Roll-to-Roll Coating and Forming of Stainless Steel for Metallic Bipolar Plates

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The Fraunhofer-Gesellschaft has 76 institutes and research institutions all over Germany
- Main locations
- Secondary locations

3 fields of science
5 locations
660 employees (permanent staff, guest researcher and research assistants)

Founded
1991
Headquarter in
Chemnitz

Approx.
€49 million annual budget 2021
Industrial income
€9,3 million annual budget 2020
76 Institutes and research facilities at locations throughout Germany
Fraunhofer IWS
About Us

Vision Statement
We are the world’s leading institute for complex system solutions in materials and laser technology.

Mission Statement
We passionately drive ideas and implement customized complete solutions for the industry of the future by means of laser applications, functionalized surfaces and material-based innovations.

Unique selling propositions
- Processes and Technologies
- Materials
- System Engineering

Key figures 2022

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
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<tr>
<td>Permanent staff</td>
<td>229</td>
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<tr>
<td>Guest researcher</td>
<td>48</td>
</tr>
<tr>
<td>Research assistants</td>
<td>177</td>
</tr>
<tr>
<td>Apprentices</td>
<td>10</td>
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<tr>
<td>Budget</td>
<td>28.2 Mio. €</td>
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<tr>
<td>Investment</td>
<td>3.9 Mio. €</td>
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<tr>
<td>Industrial revenue</td>
<td>34.0 %</td>
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Locations

Dresden
Zwickau

Dortmund
Fraunhofer IWS is a partner of a public private partnership with Thyssen-Krupp at Dortmunder Oberflächen-Centrum DOC®.
Profile of Fraunhofer IWU & IWS
Hydrogen and Fuel Cell Production

Hydrogen as bearer of hope – production technologies are the key

- Overall coordination of the National Plan of Action for Fuel Cell Production for considerably accelerating the structured rollout in industry and society
- Construction of reference factory for manufacturing fuel cells and electrolyzers, focusing on technologies capable of maximum rates for manufacturing components and stacks
- Developing new manufacturing technologies capable of maximum rates for bipolar plates all the way up to industrial mass production (e.g. embossing by rolling, coil coating)
- Construction of Fraunhofer Hydrogen Lab Görlitz (HLG), offering services regarding the evaluation of stacks and systems, analysis and diagnostics of microstructures, digitalization, manufacturing processes, power electronics and certification
Agenda

(1) Manufacturing processes for metallic BPP
(2) Production concepts for high quantities
(3) Technology development coating process
Manufacturing process for metallic bipolar plates
Process flow diagram and selected process chains

Fig.: Process flow diagram for the production of metallic BPP [1].

References:
[1] https://s.fhg.de/NdR.

Single cell
Active area 240x120 mm
Dimensions 380x150 mm
Single cell height 1,3 mm
## Manufacturing process for metallic bipolar plates

Comparison of selected processes for the BPPs production

<table>
<thead>
<tr>
<th></th>
<th>Hollow-Embossing</th>
<th>Hydroforming</th>
<th>Hollow-Embossing - Rolling</th>
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<tr>
<td>Plate area (total)</td>
<td>500 cm²</td>
<td>500 cm²</td>
<td>500 cm²</td>
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<tr>
<td>Production rate</td>
<td>60 BP-HP/min</td>
<td>6.7 BP-HP/min</td>
<td>&gt; 120 BP-HP/min</td>
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</table>

Comparison of the evaluation criteria:
- Formability / geometry
- Production rate
- Process complexity

Interrelationships between the manufacturing processes of **forming, cutting and joining**

- BP-HP-Test geometry is adapted to the single-cell test rig "Baltic Fuel Cell" of Fraunhofer ISE

**BP-HP – anode side**

of the demonstrator fuel cell

1. Channel distance: 1.2 mm
2. Channel width: 0.47 mm
3. Channel depth: 0.24 mm
4. Inner radius: 0.1 mm
5. Flank angle: 24°
6. Sealing: 0.41 mm
7. Gas diffusion layer (GDL): 0.17 mm

**Fig.: Fuel cell in cross-section.**

**Fig.: Reference geometry anode BP-HP with parallel linear flow field structure.**
Manufacturing process for metallic bipolar plates

Process comparison – Hollow embossing vs. Hollow embossing rolling

Hollow embossing

versus

Hollow embossing rolling

Plastic elongation (Shell middle layer)

0.50

0.01

https://hzwo.eu/project/fosta-bipolarplatten-praegen/
HOKOME – R2R manufacturing methods for fuel cell stack components
Production concepts for high quantities

Coating
- Coil coating line

Forming
- Hollow embossing rolling for BP-HP

Joining
- Laser roll welding in the gap & adhesive application

Qualification product / system

Validation / Test

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Technology development coating process
From batch to R2R- process

Development

Process development of graphite-like-carbon (GLC) based coatings from batch- to coil and finally to an Air-to-Air process (recent developments)
Technology development coating process
From batch to R2R- process – contact resistance

- Contact resistances through a graphite like carbon-based coating reduce the contact resistance of stainless steel and are at least comparable to gold coatings.
- Coating tests using PVD in batch and coil coating show comparable contact resistances.
- Varying the interlayer with some other metals shows no significant change in contact resistance.
- Technology development for GLC-based coatings from a roll-to-roll (air-to-air) system is currently underway.

ICR values of 1.4404, gold, coatings with carbon and chromium (C/Cr) as well as another metallic interlayer (C/M)
Technology development coating process
From batch to R2R- process - Corrosion

- Corrosion current density on 1.4404 stainless steel could be reduced by all coatings.
- Coatings with a chromium interlayer (C/Cr-batch and C/Cr-Band) show a breakthrough potential (increase in corrosion current) at approx. 1.2 V voltage for both strip and batch coatings.
- Other developed coating systems (C/M-batch) show a shift of the breakthrough potential to higher voltages.
- Further research in coating development has the potential to further increase the corrosion resistance of metallic bipolar plates. Corresponding developments are currently under discussion.

Measureing conditions: Elektrolyte: 0.05 M H2SO4; room temperature; Ag/AgCl reference electrode
The results presented were developed within the framework of or based on the following publicly funded projects:

- **FIT-4-AMandA** – Funding Programme H2020-JTI-FCH-2016-1 | Manufacturing Technologies for PEMFC Stack Components and Stacks, GA No 735606
- **Hollow embossing vs. hollow embossing rolling** - process comparison for shaping metallic bipolar plates IGF Vorhaben-Nr.: 21715 BR.
- **HOKOME** – FhG project of five cooperating Fraunhofer Institutes – IWU, ISE, IWS, IKTS und IPT

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