Fraunhofer IWU

3nd Czech-German Business Meeting - 18 March 2026 at VSB – Technical University of Ostrava

—

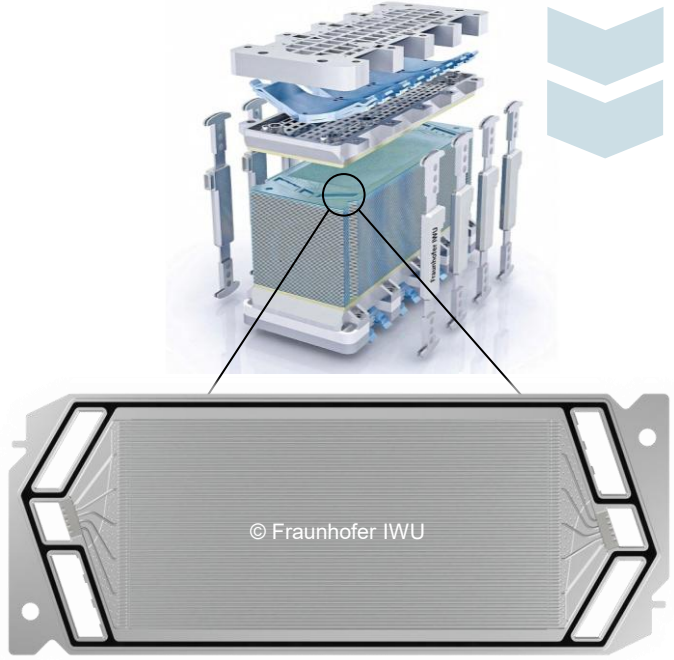
Current Trends in Production and Coating of Bipolar Plates for Electrolysis and Fuel Cell Applications

Stefan Polster, Fraunhofer IWU – Chemnitz

WHAT IS IT FOR?

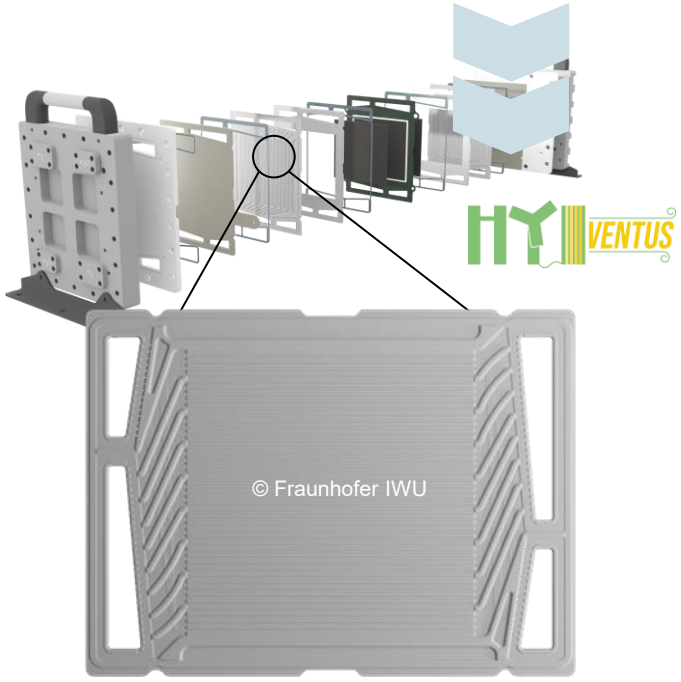
THIN METALLIC PLATES FOR MEDIA DISTRIBUTION

BIPOLARHALFPLATES (BPHP)
FOR FUEL CELLS
sheet thickness: 0.05 – 0.10 mm

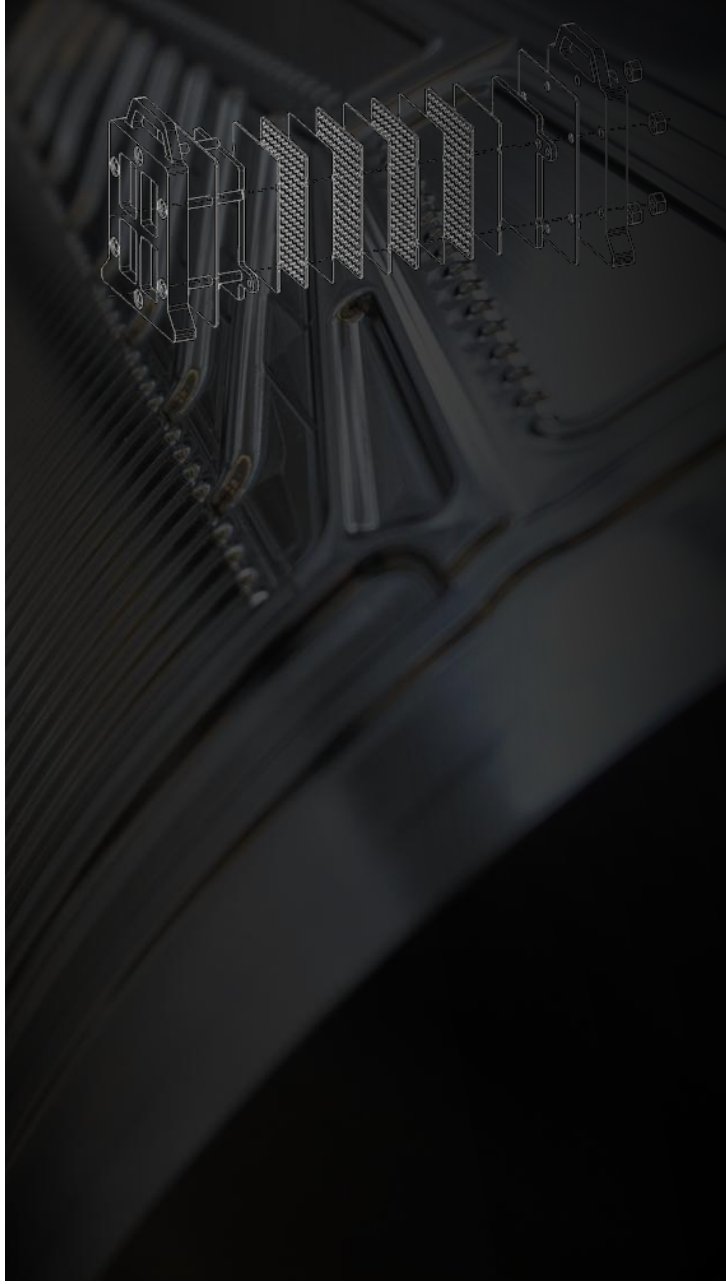


example: HyVictus-Stack
~800 bipolar half plates per stack
380 x 150 mm

BIPOLARHALFPLATES
FOR ELECTROLYZERS
sheet thickness: 0.3 – 0.5 mm



example: HyVentus-Stack: 10 kW
10 bipolar half plates per stack, 300 x 350 mm



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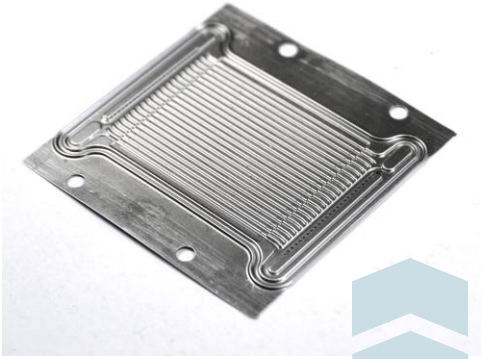
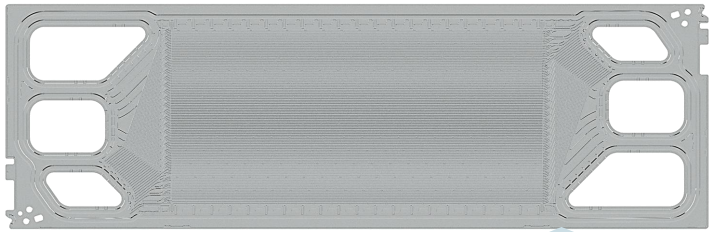
LOOKING INSIDE…
DEVELOPED PLATE DEMONSTRATORS



LABORATORY SCALE
FORMING TRIALS &
BALTIC FUEL CELL TESTING

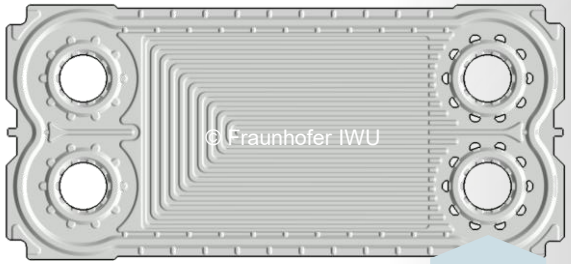
IWU-Design: HyVictus Anode



H2Go-DESIGN

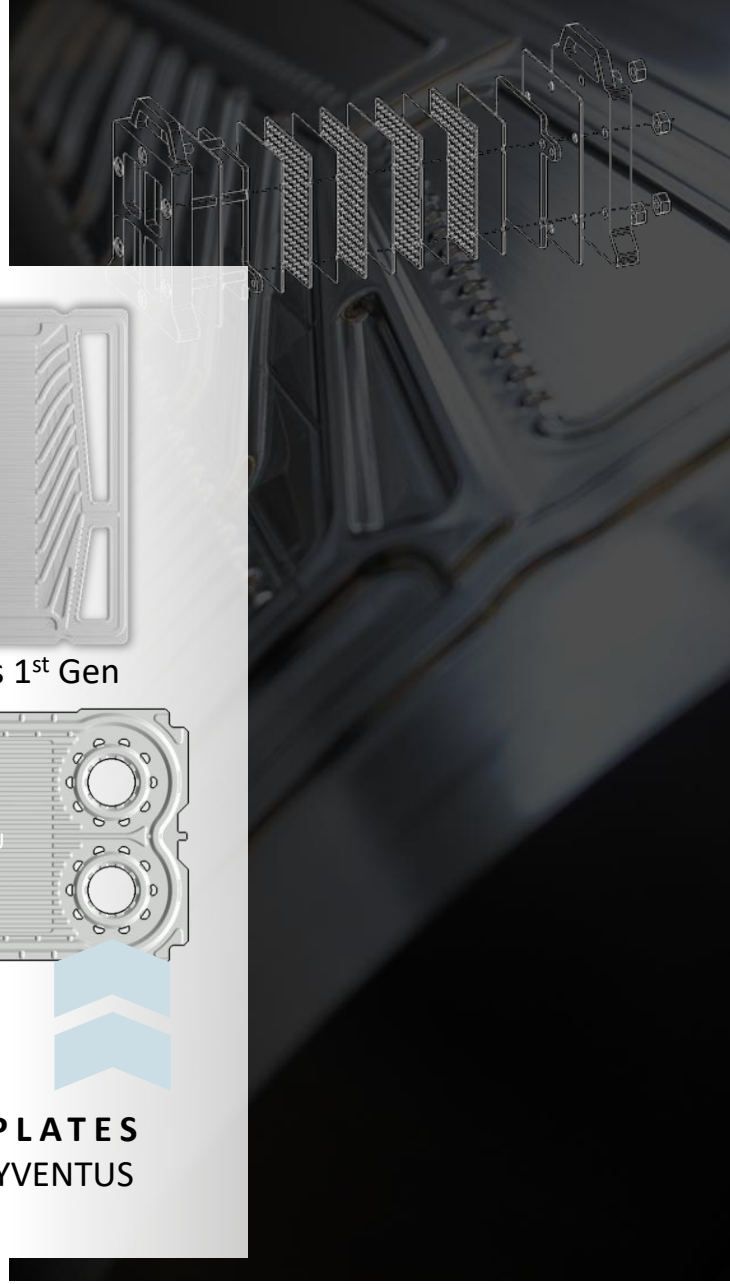
INDUSTRIAL SCALE
FUNCTIONAL FULL-SCALE BPHP
FOR FUELL CELL APPLICATIONS

IWU-Design: HyVentus 1st Gen



IWU-Design: HyVentus
Next Gen

ELECTROLYSER PLATES
IWU ELECTROLYSER HYVENTUS



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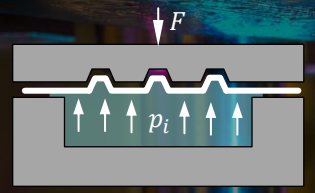
PROS AND CONS…

COMPARISON WITH CONVENTIONAL FORMING PROCESSES

HYDROFORMING



one tool die, forming by media pressure

- high quality channel forming
- only one die necessary
- perfect for forming trials / small batches

production rate: ~10 p/min

sealing force: ~100 %*

**full-scale halfplate*

HOLLOW EMBOSSING (STAMPING)

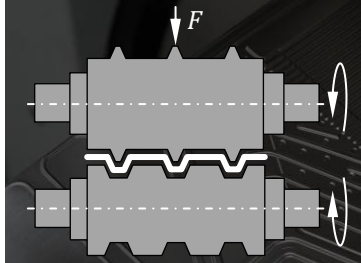
stamping tool with die and punch, optional blankholder

- high quality channel forming
- lower forming forces
- standard for industrial mass production

production rate: <60 p/min

press force: ~10 %*

HOLLOW EMBOSSING ROLLING (HER)



die and punch roller, synchronously rotating, strip feeding with tension

- lowest forming forces by continuous forming
- High production rates

production rate: >100 p/min

rolling force: ~2 %*

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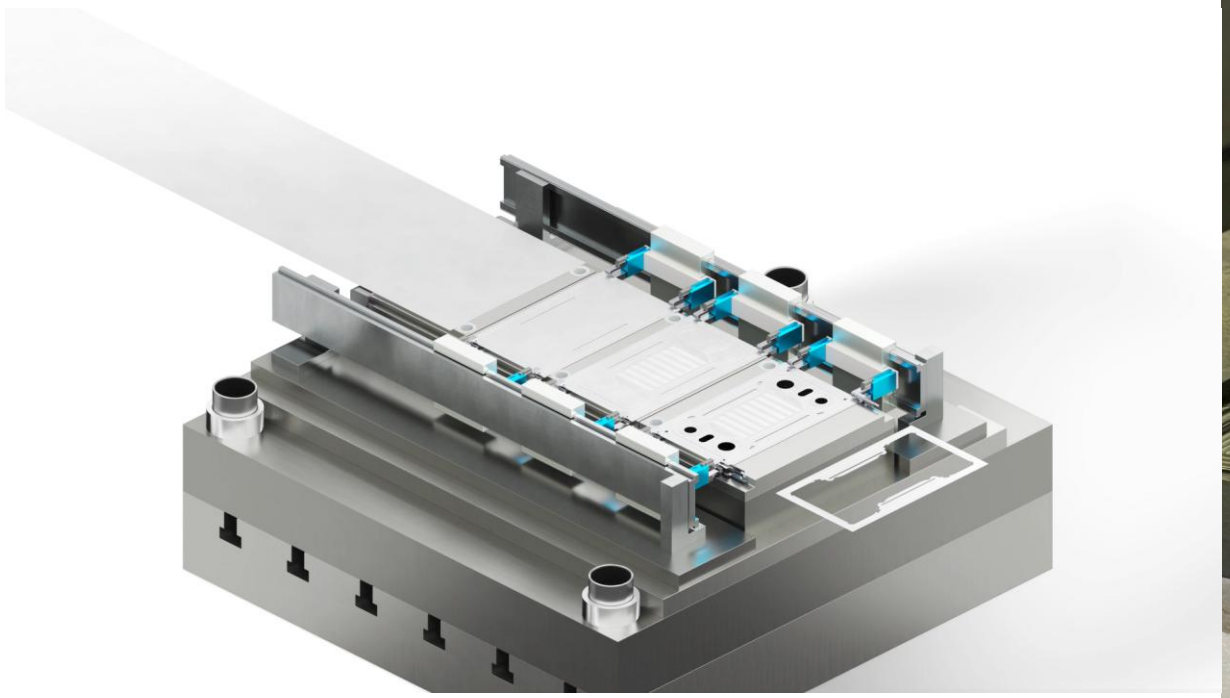
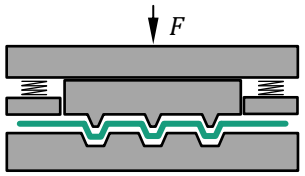
Precision Cutting & Forming!

HOLLOW EMBOSSING (Stamping): INTRODUCTION





stamping tool with die and punch, optional blankholder

HOLLOW EMBOSSING (Stamping)

- Precision fineblanking for burr-free edges
- Fineforming of complex microstructures
- High-accuracy production of metallic bipolar plates
- Industry-oriented research for fuel cell and electrolysis applications

Precision Cutting & Forming!

HOLLOW EMBOSSING (Stamping): INTRODUCTION

Production of BPP by hollow embossing forming

Hydraulic fine-blanking press FB one 11.000

- High-rate production technology
- High Forces up to 11.000 kN (1.100 t)
- Tool size up to 1150 mm x 1150 mm
- Max. coil width 520 mm

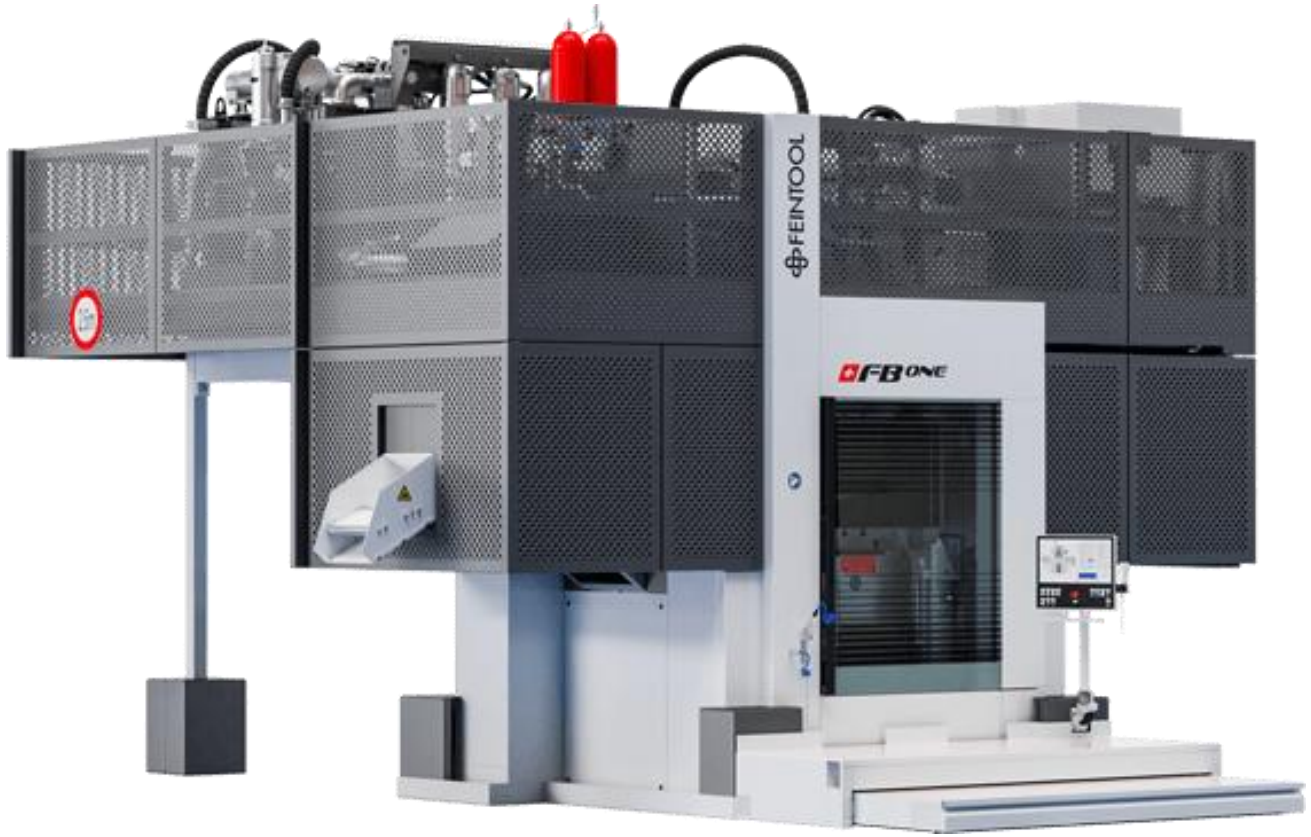


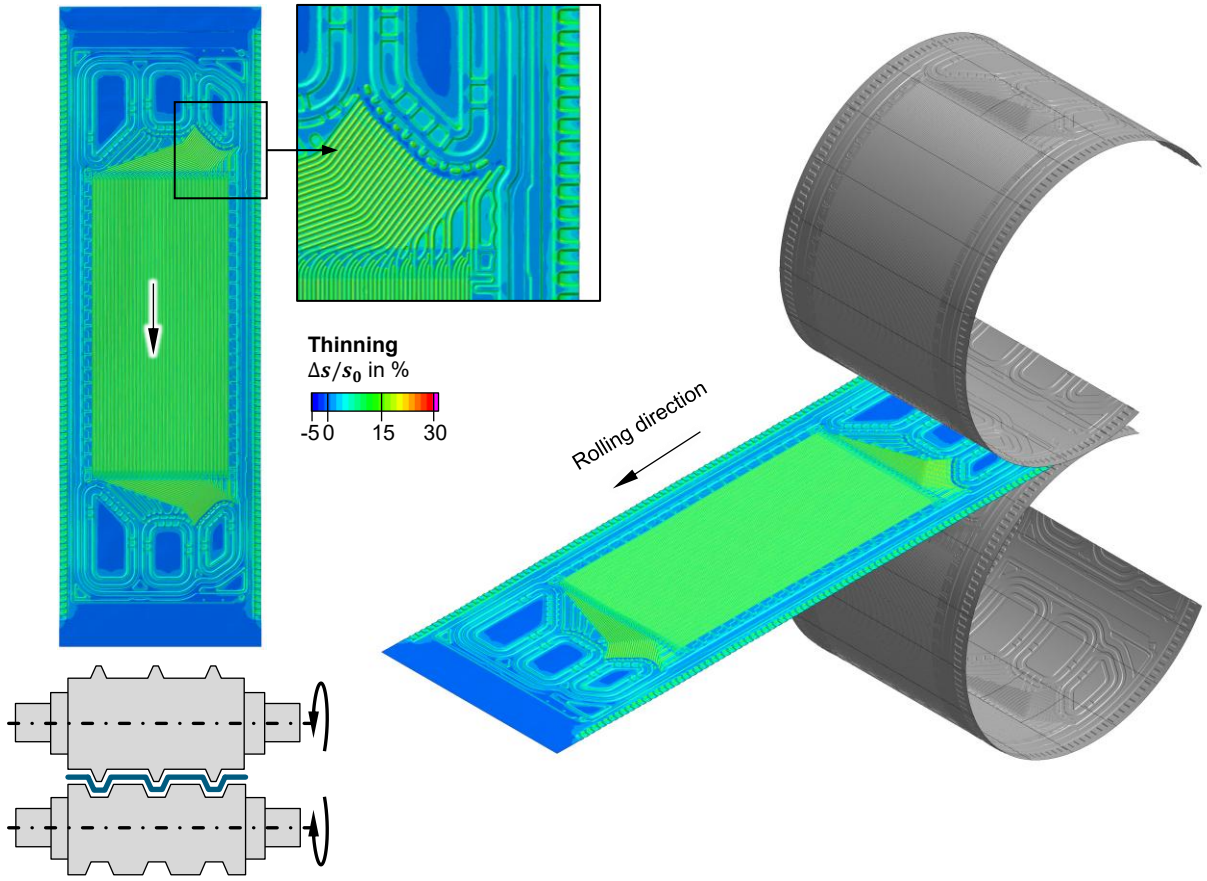
Fig.: Fineblanking Press Fbone

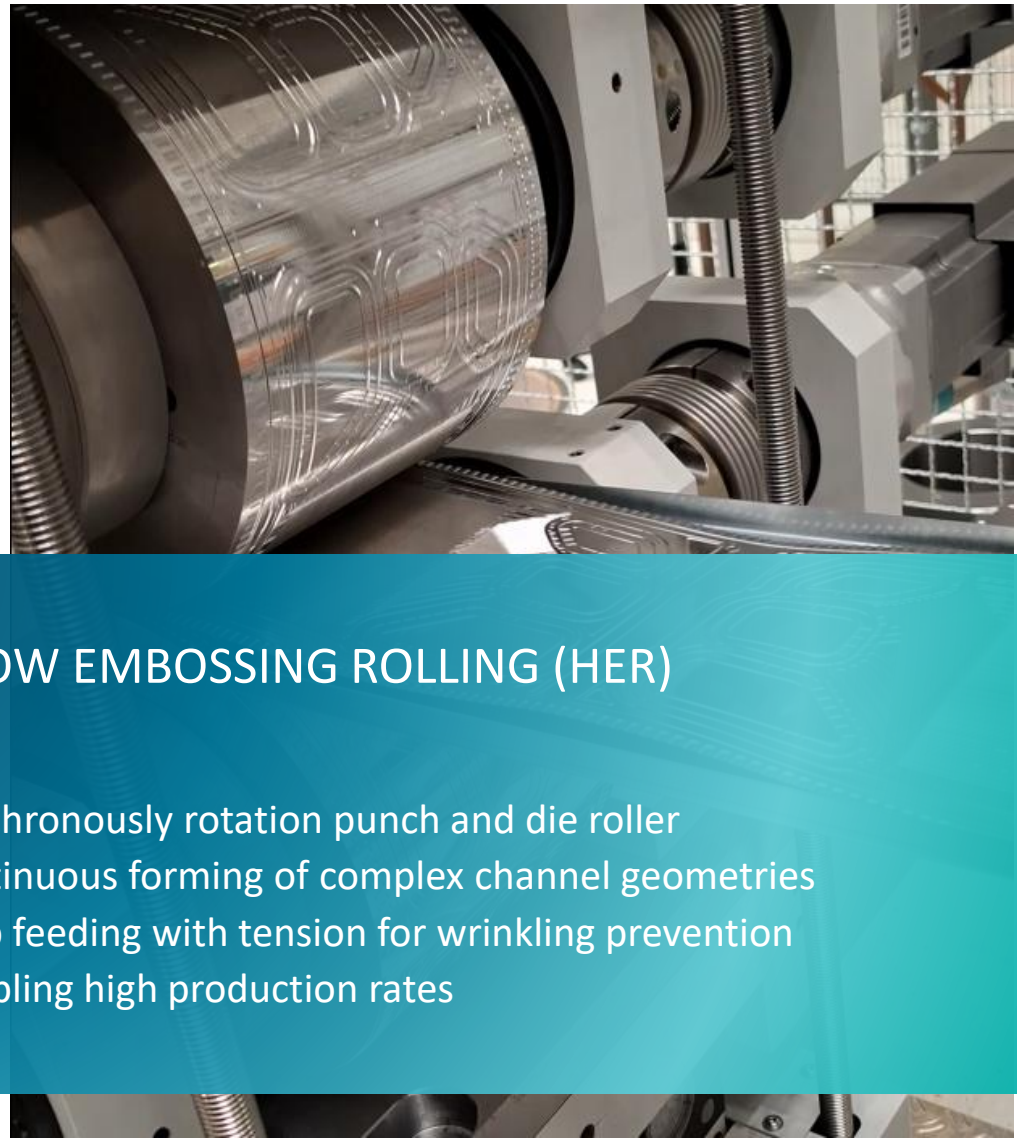
Production line @ Fraunhofer IWU


Belastbarkeit der Werkzeug Einbauhilfe
max. 10500 lbs / 4800 kg
Capacity on Tool Assembly Device max. 10500 lbs / 4800 kg
Capacité de charge de l'outil Aide
à l'installation max. 10500 lbs / 4800 kg


SPEED IT UP!

HOLLOW EMBOSSING ROLLING: INTRODUCTION





HOLLOW EMBOSSING ROLLING (HER)

- synchronously rotation punch and die roller
- continuous forming of complex channel geometries
- strip feeding with tension for wrinkling prevention
- enabling high production rates

HOW ITS MADE?

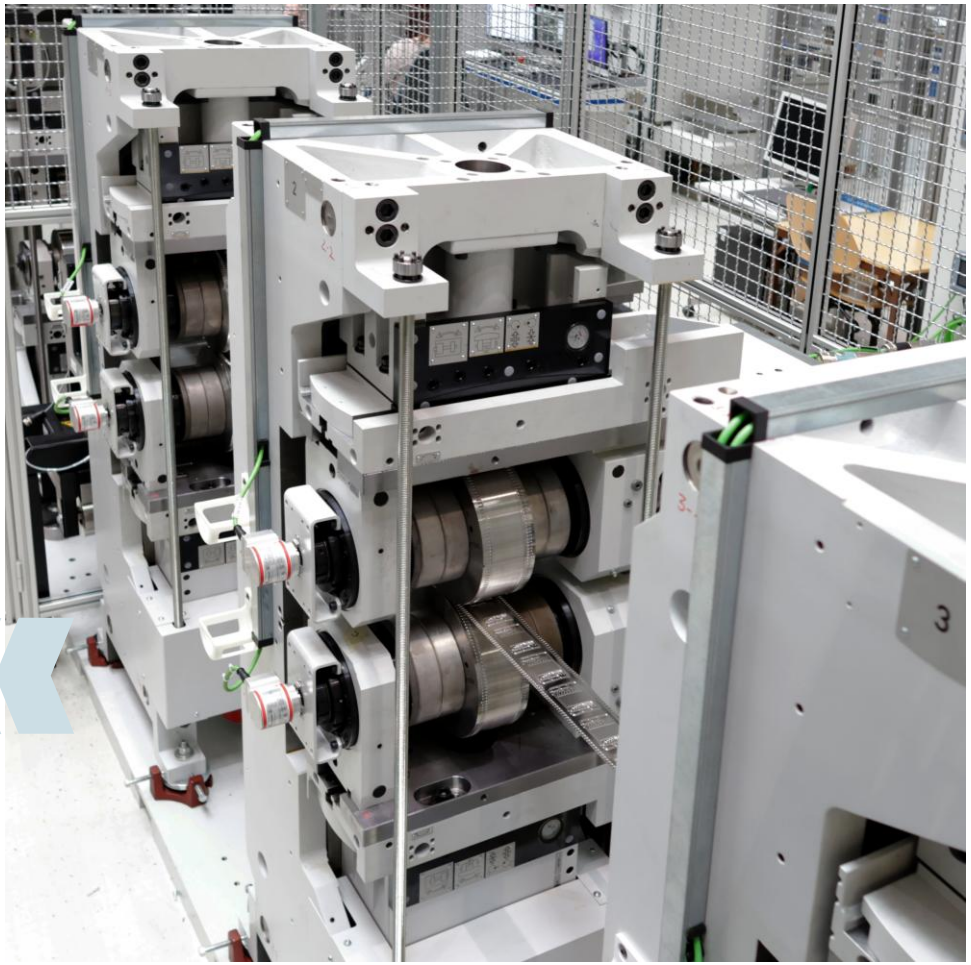
Machinery at Fraunhofer IWU

BPPflexR QL

- max. strip width: **200 mm**
- strip thickness: **0.05 – 0.1 mm**
- diameter range: **240 – 310 mm**
- max. strip speed: **46 m/min** (D245)
- max. torque: **1800 Nm**
- max. rolling force: **75 kN**

- **new feature: multi-step forming**

BIPOLARHALFPLATES
FOR FUEL CELLS

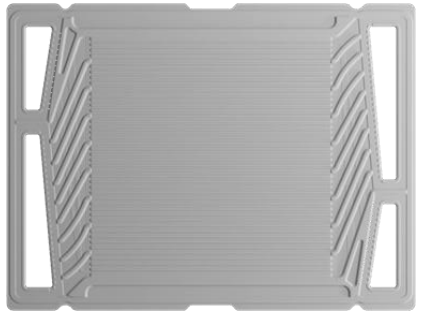


SCALE IT UP!

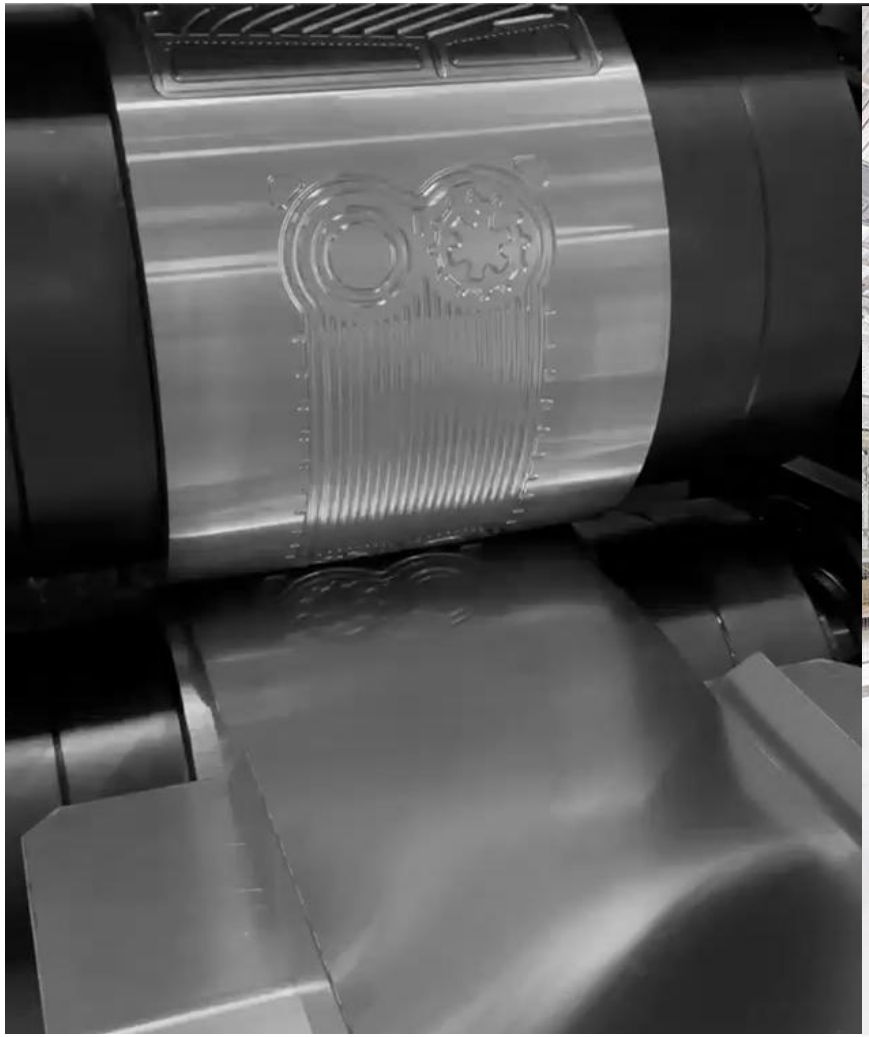
Hollow embossing rolling of electrolyser plates with flexROLL^{MAX}

flexROLL^{MAX}

- max. strip width: **500 mm**
- srip thickness: **0.1 – 0.5 mm**
- diameter range: **320 – 400 mm**
- max. strip speed: **25 m/min** (D400)
- max. torque: **4900 Nm**
- max. rolling force: **600 kN**

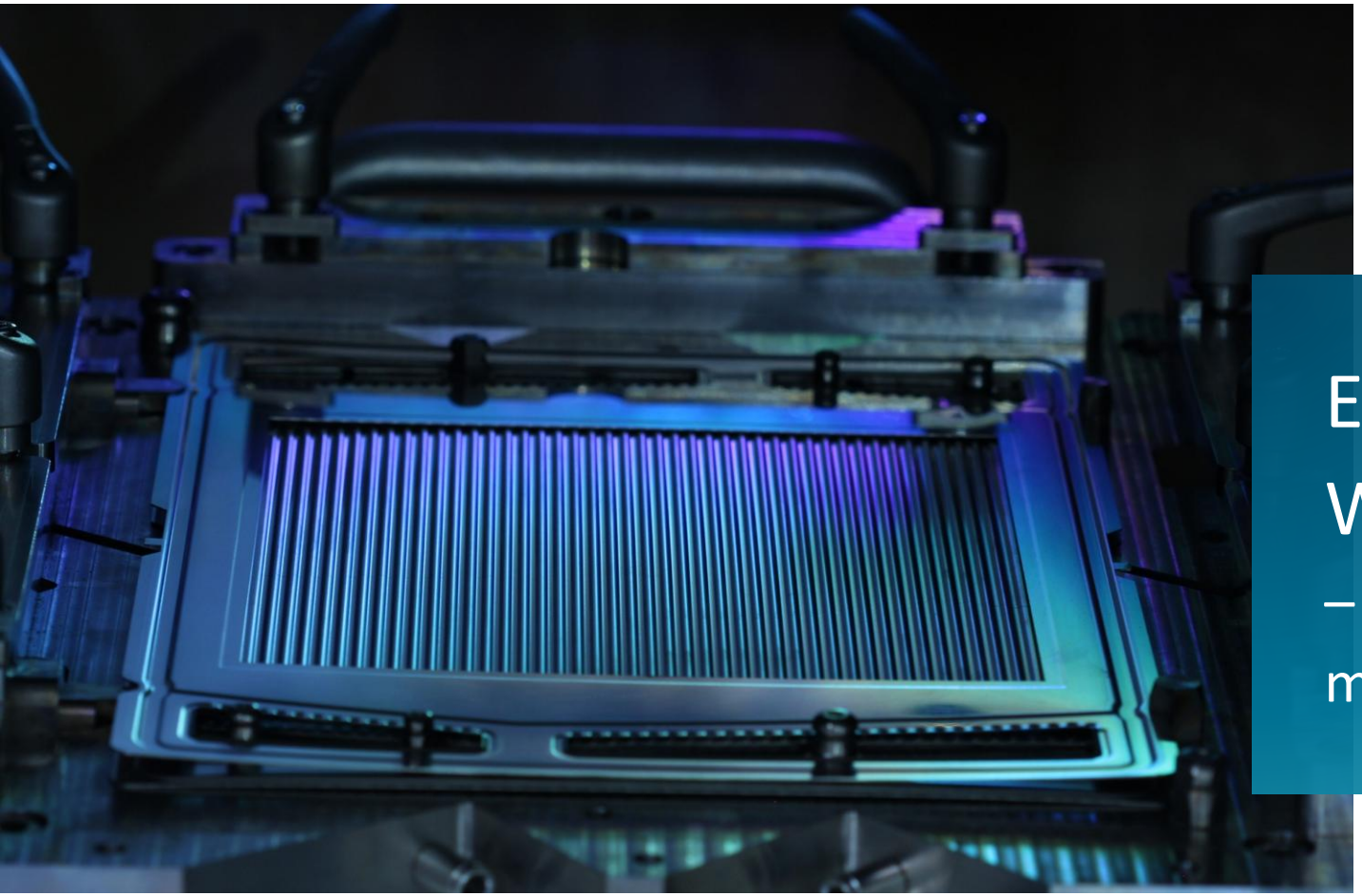


BIPOLARHALFPLATES
FOR ELECTROLYZERS



High-rate joining processes for bipolar plates

High-speed welding processes

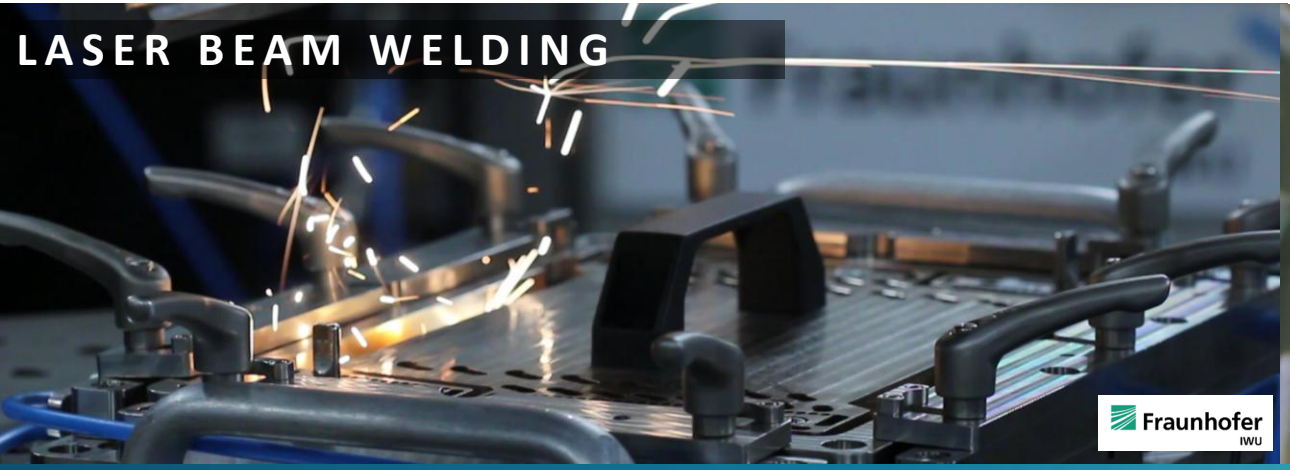


ELECTRON BEAM WELDING

– Technology innovation for joining metallic bipolar plates

High-rate joining processes for bipolar plates

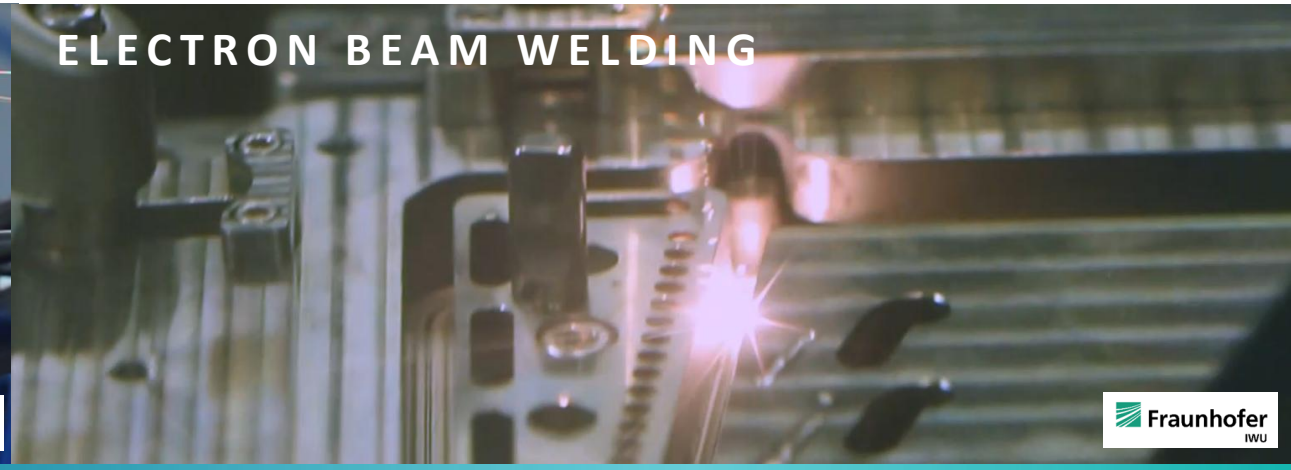
High-speed welding processes



- High weld seam quality, but costly inert gas supply
- Narrow, filigree weld seams
- Fast and flexible production scaling through parallelization

Production Rate: ~ 20 BPPs /min *(1 Strahl / 1 Scanner)*

Welding speed: > 1,0 m/s



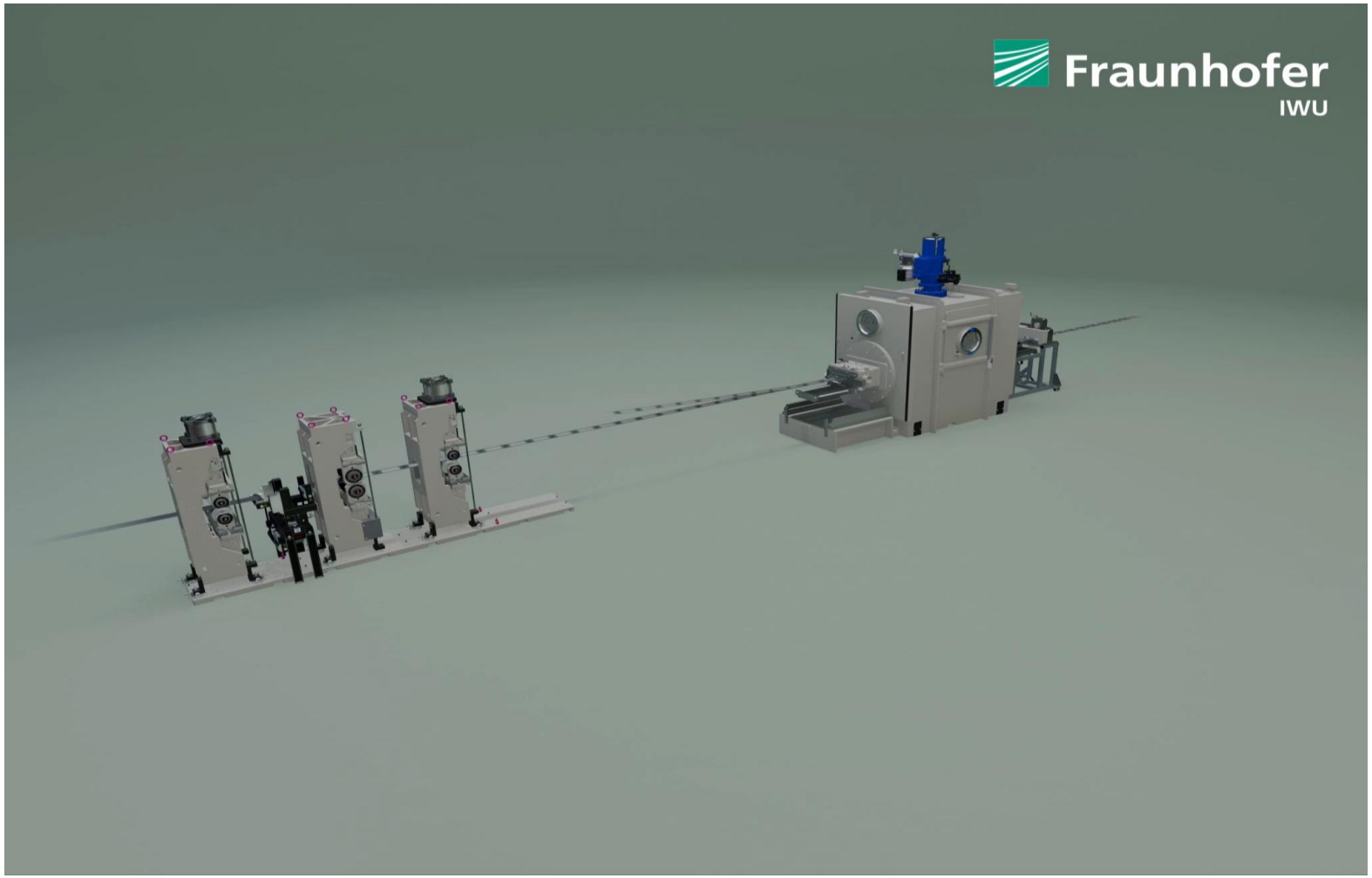
- Highest weld seam quality
- Multiple process zones with just one beam
- stable process conditions, as the process is in a vacuum environment

Production Rate: ~ 40 BPPs /min *(1 Beam, 4 Melt Pools)*

Welding speed: > 0,6 m/s

High-rate joining processes for bipolar plates

High-speed welding processes - ELECTRON BEAM WELDING



High-rate joining processes for bipolar plates

High-speed welding processes - ELECTRON BEAM WELDING

FUEL CELL

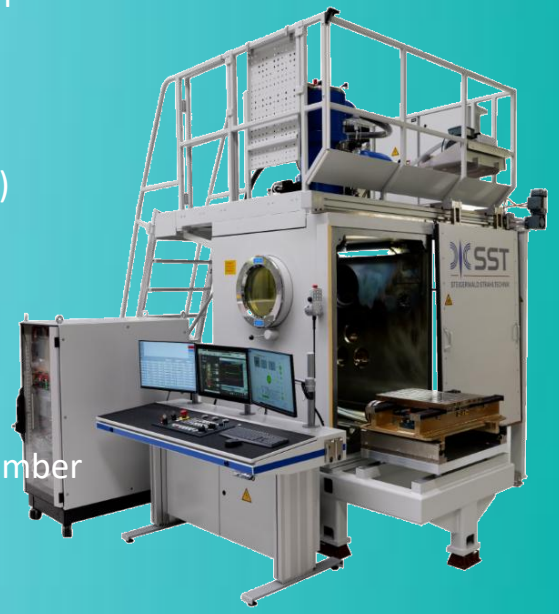
TechnologyFOCUS: WELDING of thin metal sheets $t \leq 0{,}10$ mm

- Welding area: < 300 x 300 mm
- Working chamber: 4,9 m³
- Vacuum: < 20 min ($7*10^{-4}$ mbar)
- Power: 30 kW
- Beam-Ø: < 150 µm
- High-rate capability: Strip feed vacuum lock

ELECTROLYSERS

TechnologyFOCUS: FUNCTIONALIZATION of metal sheets $t > 0{,}10$ mm

- Welding area: < 160 x 160 mm
- Working chamber: 1,25 m³
- Vacuum: 12 min ($7*10^{-4}$ mbar)
- Power: 15 kW
- Beam-Ø: < 150 µm
- High-rate capability : only chamber

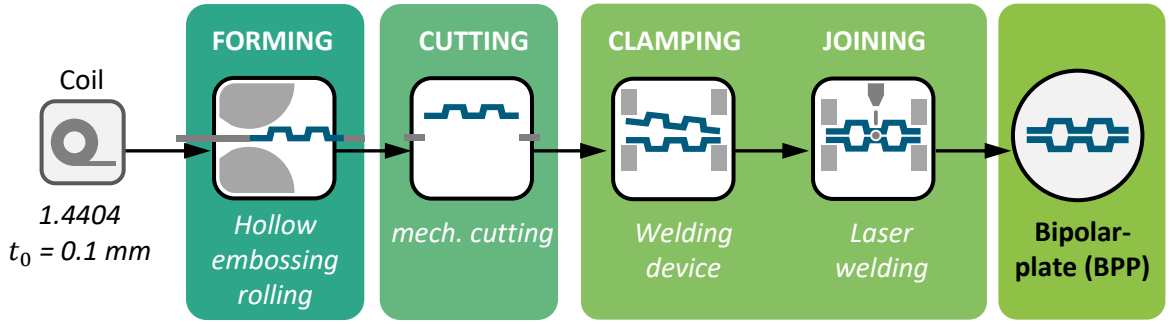


Methodology for holistic process chain analysis and modeling

using the example of bipolar plate production

Deutsche Forschungsgemeinschaft

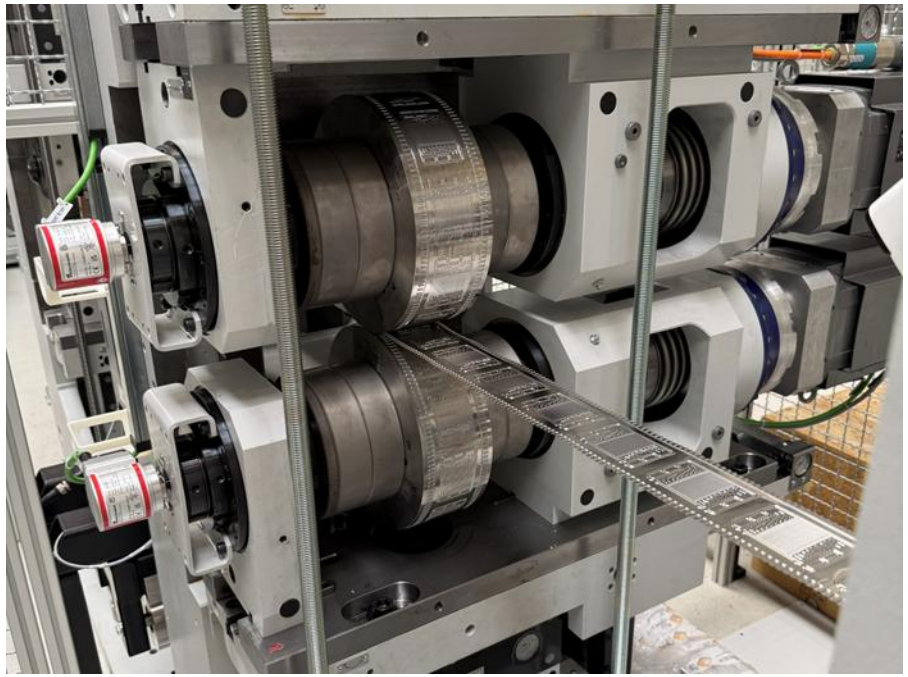
A **coupled process chain model** enables multi-criteria inverse **optimization** of the BPP manufacturing process.



Research focus:

key control and disturbance variables influencing quality

efficient process modelling and global **inverse optimization** by FE and surrogate modelling



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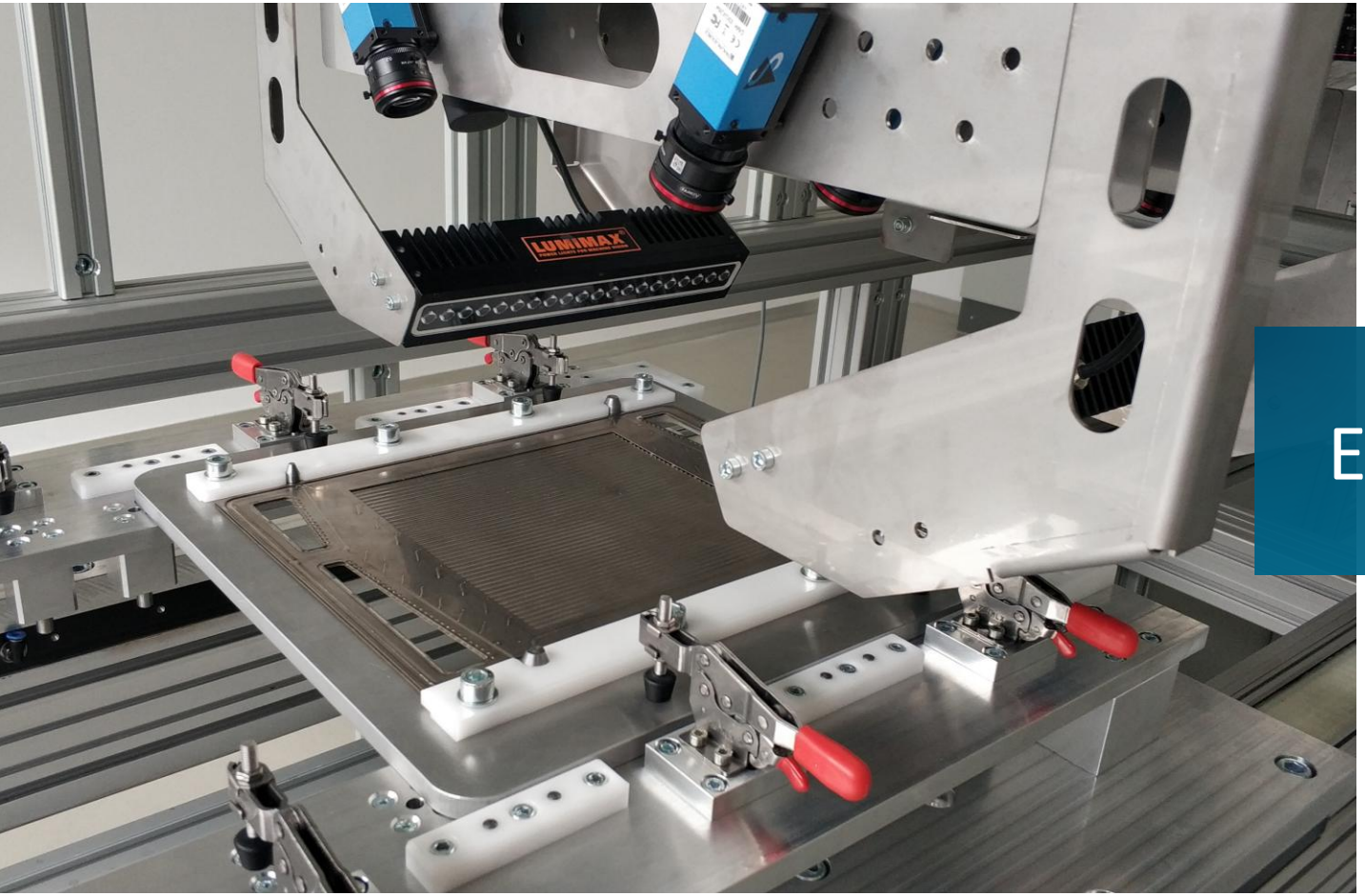
SPP 2476 wpt werkstoff-prüftechnik Fraunhofer IWU

Inline-capable quality inspection in high-rate bipolar plate production



EOL testing of bipolar plates

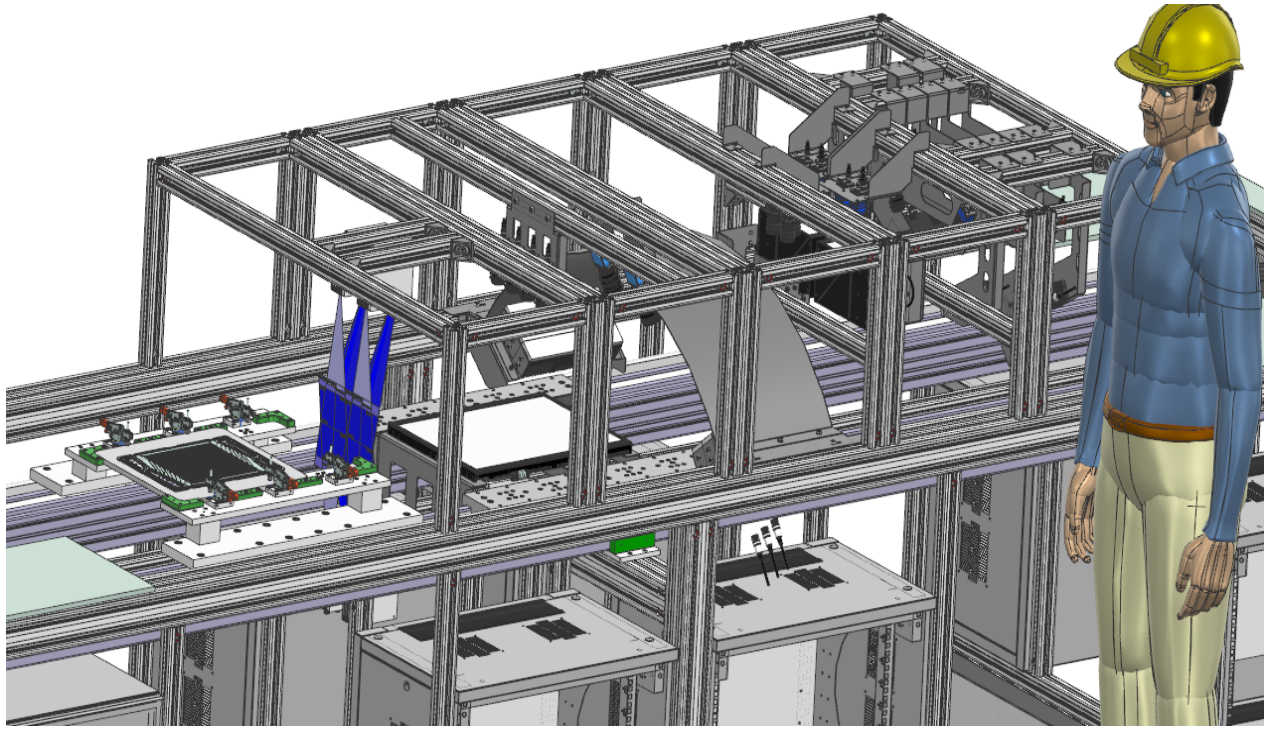
Gefördert durch:
Leitprojekt H2Giga
Bundesministerium für Forschung, Technologie und Raumfahrt
Finanziert von der Europäischen Union NextGenerationEU

Inline-capable quality inspection in high-rate bipolar plate production

Efficient Inline Quality Control for Electrolyzer Plates

High-rate inline testing system

- AI-based quality inspection within 1 second per component in the longitudinal direction on product carriers (inspection at speeds of up to 500 mm/s)
- Sensor and data fusion of 2D, 3D and eddy current sensors in combination with different lighting concepts enable reliable detection of critical defects
- Parallel data processing up to **2.5 GByte/s** (hardware dependent)
- Modular substations, designed for flat components Quality assurance with high resolution (hardware dependent)



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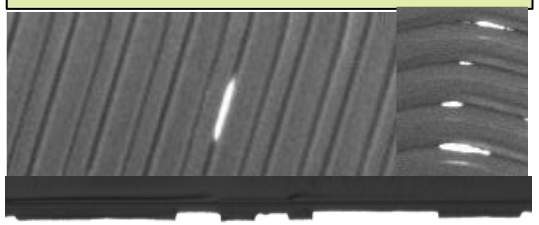
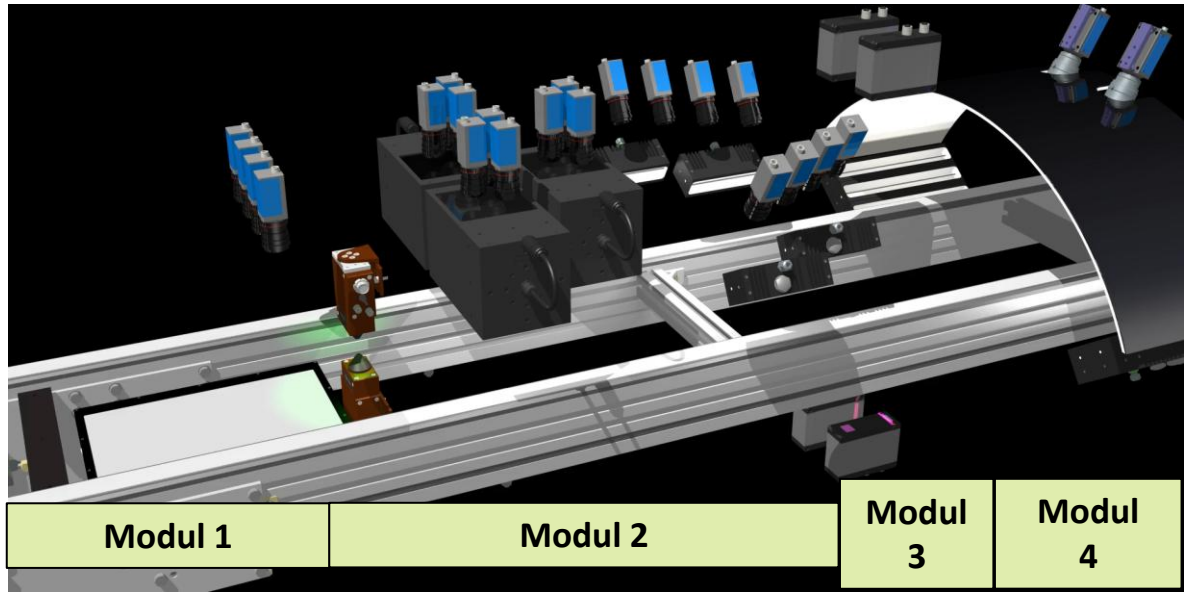
Inline-capable quality inspection in high-rate bipolar plate production

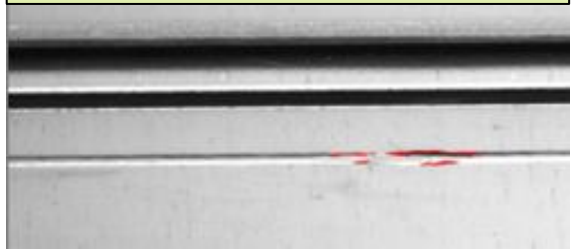
1. Cracks and burr residues



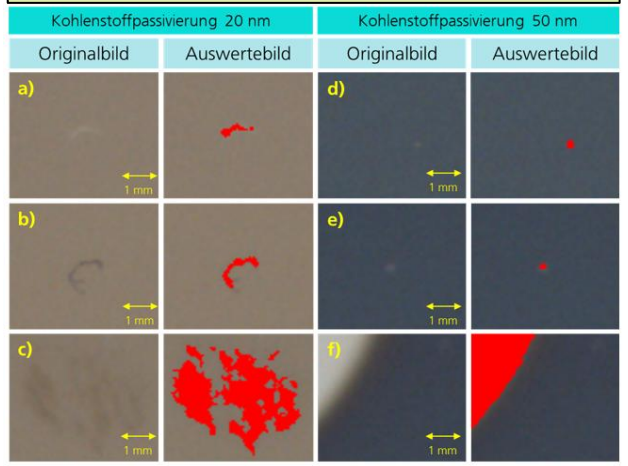
2. Forming defects



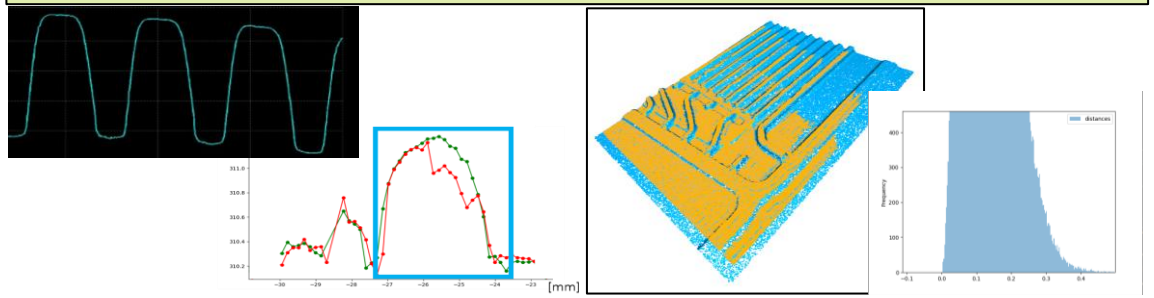
2. Joining errors



4. Coating defects



3. Geometric shape deviations



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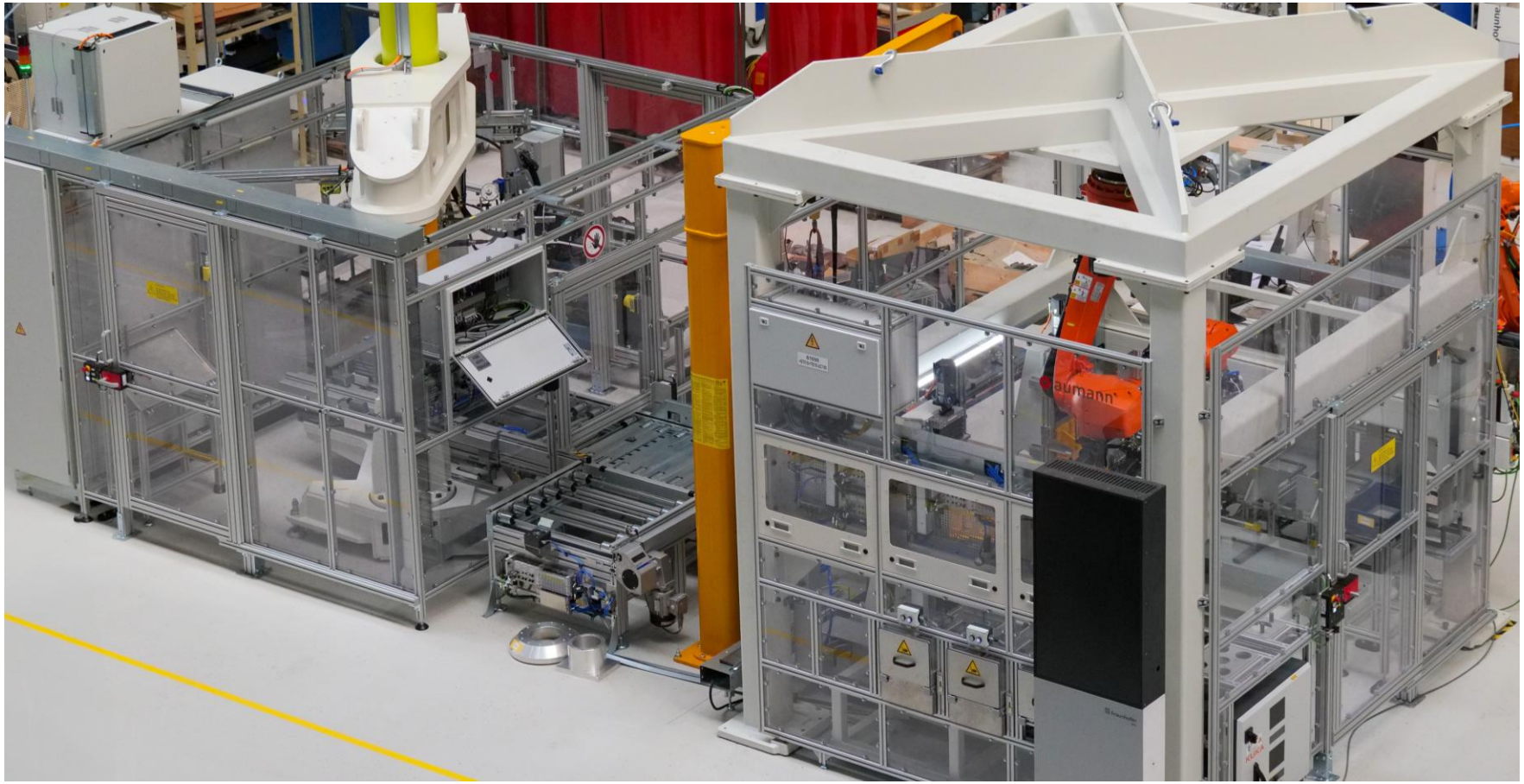
Stacking system

Automated production of Electrolyzer and fuel cell stacks

Stack - Assembly technology

Stacking system

Automated production of Electrolyzer and fuel cell stacks



- Stacking system developed in cooperation with Aumann
- installed in the Fraunhofer IWU research factory;
  put into operation and ready for use since 06/2025
- From left to right:
  - 500 kN Servo Electric Press,
  - Transfer and assembly station with crane,
  - Automated robot cell with drawers for single part delivery

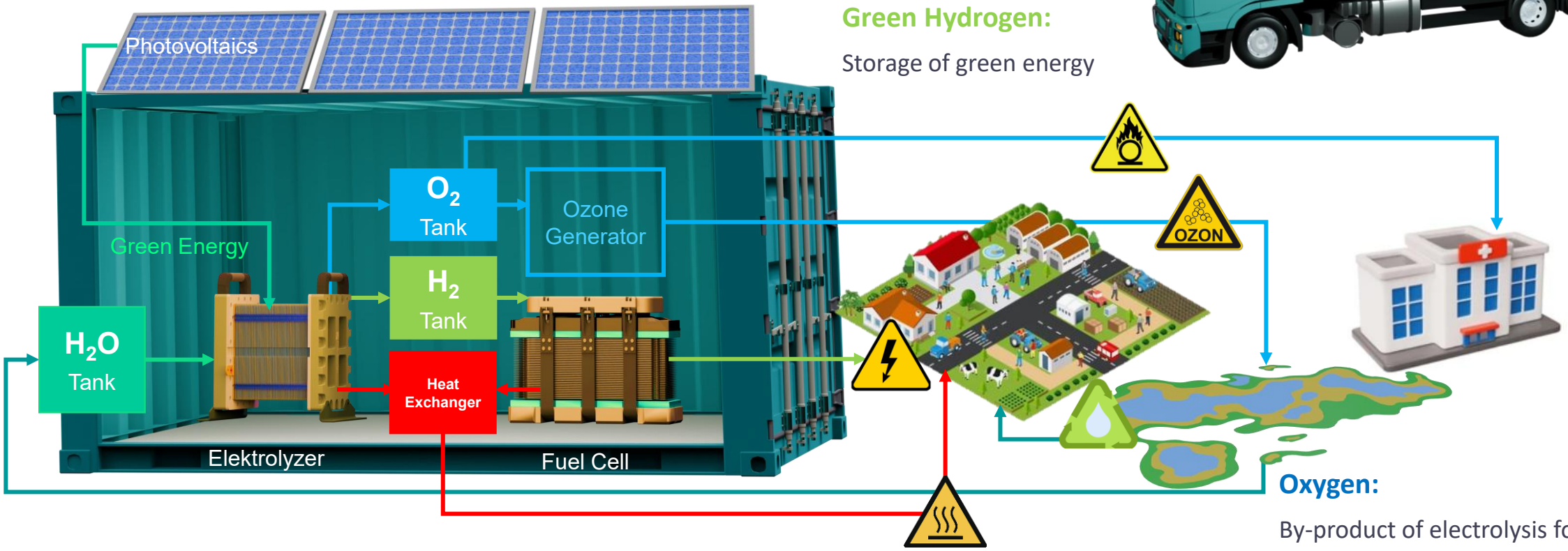
Microgrid

Hydrogen Microgrids Make Sun and Wind Storable

Hydrogen Microgrids

Mobile Microgrid

Setup and Use



Green Hydrogen:

Storage of green energy

Oxygen:

By-product of electrolysis for:

- Water treatment, e.g. disinfection
- Medical application - ventilation

25% Efficiency Increase :

Utilization of waste heat of electrolyzer and fuel cell to improve overall system efficiency

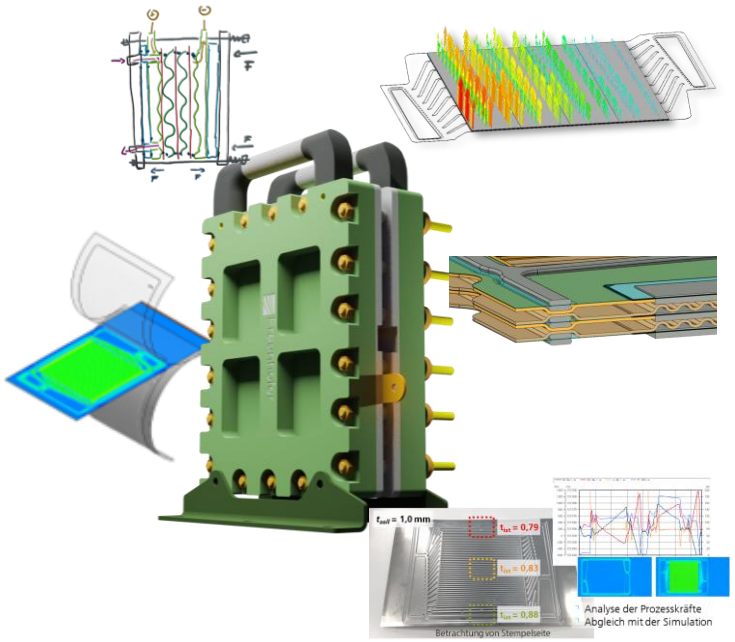
Electrolyser

Development and Sustainability

DESIGN

- Methods of DFMA applied
- Robust designed for manufacturing
- Numerically simulated & technically validated

➔ **Concept**



PRODUCTION

- High-rate capable technologies developed
- Manufacturing costs reduced by 50%
- Partnerships established

➔ **Platform**

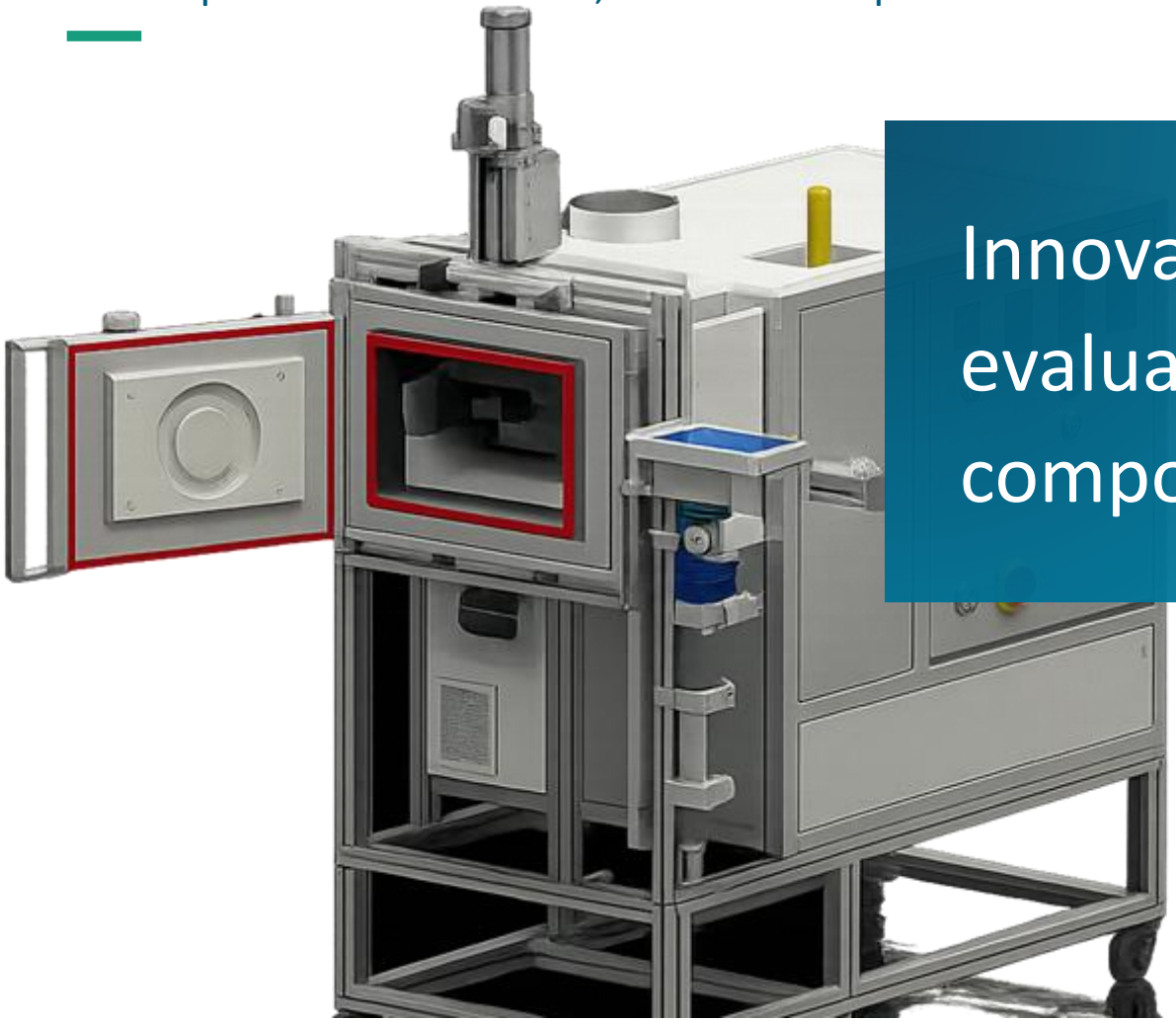
USE

- Implementation in developed microgrid
- Long-term storage of green energy
- Production of oxygen for water treatment

➔ **Demonstrator**

HZwo: CoatProof – Ready for Hydrogen

Development of a universal, modular component test bench for joining technologies and coatings



Innovative universal test bench for evaluating coatings and components/fittings under H_2 exposure

Hegewald & Peschke Meß- und Prüftechnik GmbH

Mechanical Engineering / Testing Technology
Uwe Naumann, BEng (FH)
u.naumann@hegewald-peschke.de

AZ INTEC

Fittings / Piping Technology
André Hänig, Ronny Walther
andre.haenig@azintec.com
ronny.walther@azinztec.com

CoatProof – Ready for Hydrogen

Motivation

Enabling rapid, standardised certification of hydrogen-exposed assemblies and components.

Contributing to ensuring the functionality, safety and longevity of hydrogen system components.

AZ INTEC

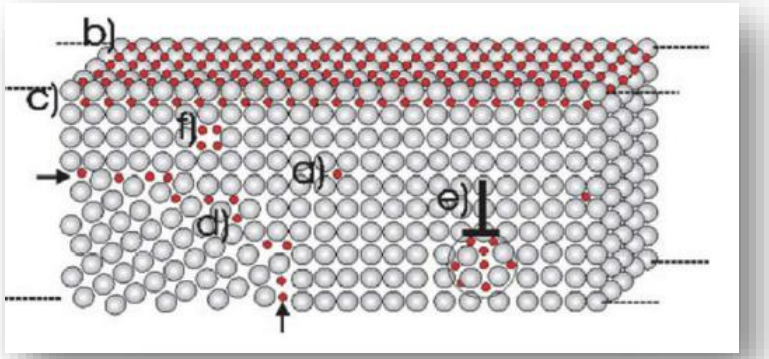
3-way ball valve

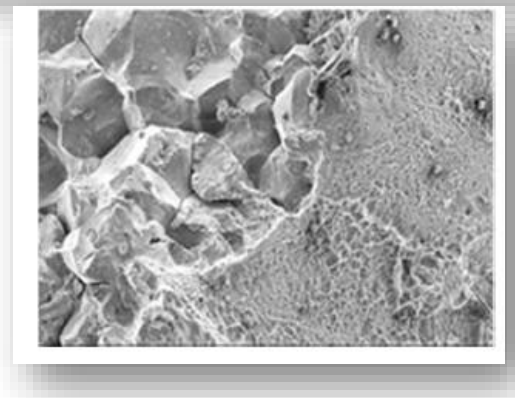
AZ INTEC

Differential pressure gauges

AZ INTEC

Regulating and shut-off valves





The relationship between defects in steels and the accumulation of hydrogen atoms
top: schematic representation
below: fracture surface of a ferritic steel component cracked as a result of hydrogen embrittlement

CoatProof – Ready for Hydrogen

Technical development and initial results

Modular pressure-tight test chamber

- Pressure-tight
- Modular, variable test set-ups

Safe media routing and safety technology

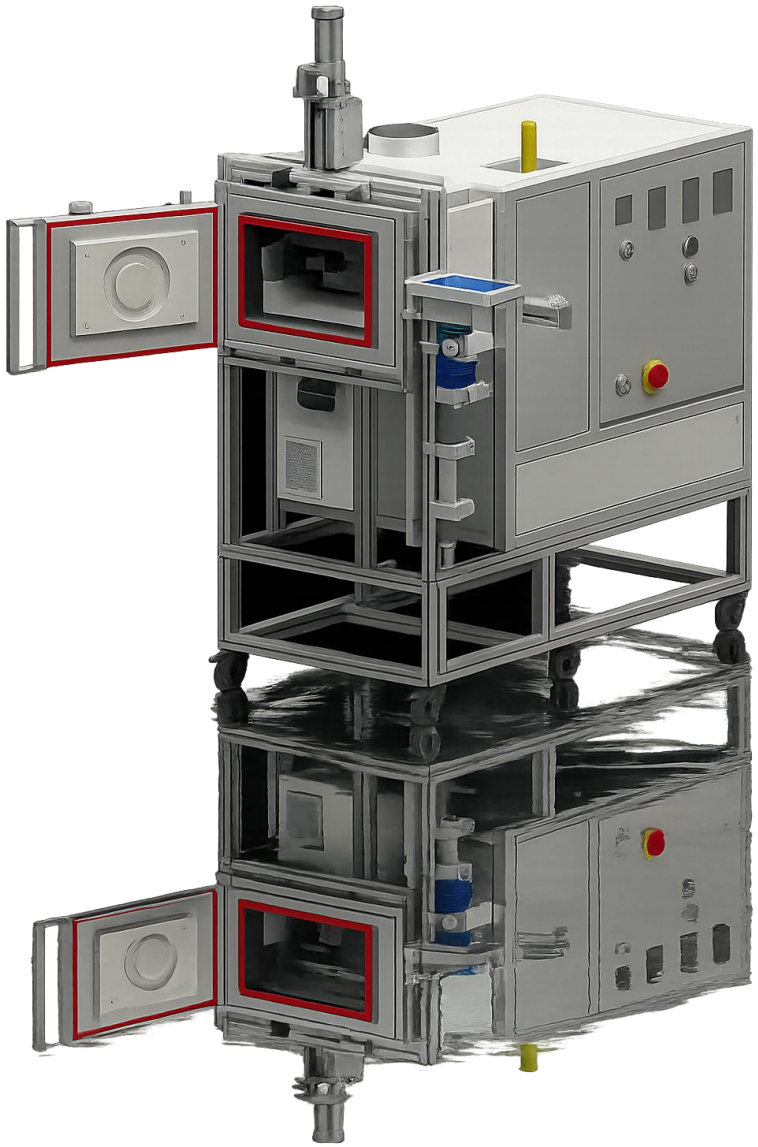
- Separate piping systems for hydrogen and inert gas
- Safety components such as non-return valves and monitoring sensors ensure a high level of safety

Mechanical dual drive concept

- Axial force drive and torsional torque drive operate outside the chamber
- Force transmission is gas-tight
- The basic mechanical design, with separation of hydrogen-carrying areas and electrical components, ensures safety.

Control and regulation technology

- The Beckhoff-based platform synchronizes force- and position-controlled movements with high control quality.



GET IN TOUCH WITH US!

Service portfolio

PROCESS OPTIMIZATION

MACHINE DESIGN

BPHP DESIGN

WELDING AND SEALING

VIRTUAL MODELLING

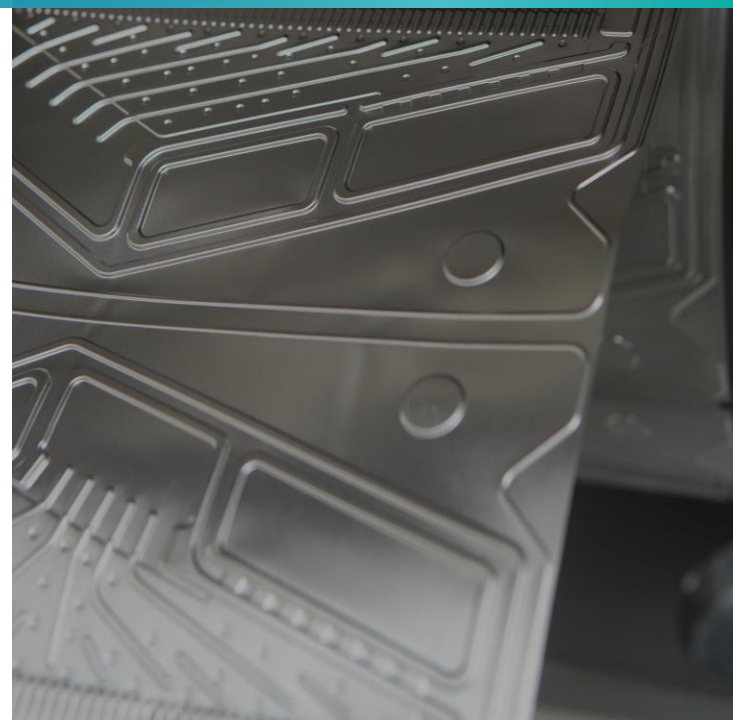
EXPERIMENTAL TRIALS

SENSOR INTEGRATION

QUALITY CONTROL

FROM DESIGN TO PLATE

Fraunhofer IWU offers a complete portfolio of services ranging from the design of bipolar plates and forming simulation to the development of customer-specific manufacturing systems.



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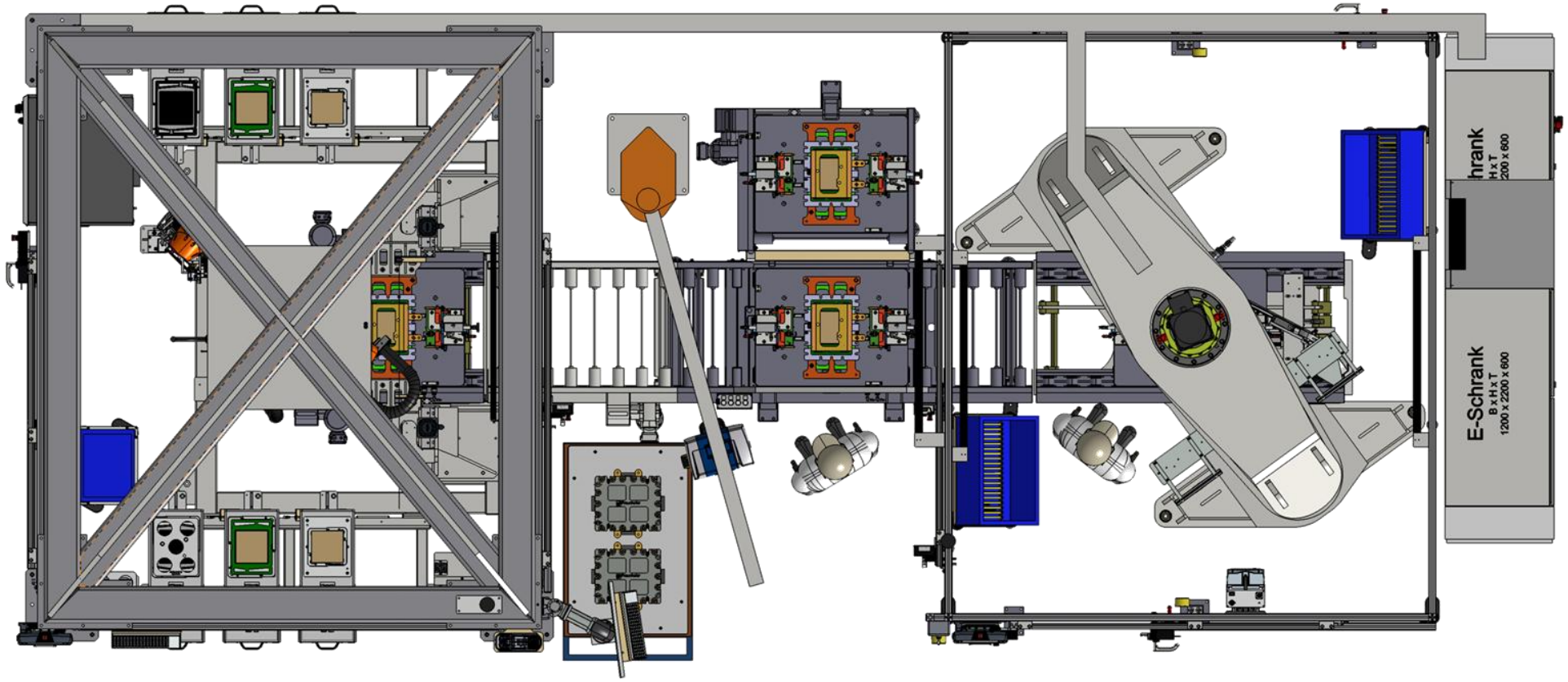
Stacking system

Structure of the stacking unit

Station 10 - Stacking

Station 20 - Assembly

Station 30 - Press



Automatic machine. Stacking of up to 6 components with robot and cameras for position correction

Placing the lower and upper end plates

Pressing the stack, manual screwing with torque

High-rate joining processes for bipolar plates

High-speed welding processes - ELECTRON BEAM WELDING

H2GO

BPP FUEL CELL Production

Material infeed section	Process / welding section	Strip outfeed section