



**CENTER
FUEL CELL
INDUSTRIALIZATION**



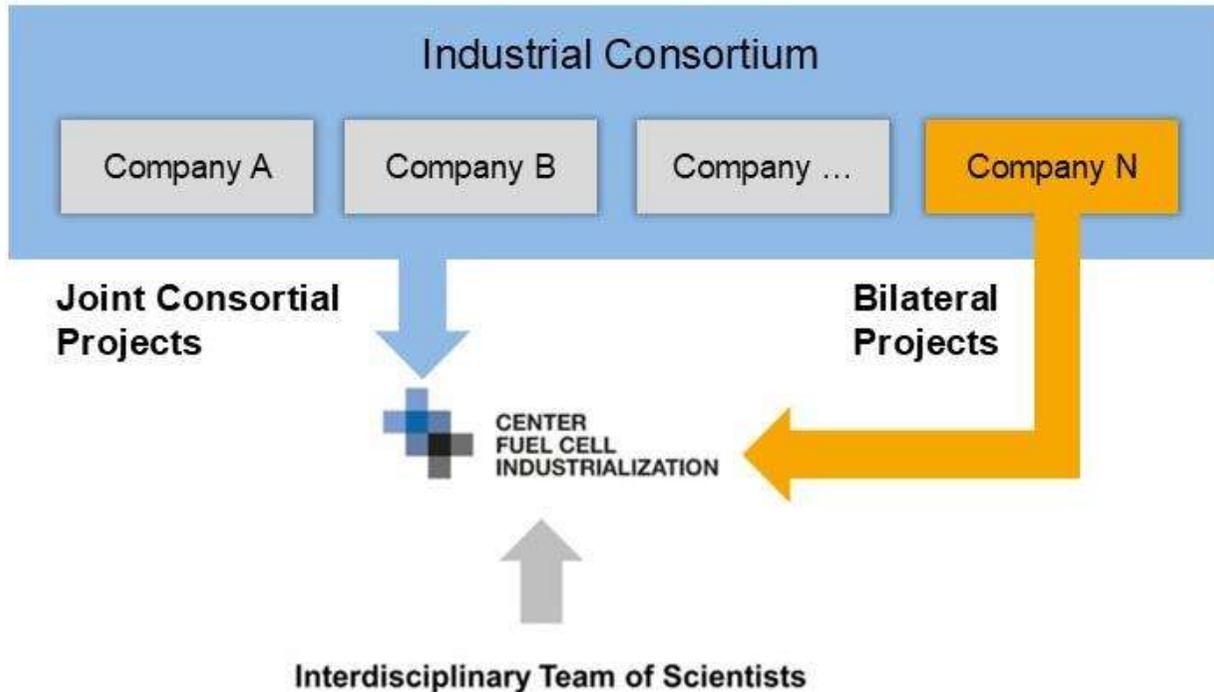
Fuel Cell Industrialization

Center Fuel Cell Industrialization - FCI

Enabling Hydrogen Economy

Introduction

Introduction FCI – Outlook to Center Year 2025

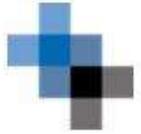


- Utilization of previous results in knowledge projects and physical test environment, e.g. FCI FC-Stack an FCI EL-Stack
- Strong demand for additional bilateral deep dive technology projects by partner companies
- Wider scope in Hydrogen Infrastructure & Systems



Center Overview 2025

Projects and Workgroups



	Market & Technology	Fuel Cell Technology	Electrolyzer Technology	Hydrogen Infrastructure & Systems
High-Level Workgroups*	Market- and Technology-Monitoring	FC Technology Monitoring	EC Technology Monitoring	Hydrogen Systems & Infrastructure Monitoring
Detailed Projects	Meta Projects (Knowledge & Research)	Research and Prototyping Projects for FC	Research and Prototyping Projects for EC	Research and Prototyping Projects for Hydrogen Systems

Incl. in Premium Center Partnership

* Basic Partnership content is included in Premium Partnership

Technical Updates on Stack Bipolar Plates – Mass production capability in the industry

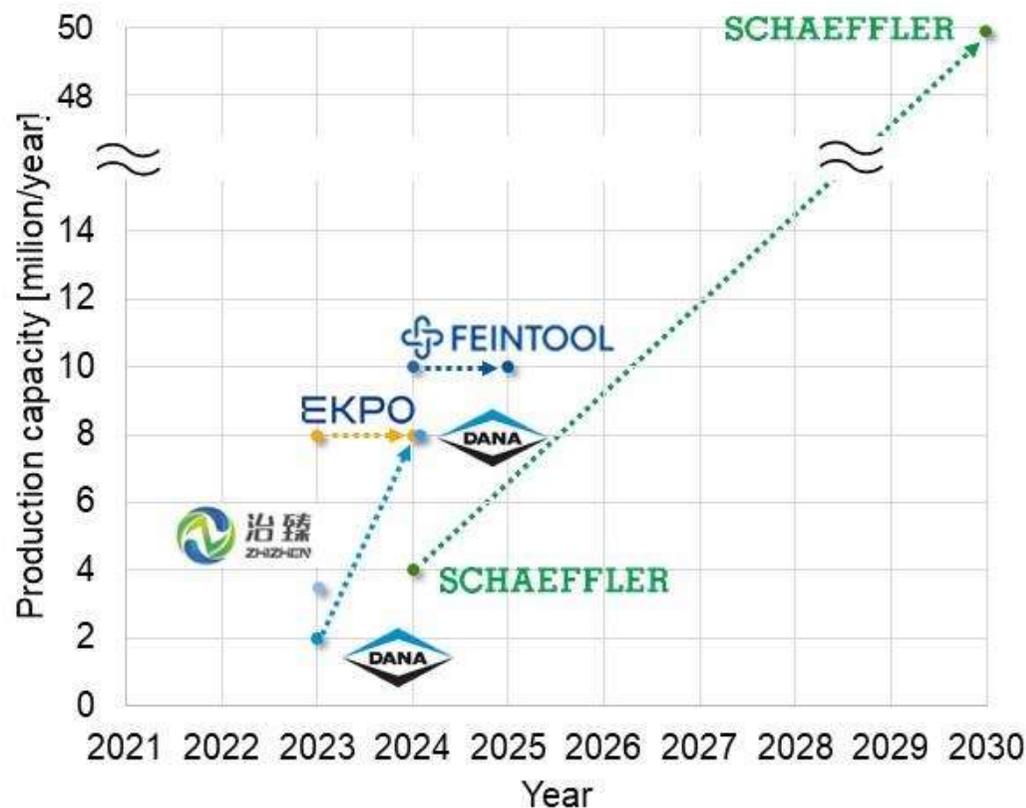


BPP production capability of different industries

Company	Year	Production scale [mil/year]	Partner
Feintool	2024	10 [FEIN23a]	N/A 'FC manufacturer in China'
Dana	2023	2 [DANA23]	Bosch
Dana	2024	8 [DANA23]	Bosch
Schaeffler	2024	4 [SCHA23b]	Symbio
Schaeffler	2030	50 [SCHA23b]	Symbio
EKPO	2023	8* [EKPO23]	N/A 'Global Automotive Manufacturer'
Zhizhen	2023	3,5 [ZHIZ23]	N/A

The production figures were mostly published in 2023 and 2024. It is assumed that an expansion of production would have been announced.

* Company can produce 10000 stack/year [EKPO23], considering that each stack contains 400 bipolar plates it would result in 8 million BPPs



Fraunhofer Hydrogen Capabilities

Introduction to H₂ related activities at Fraunhofer IPT

Our Ecosystem

Access to two unique networks as a breeding ground for industry-oriented research and consulting

 **Fraunhofer**
Gesellschaft

75

Institutes & research facilities

3

Institutes in Aachen

29.000

Employees

> €2.8 billion

Research volume per year

**Europe's largest organization
for applied research**

 **Fraunhofer**
IPT

216

Scientists, consultants & employees

31 million €

Operating budget

8.000 m²

machine halls and laboratories

32

Spin-offs

RWTHAACHEN
UNIVERSITY

260

Institutes

540

Professors

(66 at the Faculty of Mechanical Engineering)

5.370

Scientists

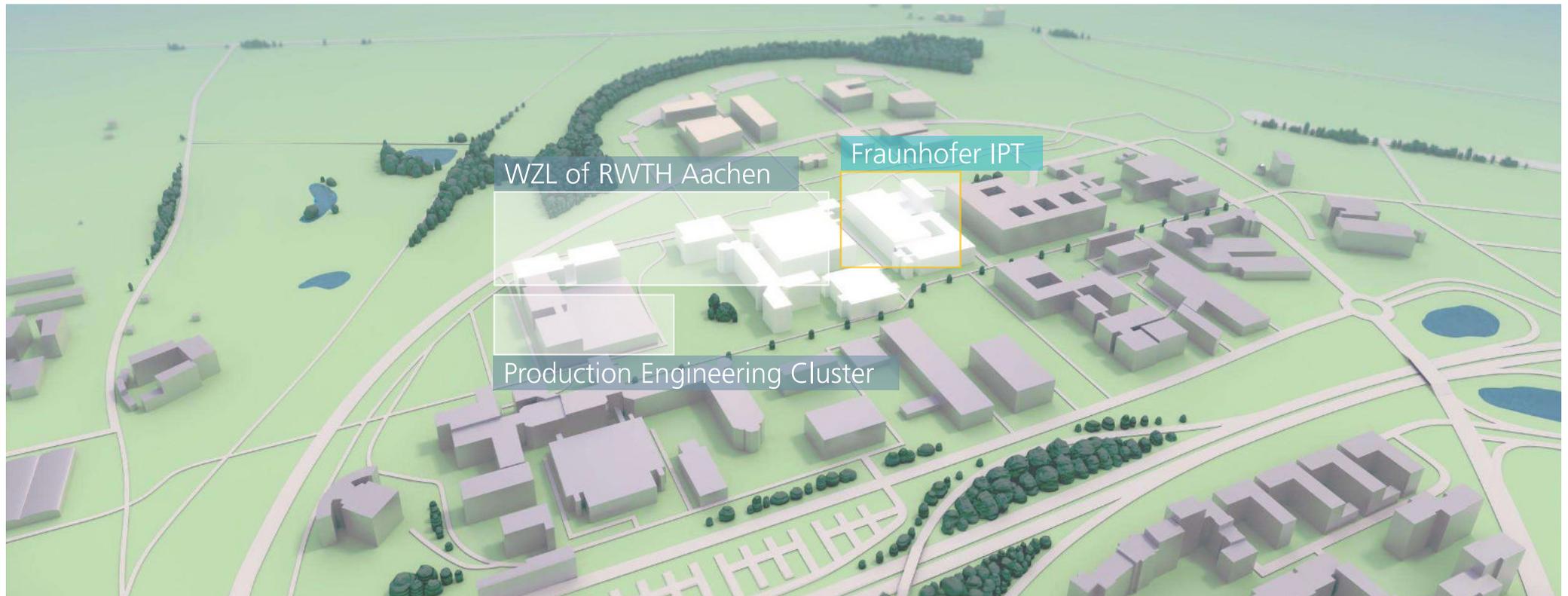
(1,340 at the Faculty of Mechanical Engineering)

900 million €

Budget (€ 325 million third-party funding)

The Fraunhofer IPT is located in Aachen

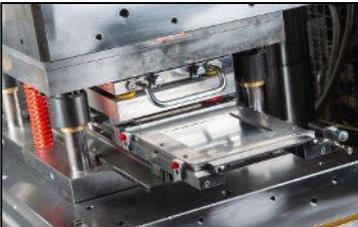
One of the largest research centers for production technology



Technology Study for Emirates Hydrogen Valley

Fraunhofer IPT competence

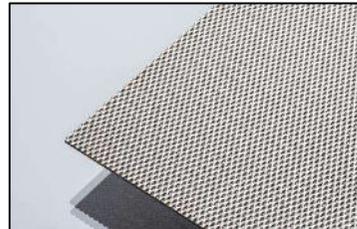
Machines and Tool manufacturing



System testing

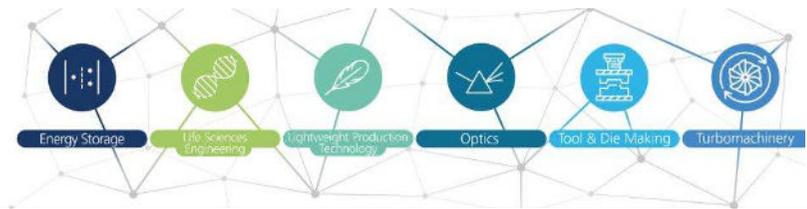


Products



IPT Competence

- Technology overview for hydrogen systems
- Prototype manufacturing of parts and products
- Process development and optimization
- Technology benchmarking and evaluation
- Definition and evaluation of production chains
- Handling, automation, and digitalization
- Cost analysis & scale-up
- Economic feasibility studies
- Market analysis and market trends

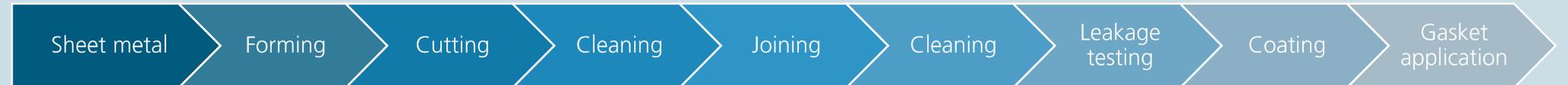


Source: Fraunhofer IPT

Bipolar plate production

Manufacturing process chain and technologies overview

Process Chain for BPP production assembly (handling steps excluded)



Capabilities along the process chain

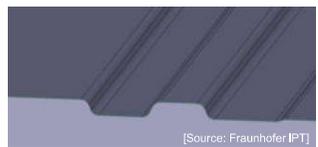
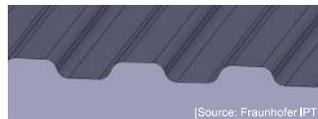
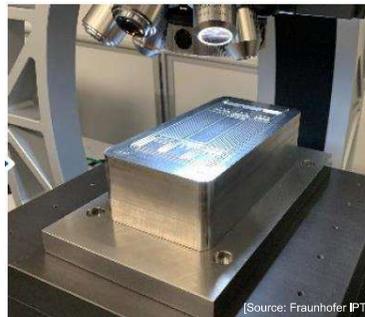
Forming of Bipolar plates



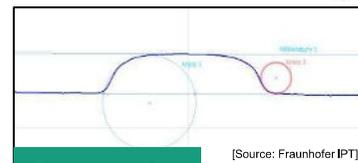
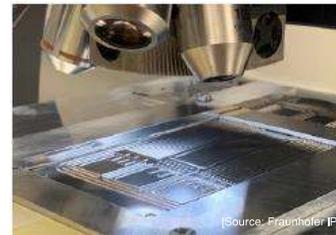
Investigation of forming results

- Analysis of the dependencies between product design and production process
- Interaction between process variables and channel geometries of BPP
- Design of Experiment (DoE)

Measuring Tools



Measuring the BPPs



Cross section

Cross section analysis

1200 kN



1600 kN



Capabilities along the process chain

Cutting and Joining of Bipolar plates



(Remote) Laser cutting of half plates



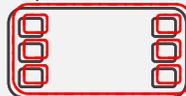
Laser Welding of two half plates



Designing of fixtures and mechanical handling

Mechanical alignment

- Use of BPP for a form fit
- Large formed surface areas
- Deviations from toolmaking and forming process add up



Optical alignment

- Camera based detection of the formed BPP outlines
- Align laser path to calculated BPP position and rotation

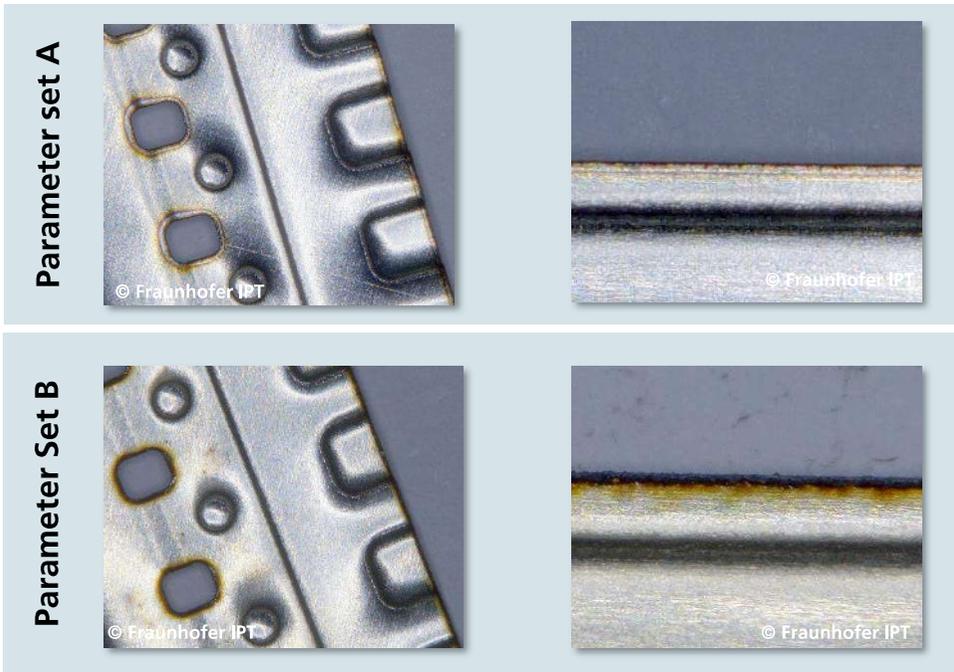


Capabilities along the process chain

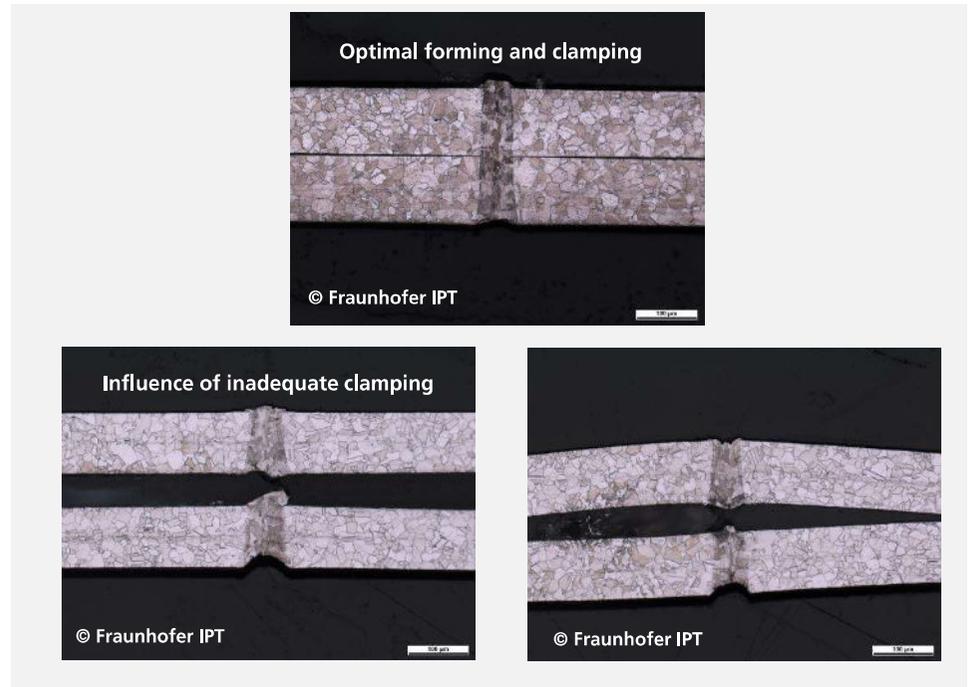
Cutting and Joining of Bipolar plates



Parameter studies



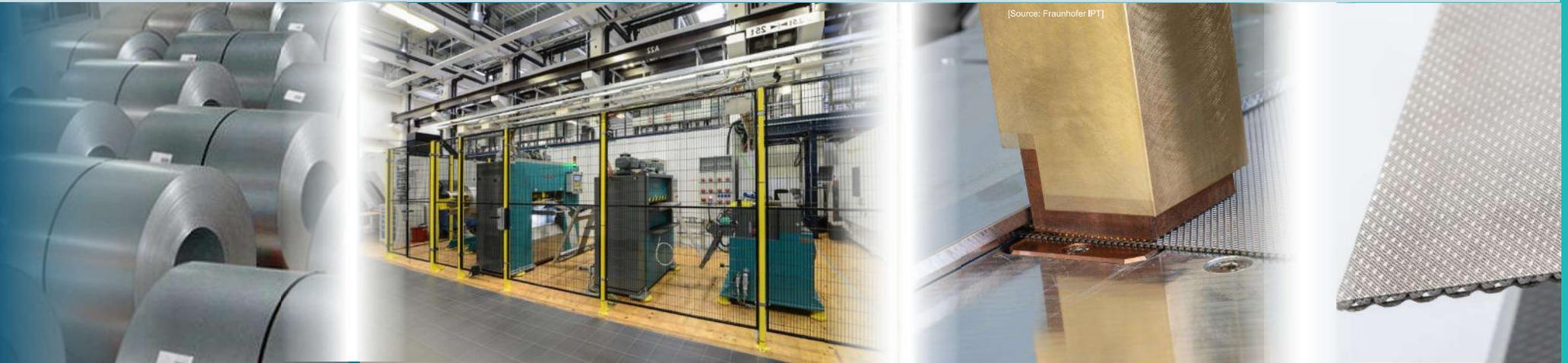
Alignment errors affect the welding – Cross Section Analysis



Expanded metal-based PTL production

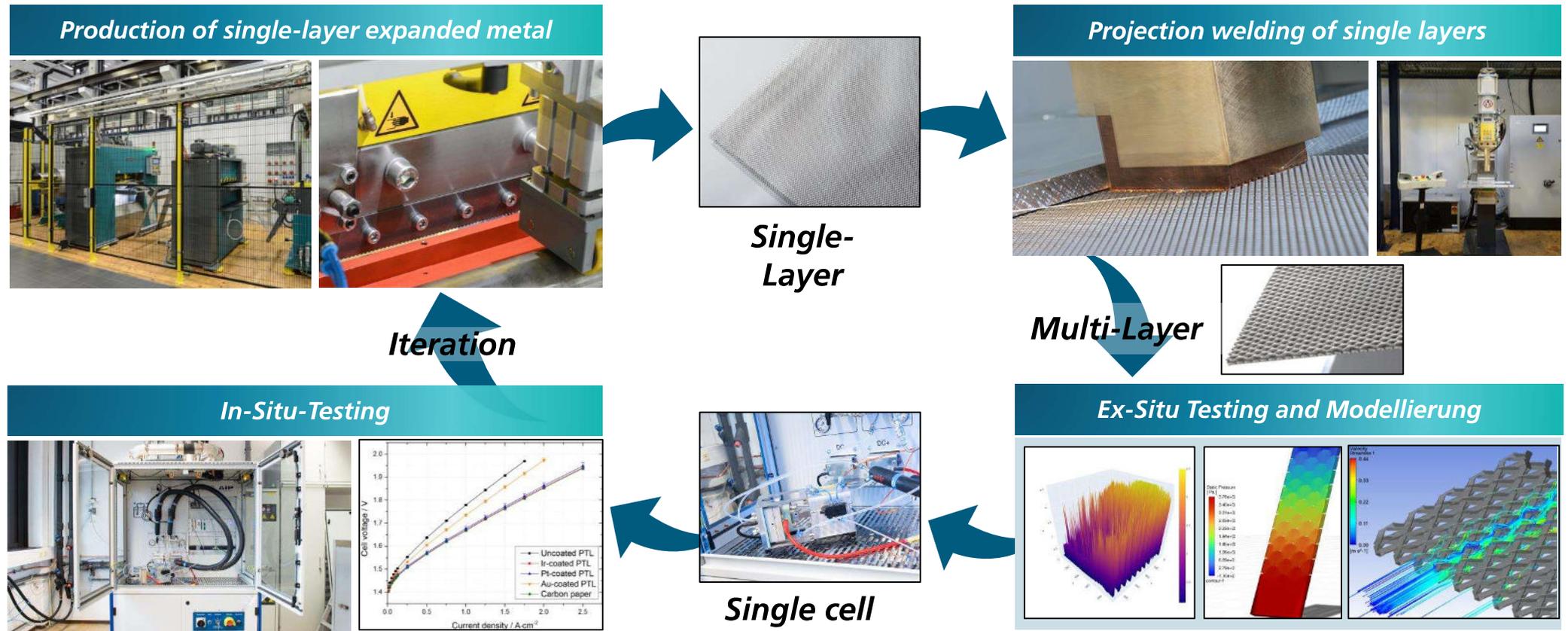
Overview of the production chain and technologies

Process chain for multi-layer PTL production (without handling steps)



Iterative optimization of expanded metal based PTLs

Interdependencies between production process and performance are currently researched

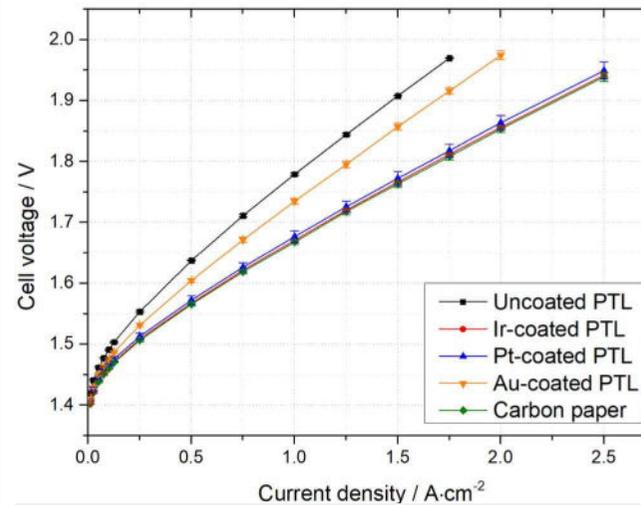


Testing methods for PEM-EL characterization

Current technologies for In-Situ measurement of PEMEL components

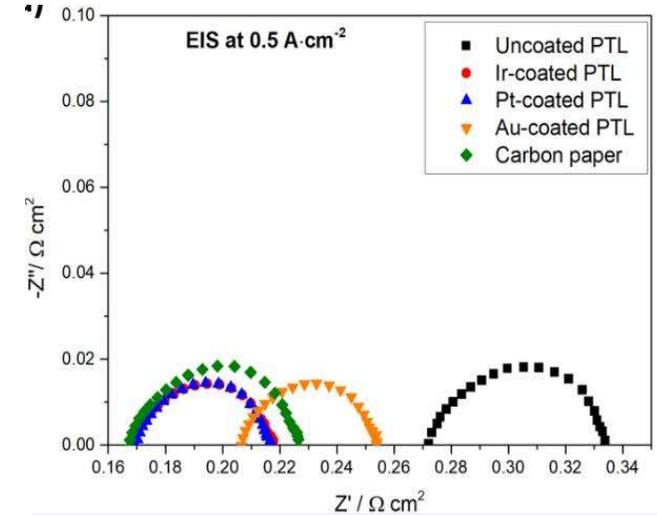


Determination of current/voltage curves



Benchmark and longterm stability test can be conducted by analyzing the **U/I characteristics** of a stack/single cell

Analysing specific resistances using EIS



Electrochemical impedance spectroscopy (EIS) is used to analyse loss mechanisms and characterize electrochemical kinetics.

Capabilities at Fraunhofer IPT

R2R development system

Machine Specification

- Film speeds: 0,1–20 m/min
- Film width: ≤ 300 mm
- Film thickness: ≤ 250 μm
- Modular „Plug-n-Produce“-Concept
- Standardized interconnections
- Operated by HMI or mobile device (App)

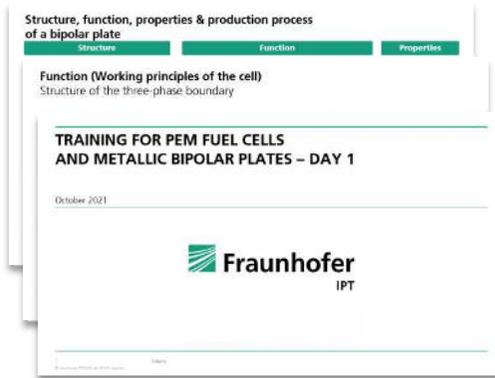
R2R-Modules

- Unwinder & Rewinder
- Single-Pass Inkjet
- IPL-Sintering
- Assembly cell
- UV-Nanoimprint Lithography (NIL)
- Multilayer Lamination
- Laser structuring/ welding/ cutting
- Continuous galvanic
- Thermal-NIL
- Calendering



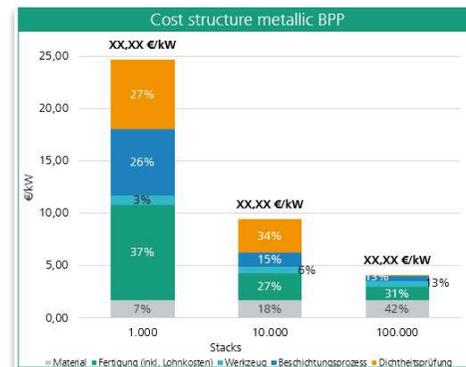
Competencies and services of Fraunhofer IPT in the hydrogen economy

The Fraunhofer IPT offers a wide range of services



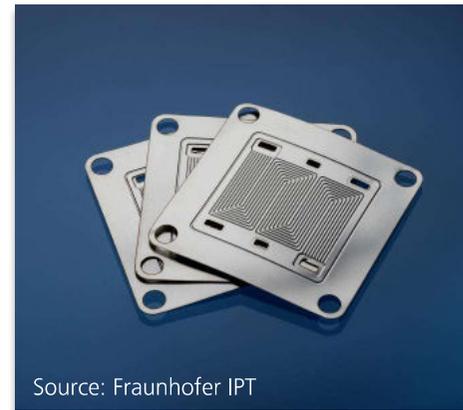
Training for part production & product knowledge

Transfer of knowledge in the field of hydrogen economy and production technology for fuel cells and electrolyzers.



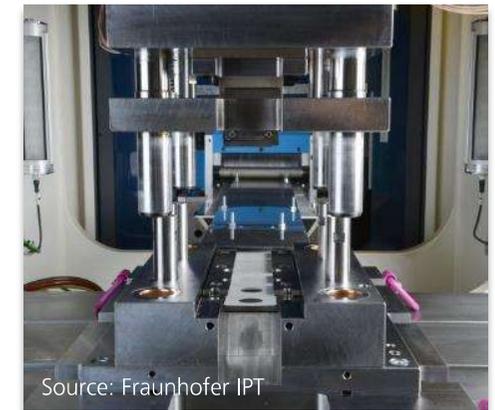
Market & Economic feasibility studies

Economic evaluation of production concepts for fuel cells and electrolyzer components.



Empowerment of the industry

Lowering the barriers to entry for manufacturers to participate in the hydrogen industry. **Support for the development of own components.**



Process simulation, development & optimization

Development and optimization of **individual processes** (forming, cutting, joining, handling, ...) and **process chains** in production.