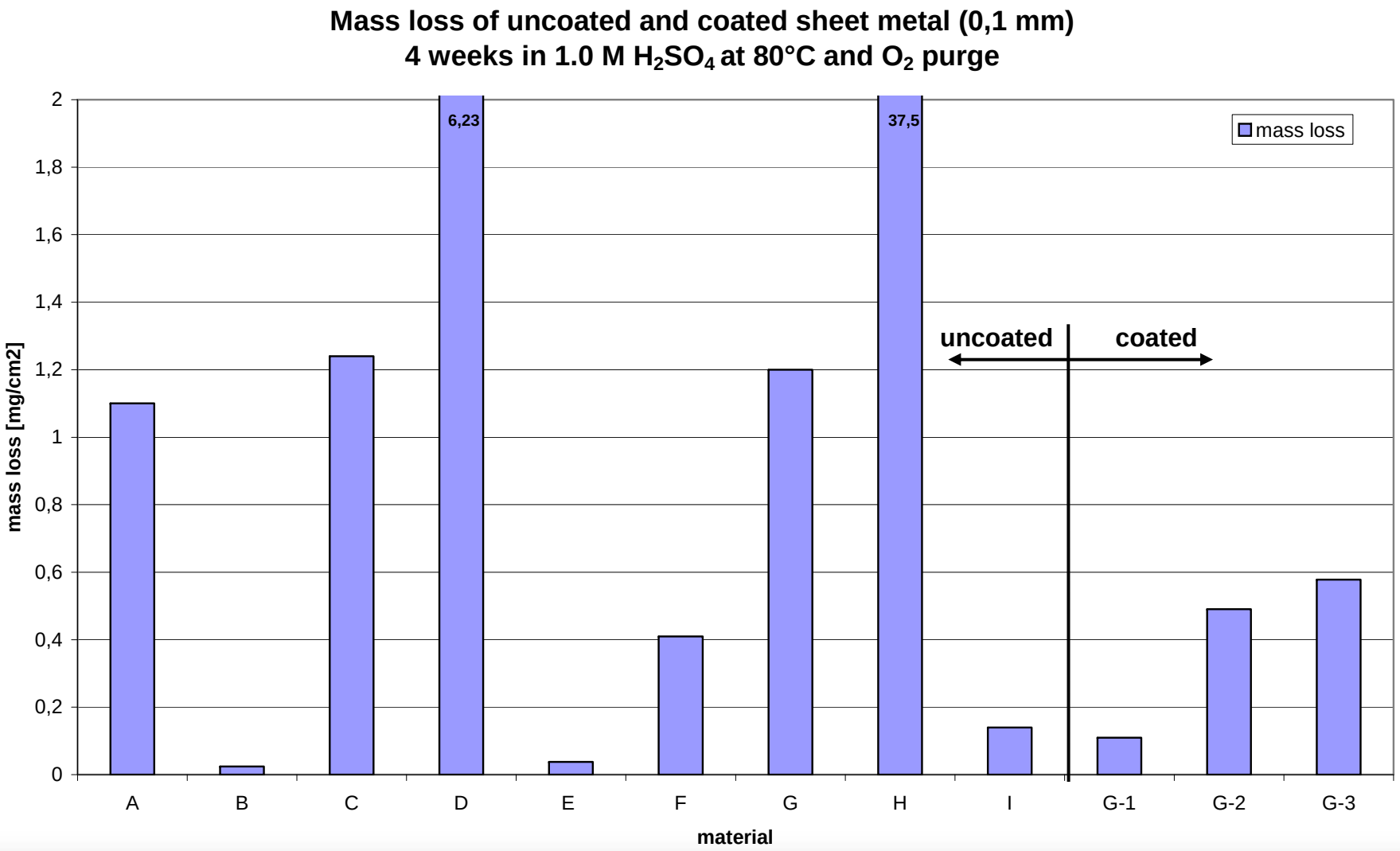
- **sample mass**
- sample thickness
- roughness / waviness
- modulus of elasticity
- nano structure (REM)

Ageing characteristics of soaking liquid:

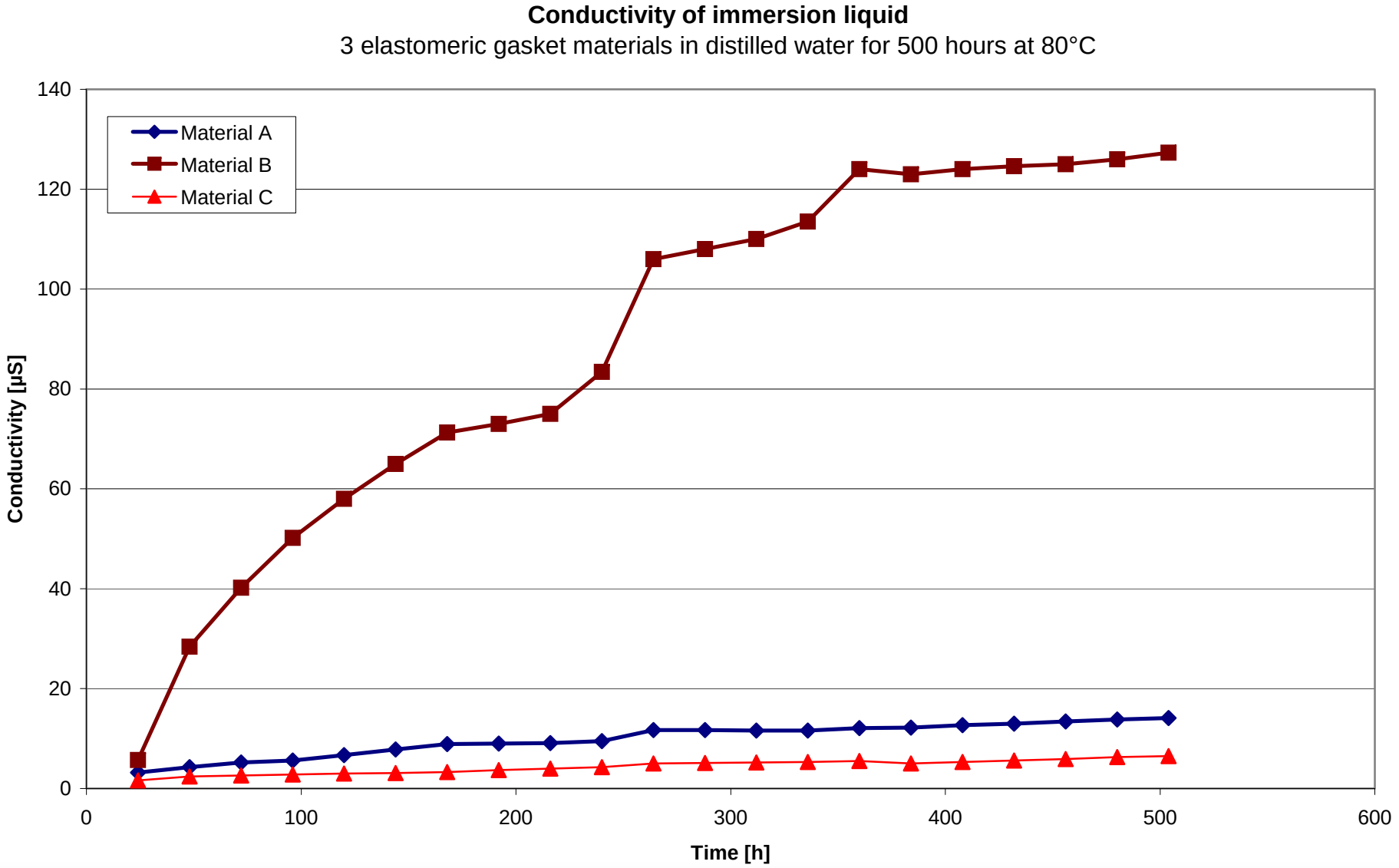
- conductometry

„Potentiostatic and potentiodynamic voltammetry **is being established** for determination of **corrosion restance**.“

Immersion test – results



Immersion test – results



Density - method of measurement

Determination of density:

- Gas Pycnometry (Quantachrome, Ultrapycnometer 1000)
- Measurement referring to Boyle-Mariotte
- Using He as displacement gas
- Dimension of measuring chamber Ø 49 mm x 75 mm
- Measuring at standard temperature (25°C)
- Averaging 5 measurements

„Used as quality assurance tool for compound material developement.“

Calibration spheres

Thermal Conductivity - method of measurement

Is being established

- Determination of thermal conductivity

“ Measurement of through plane- and in plane thermal conductivity of anisotropic materials.”

- Determination of heat capacity
- Determination of temperature conductivity

„To be used as quality assurance tool for compound material developement.“

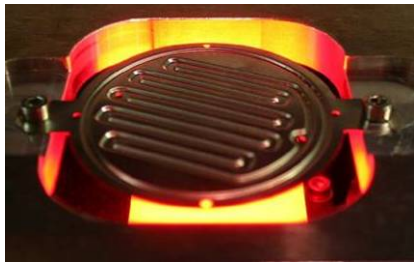
„Hot disk“- thermal conductivity measuring device

Additional measurements

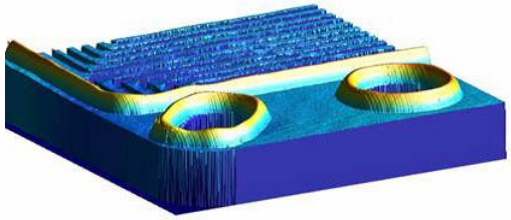
3D-Scan (FRT, MicroProof-TTV)

- Determination of topographical deviation

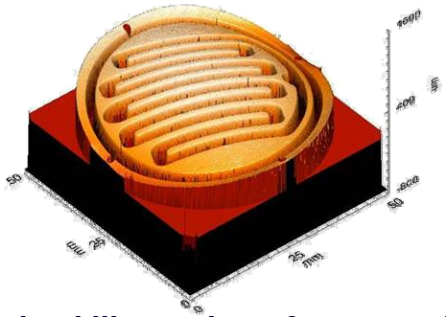
Measurement setup



Sheet metal bipolar plate



Screen printed sealing on compound bipolar plate



Raised illustration of topography

Contact angle measurement

		Method	
Material	Surface preparation	Laplace - Young	Tangential
104 St	**untreated**	**108,7°**	**114,8°**
104 St	**treated**	**117,4°**	**124,7°**

Long-term testing of short stacks / cell components

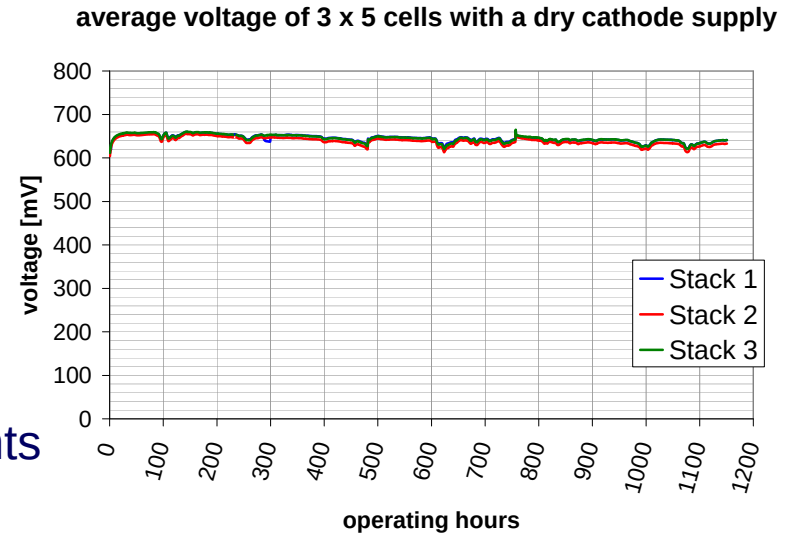
The test rig consists of three identical testing places. It is designed to compare small differences between the three setups respective stack components or operating conditions.

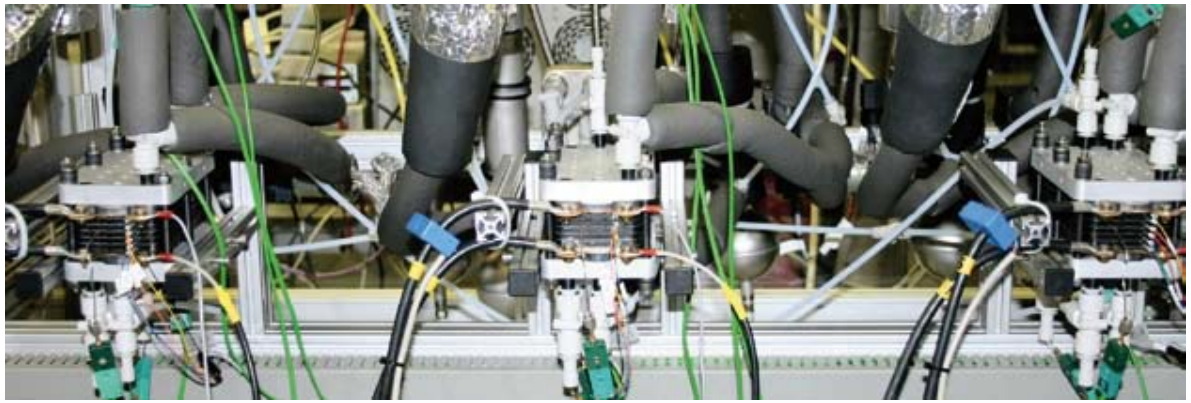
Testing goals: Qualification and comparison of

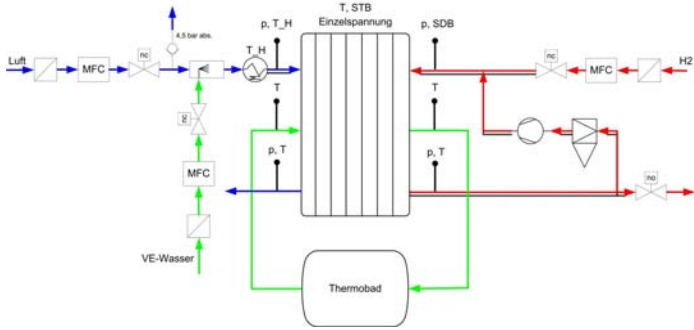
- stack components (gaskets, bpp materials etc.)
- media supply, control strategies, BOP components

Test setup (standard setup)

- 3 short stacks (5 cells) in parallel
- H_2 recirculation, (no) cathode humidification

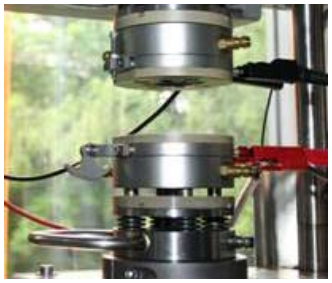




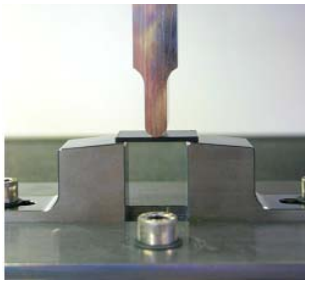


Summary

- ZBT has developed graphite based and metallic bipolar plate technologies since ~ 2002
- A large bandwidth of qualification procedures and technologies have been established for bipolar plates and materials
- Services are being offered for industry and science



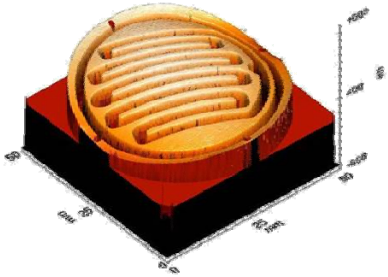
Electrical conductivity



Mechanical properties

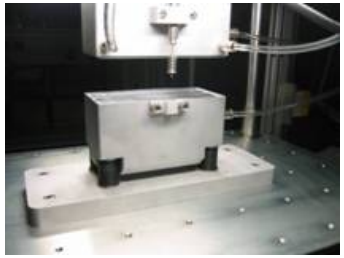
Material density

Heat conductivity



3D-Topography- and thickness

Optical inspection (Stereo-microscope)



Force-deflection / Stability

Leaching tests / In-Cell-Tests

Thanks for supporting:

- State of Northrhine Westfalia and European Union for supporting
  - ZBT and the initial R&D regarding bipolar plates
  - Project “NETZ”
  - Project “HiperLoco”
- Bundesministerium für Wirtschaft supporting
  - Lebensdauerprognose 03ET2006A
  - Projects of Industrial Gemeinschaftsforschung regarding bipolar plates
- Bundesministerium für Bildung und Forschung
  - Project CarboPlate
  - Project MetallBip
- Our R&D partners
- The team at ZBT (Thorsten Derieth, Lars Kühnemann, Claus Irsa, Sebastian Brokamp and many others)