Christian Beinert

# Reliability and Safety along the value-chain

# Fraunhofer LBF

## Facts and Figures 2024

70 Work in international expert comittees and panels

25 Lectures

86 Scientific publications

8 New Patents

29 Academic degrees

332 Employes at LBF

29 Employes at Technical University Darmstadt


 

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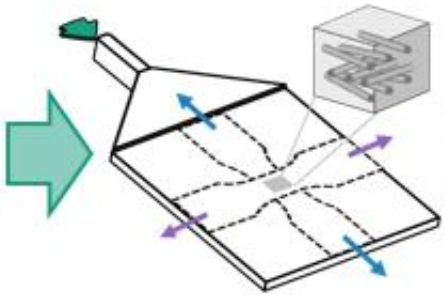
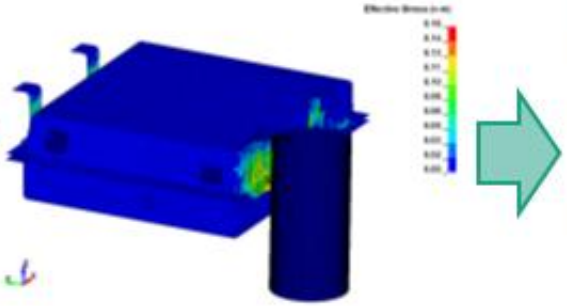
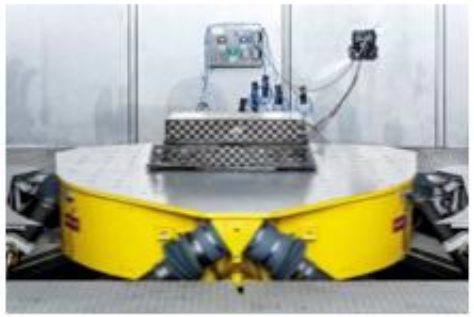
# Fraunhofer LBF

## Reliability and Safety along the value-chain

Digitalisation



**Reliability Design:**

- Development of methods for the numerical and experimental design and assurance service life of materials, components, systems
- Operational strength and system reliability evaluations considering combined multi-physical loads

**Circular Economy:**

- Development of high-performance polymers by additivation to define the properties of (recycled) material
- Development of bioadditives and biopolymers as substitutes for commercial systems
- Design of sustainable, recyclable lightweight solutions

**Energy / Future Mobility:**

- NVH design of electrically powered vehicles
- Multiphysical simulation and validation of energy storage and fuel cell systems
- Electric storage concepts, e.g., for bicycles, drones, and other modes of transportation

# Battery-Systems for E-Mobility

- **Safety regulations:**
  Compliance with safety standards and regulations to minimise the risk of fire or other hazards
- **Shock and vibration resistance:**
  Protecting the battery from mechanical impacts and vibrations
- **Resistance:**
  Use of materials that are resistant to environmental factors such as moisture and chemicals
- **Thermal management:**
  Ensuring that the battery operates at optimal temperatures
- **Weight:**
  As light as possible and robust enough to protect the battery
- **Space constraints:**
  Housing design must fit into the limited space available in a vehicle
- **Sustainability:**
  In future, the housing must contain recycled materials
- **Cost:**
  Cost-effective housing is essential

# EU-Project OPTEMUS
# Optimized Energy Management and Use

- Reducing the energy consumption for comfort and component cooling as well as traction to increasing the driving range of electric vehicles.
- The technologies developed have been virtually tested as well as implemented in a Fiat 500e Demonstrator Car
- Part LBF:  Battery as Thermal Storage
  - First development of thermoplastic based battery housing
  - Development and integration of phase-change-materials

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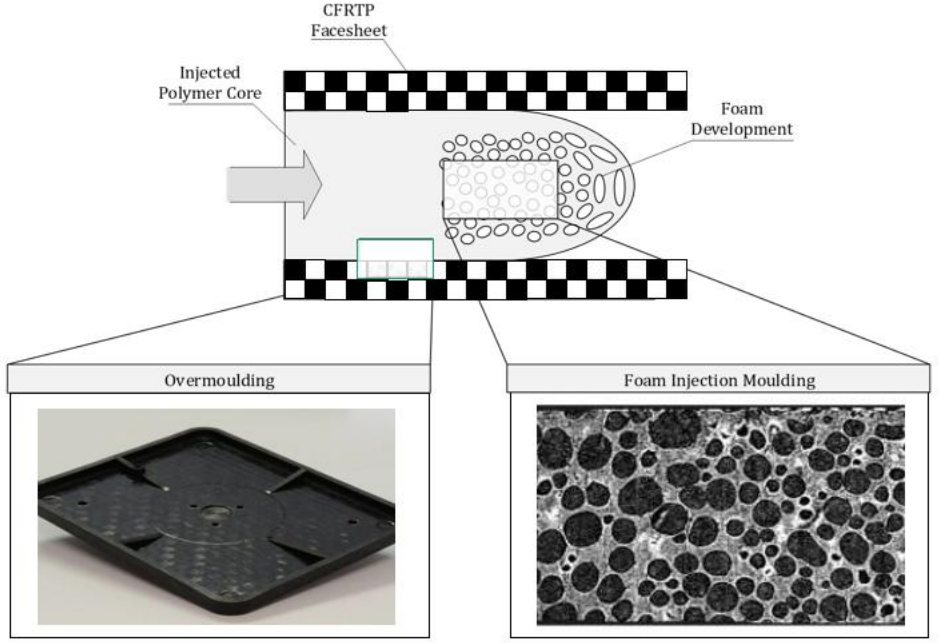
# Lightweight Composite Battery Housing

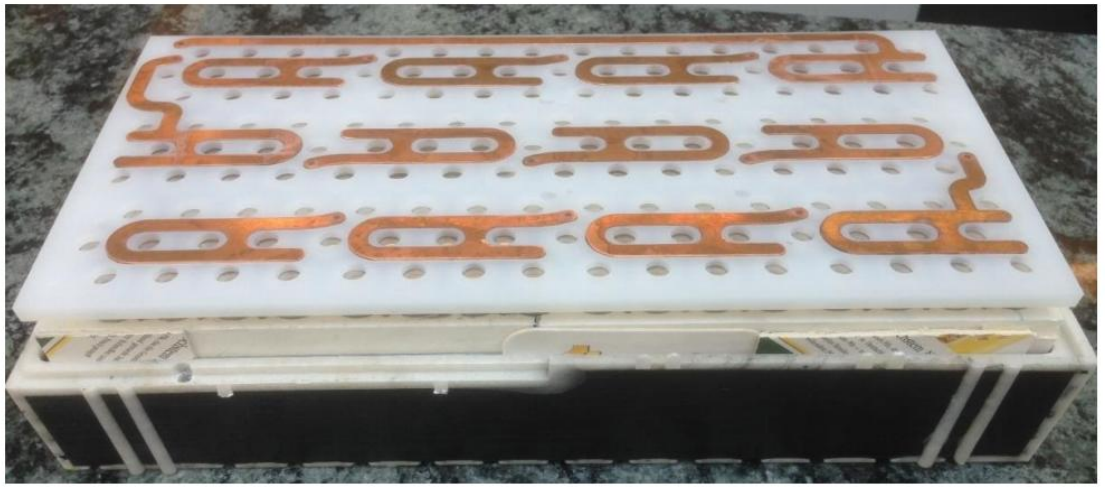
**Novel manufacturing method:**
**In-Situ FRTP Sandwich Moulding**

- Combination of foam injection moulding with overmoulding technology

- Overmoulding
  - Welding of core and facesheets
    - Without preheating

- Foam Injection Moulding
  - Generation of the foam core
  - Reduction of weight

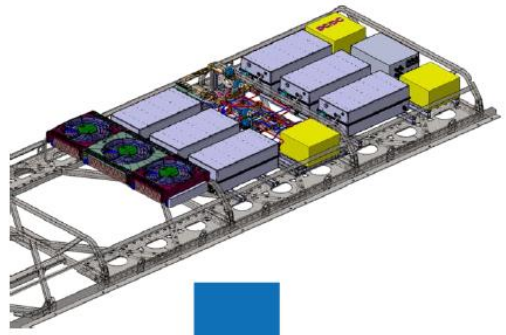


# EU-Project GHOST

## Integrated and Physically Optimised Battery System for Plug-in Vehicles Technologies

- Design of a novel and modular battery system with higher-energy density (in weight) up to 20%;
- Development of mass producible innovative and integrated design solutions
- Definition of new test methodologies and procedures to evaluate reliability, safety and lifetime
- Demonstration of GHOST solutions in two demonstrators (BEV bus and Fiat 500)



400 V

Energy: 7,6 kWh

Power: 60 kW

Water-glycol-cooled


800 V

Energy: 45,6 kWh

Power: 360 kW

Refrigerant-cooled



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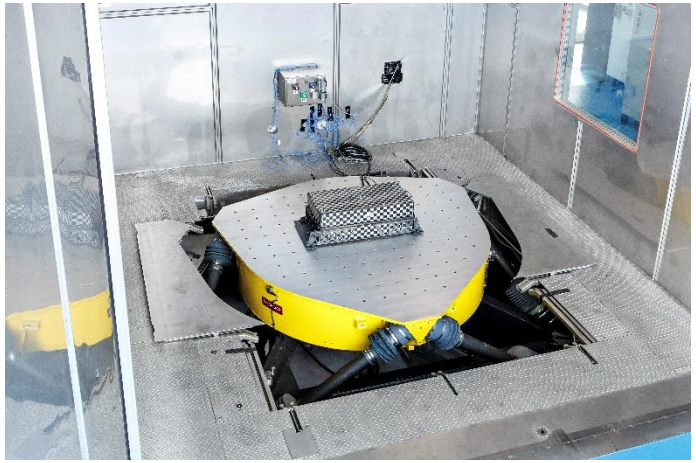
# Lightweight Composite Battery Housing

## Testing

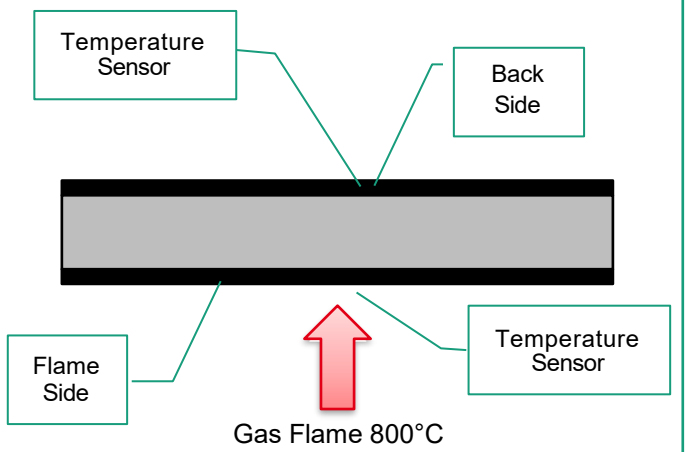
- Development of acceleration tests on LBF-testing facility
- Combined acceleration and vibrations in all directions
- Successful testing under full electric load including cooling

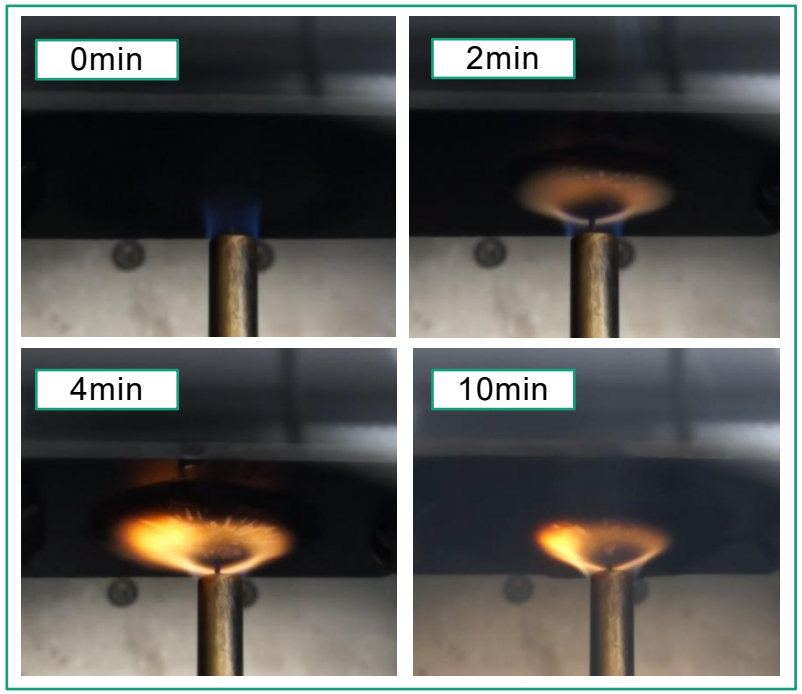


# Lightweight Composite Battery Housing

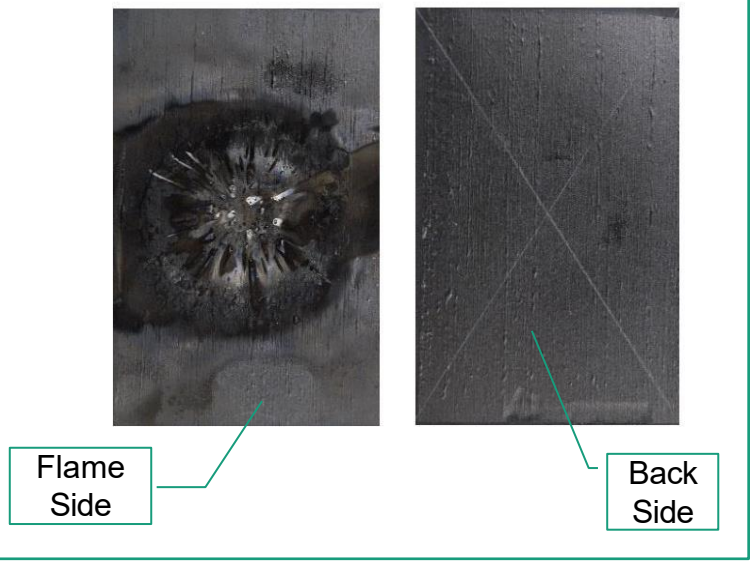
## Flame resistance

Fire Test Set-Up



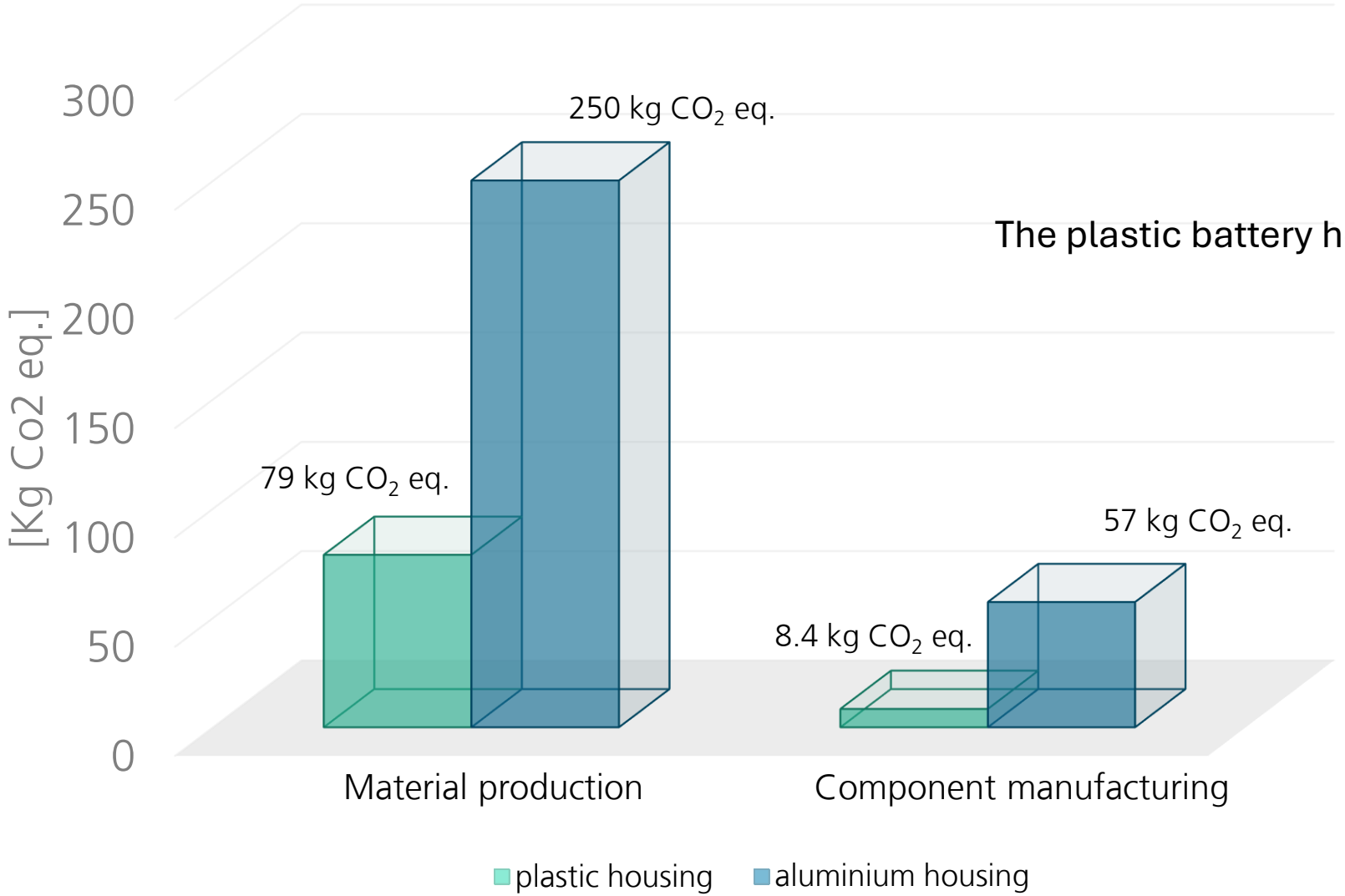




Results: Fire Damage



# Lightweight Composite Battery Housing

## Carbon Footprint




The plastic battery housing is 35% lighter

# EU-Project SELFIE

## Self-sustained and Smart Battery Thermal Management Solutions for Battery Electric Vehicles

- Development of modular battery pack, with excellent internal thermal conductivity properties, a refrigerant cooling system and a PCM based thermal storage system (heat buffer)
- Development of an advanced battery thermal management system (BTMS), to prevent overheating (and battery degradation) due to fast charging.
- Integration, assembly and manufacturing and bench testing of the developed compact battery system
- Demonstration and validation of the battery system using a Fiat Doblo

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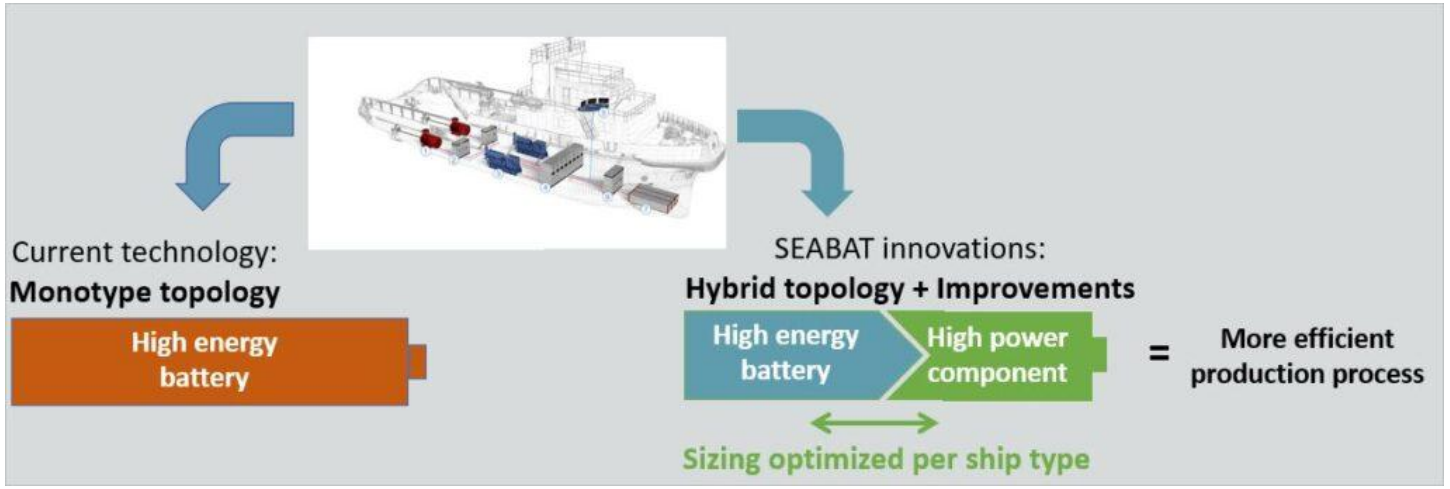
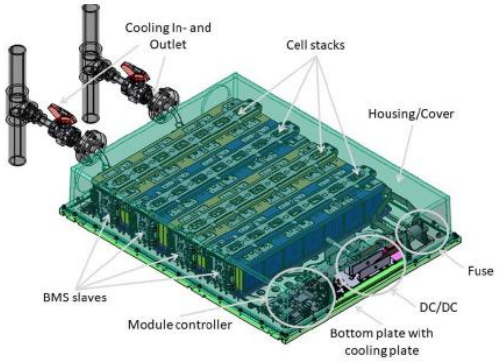
# EU-Project Seabat

- SEABAT apply a modular approach, with the aim to reduce component costs (battery, convertor) so that unique ship designs can profit from economies of scale by using standardised low-cost modular components
- In SEABAT existing commercial battery cells are used, the concept will be suitable for future battery generations and high-power components that may have higher power densities or are based on different chemistries.





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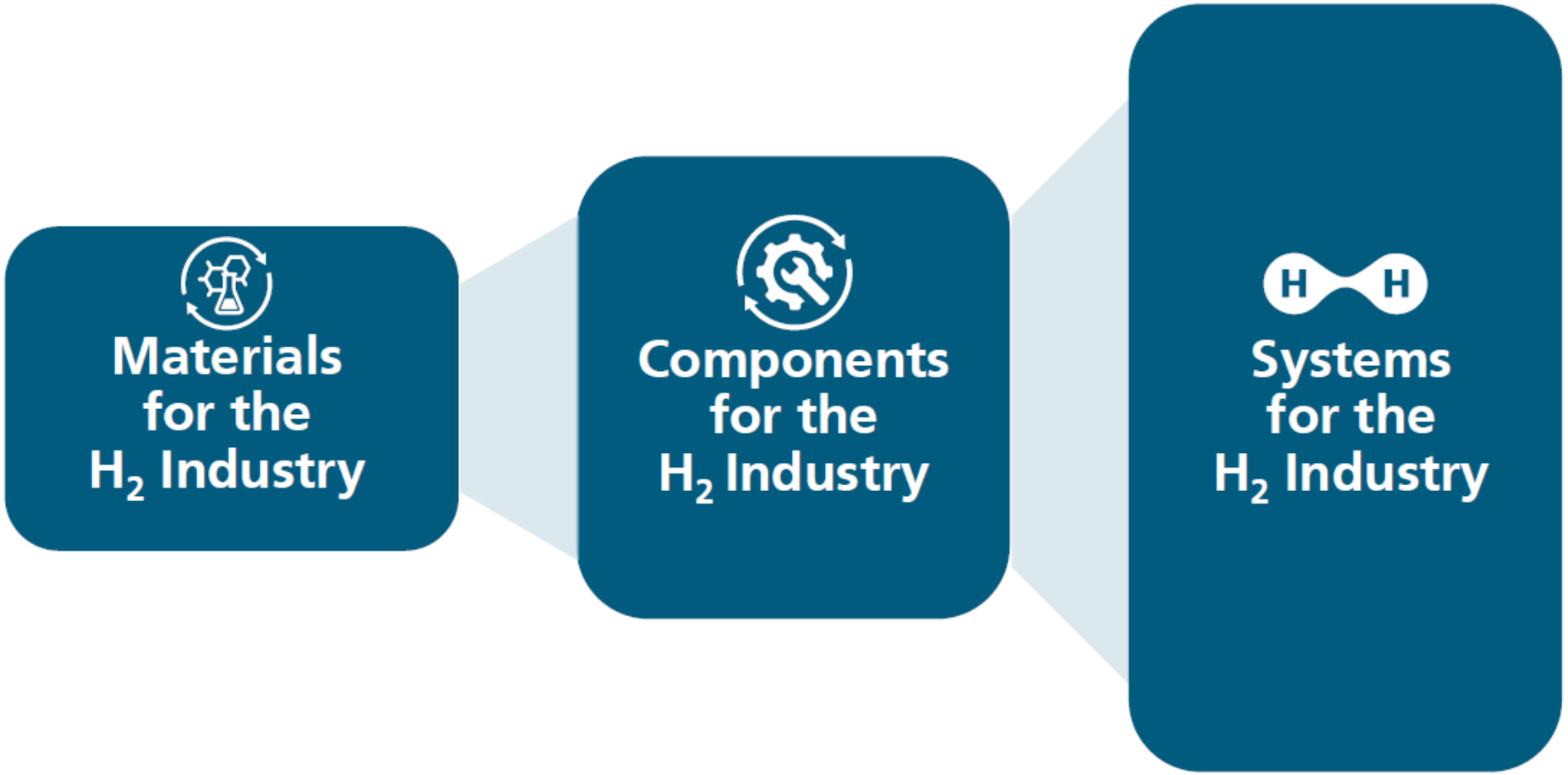
# Materials, Components and Systems for a Reliable Hydrogen Industry

## Services for the hydrogen industry provided by the three divisions of the LBF




→ The following slides show some examplary acivities of LBF in these fields

# Materials **for the $H_2$ Industry**

## Test Bench Development and Realistic Testing of Materials

**Our services:**

- Fatigue tests under pressurized hydrogen and nitrogen for component lifetime analysis
  - Pressure range: 7 to 50 bar (for **Q4/2025: up to 100 bar**)
  - Temperature range: - 40 °C to + 110 °C (for **Q4/2025: below -40 °C**)
  - $H_2$ / $N_2$ concentration up to 99.9999 %
  - $O_2$ concentration < 4 ppm
  - Performance of tensile tests and creep tests
  - Rate 0.1 mm/min to minimum 0.018 mm/min
  - Servo-hydraulic test system with nominal load of 63 kN
  - Compliance with gas purity requirements according to ANSI_CSA_CHMC1-2014
  - Fulfilment of the required accuracy in the execution of tests according to ISO 1099 and the code of practice (ISBN-92826-9681; EUR 161382_EN)

Test rig for tests under $H_2$ atmosphere up to 50 bar

# Components for the $H_2$ Industry

## Vibration Load Tests Using a uniaxial and **M**ulti**a**xial **S**haker **T**able (MAST)

**Our services:**

Realistic and multiphysical (mechanical, electrical, thermal) testing of PEM FC stacks and systems

Electrodynamic monoaxial shaker:

- load range up to 55 kN, frequency range up to 2.5 kHz
- Climatic chamber: volume 1 m³, temperature -60 °C to +120 °C, electrical load up to 100 kW

Electrodynamic multiaxial shaker:

- mass ≤ 1000 kg, frequency range up to 200 Hz
- Climat chamber: volume 16 m³, -40 °C to +80 °C

Further electrodynamic shakers and climatic chambers for flexible experimental setups

**Your benefits:**

Knowledge for evaluating the mechanical load capacity and operating vibration behaviour of fuel cell systems

# Systems for the $H_2$ Industry

## Tank systems

**Our services:**

- Analysis of $H_2$ pressure tanks (expansion, material stress, pressure tests, impact)
- Reliable assembly in the vehicle for pressure cycles and crashes.
- Specific generation and detection of fibre fractures, matrix fractures and delamination in the tank material during lifetime testing and in operation.
- Algorithms for evaluating lifetime consumption based on measurement data.

**Your benefits:**

- Reliable tank installation in the vehicle
- Monitoring the lifetime of pressurised hydrogen tanks
- Mobile or stationary monitoring system for tank systems
- Support in evaluating tank safety after a road accident


# Contact

**Dr.-Ing. Christian Beinert**
**Head of Department Polymer Processing and Component Design**

**Fraunhofer Institute**
**for Structural Durability and System Reliability LBF**
**Schlossgartenstr. 6**
**64289 Darmstadt, Germany**
**Phone: +49 6151 705-8735**
**Christian.Beinert@lbf.fraunhofer.de**