

Fraunhofer Research Field Lightweight Design
FROM CONCEPT TO PRODUCT
» CUSTOMISED EXPERTISE FROM 16 INSTITUTES«



Dr.-Ing. Thomas Hipke

55 years old, married, 3 children

Profession: Tool manufacturer

Study: mechanical engineering

Study specialization: machine tool design

1996: start as scientist at Fraunhofer IWU

2001: doctoral thesis: "Design parameter of metal foams"

**Since 2021: Head of division: Light weight design,
Energy storage and Circular Economy**

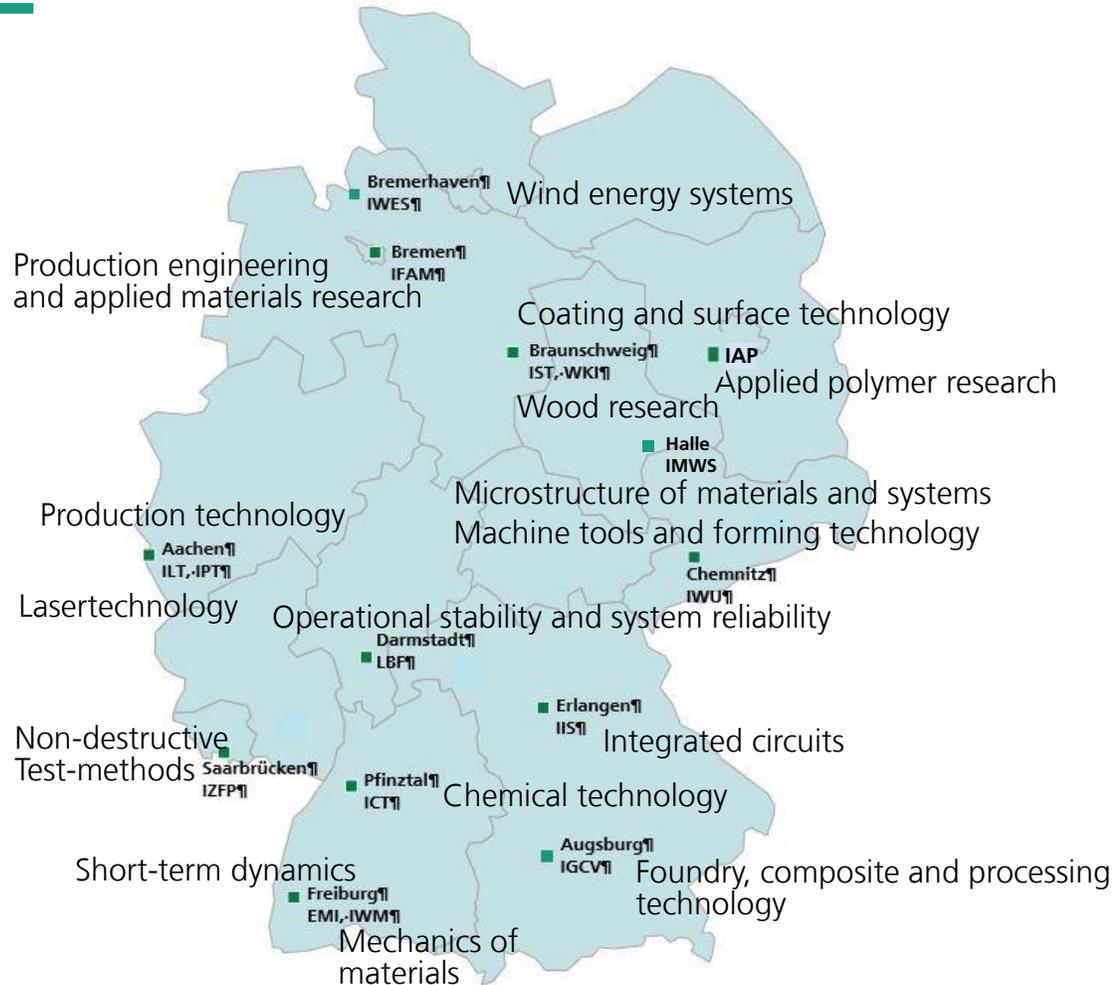
**Since 2022: Board Member of ELCA
(European Lightweight Clusters Alliance)**

**Since 2025: Speaker of Fraunhofer Research Field
"Lightweight Design"**



Fraunhofer Research Field Lightweight Construction

A consortium of 16 cooperating Fraunhofer Institutes



Cooperating Fraunhofer Institutes

Short-Term Dynamics, Ernst-Mach-Institut, EMI | Applied Polymer Plastics, IAP | Chemical Technology, ICT | Production Engineering and Applied Materials Research, IFAM | Foundry, composite and processing technology, IGCV | Integrated circuits, IIS | Lasertechnology, ILT | Microstructure of materials and systems, IMWS | Production technology, IPT | Coating and surface technology, IST | Wind energy systems, IWES | Mechanics of materials, IWM | Machine tools and forming technology, IWU | Non-Destructive Test-methods, IZFP | Structural Durability and System Reliability, LBF | Wood research, WKI

Fraunhofer Research Field Lightweight Construction

Why and how do I get in touch?



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Consortium formation

R&D Services & Products

Material and component evaluation
Production and processing of structural and functional components
Further training »Composite Engineer«

Fraunhofer Research Field Lightweight Construction

Contend

1. Expertise at a glance

- Manufacturing technologies
- Evaluation
- Component testing, validation

2. Key topics

- Circular economy
- Lightweight construction of battery-powered vehicles
- Lightweight construction for hydrogen technologies
- LCA for lightweight solutions

3. Further training programme »Composite Engineer«

01



Expertise at a glance

Manufacturing technologies

Process chains, automation



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Hybrid thermoplastic structural components

RTM and high-pressure RTM
wet pressing processes
Pultrusion Tape laying,
consolidation and
compression moulding



© Fraunhofer IPT

Tape laying and prepreg processing

Systems and processes for
automated tape and prepreg
processing
Thermoplastic tape laying
Thermoset prepreg and
towpreg processing



© Fraunhofer IGCV

Wetlaid nonwoven line on a pilot plant scale

Processing of any fibre
materials - especially recycled
carbon fibres - into innovative
and novel nonwovens



© Fraunhofer IWU

Aluminium-foam sandwich structures

Rail vehicle drive head 18 %
weight reduction to 1402 kg
High rigidity
High Energy absorption

Manufacturing technologies

Processing/finishing, joining technology, surfaces



Laser cutting of lightweight structures

Fibre-reinforced materials
Metallic materials
Optimisation of cutting speed, efficiency, quality and robustness



Adhesive technology

Adhesive selection
Dosing and application technology
Creation of predictions of ageing behaviour based on kinetic models



Rotor blade production

Design for recycling
Sustainable production
Efficient use of adhesives
Condition monitoring



Multifunctional and smart surface finishes

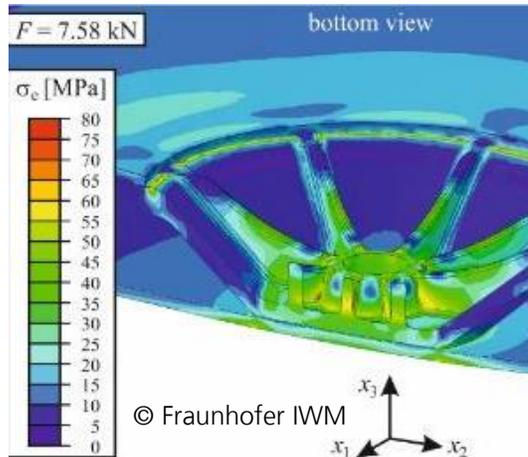
Tribological and optical functions

Non-stick or antibacterial properties

Thin-film sensor technology

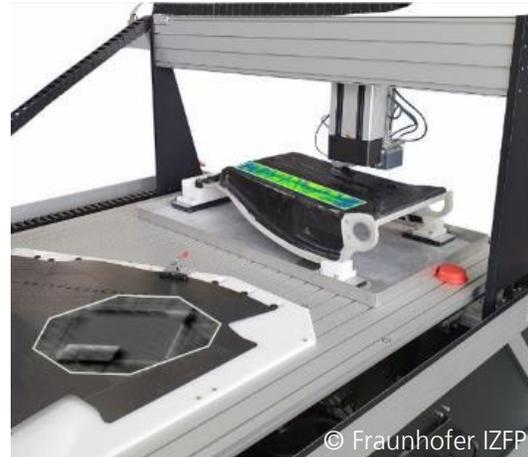
Assessment

Component simulation, quality control and digitalisation



Numerical simulation

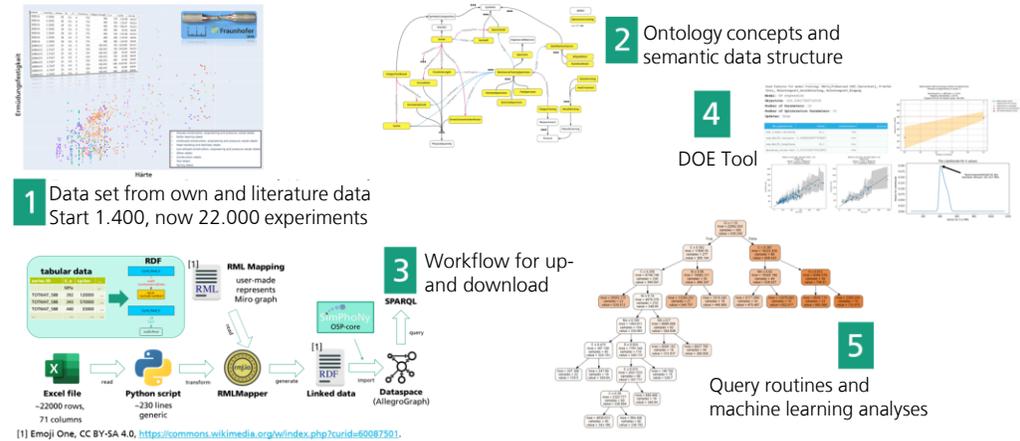
Exampel: load transfer elements, detailed analyses for concept phase and operation
Stiffness, Structural robustness; creep rupture properties, service life, ageing



Sensor systems for inline quality control

Development and implementation of hardware and software solutions
Diconde server for data archiving

Example: Fatigue behaviour of high-strength steels



[1] Emoji One, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=60987501>.

Material digitalisation along the value chain

Consolidation of scattered and unstructured data into a well-founded knowledge database
Curating data sets for machine learning analyses
Enabling traceability

Component testing

Validation



© Fraunhofer WKI

Wood-based material and natural fibre technologies

Load-bearing behaviour, quality testing and evaluation, fire protection

Recycling of waste wood and biocomposites (WPC)



© Fraunhofer IIS

XXL-CT / high-energy CT

which can be used to examine large objects, e.g. entire vehicles. Measurement data acquisition, correction procedures, reconstruction and X-ray image processing.



© Fraunhofer EMI

X-ray Car Crash

Use of X-ray diagnostics enables observation of the dynamic behaviour of hidden vehicle structures under crash load



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Full scale vehicle test bench

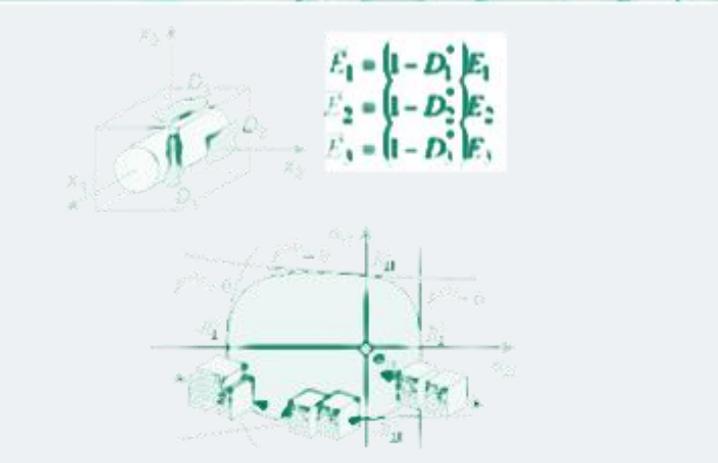
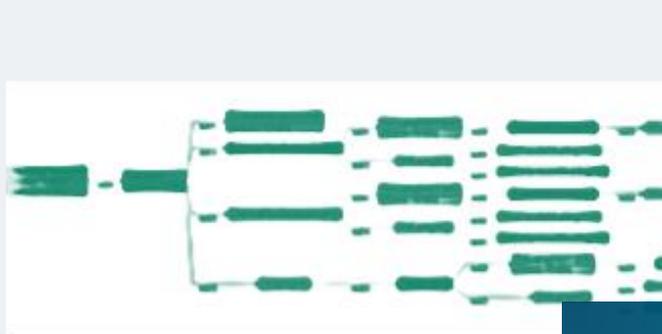
Introduction of vertical, longitudinal and lateral forces as well as steering and braking torques

For vehicles weighing up to six tonnes

02



Main topics



Circular economy

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Concepts | Methods | Components

Development of recycled plastics with a focus on their operational stability and service life for a sustainable circular economy



© Fraunhofer LBF

[Fraunhofer LBF - Plastics research area - YouTube](#)

Recycling of Composites

Separation of fibres and matrix using pyrolysis

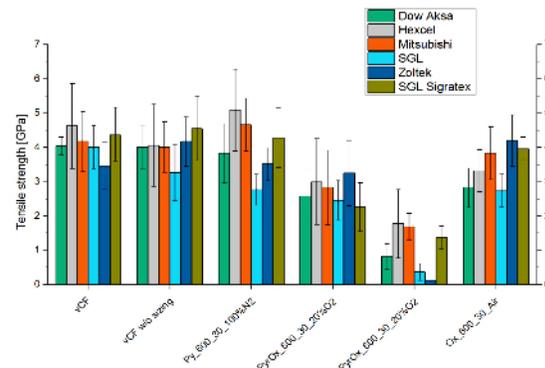
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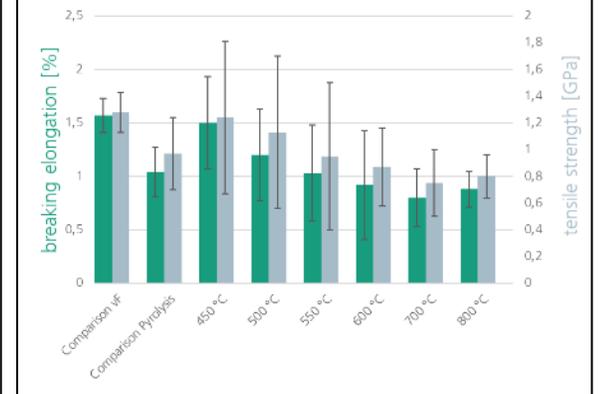
Pyrolytic oven on IGCV

- 440 x 700 x 540mm³ (WxLxH)
- Maximum Temperature: 800 °C
- Adjustable atmosphere (Ar, N₂, O₂)
- Heating rate: 6K/min
- Oxidation and partial oxidation possible

Various fibre manufacturers



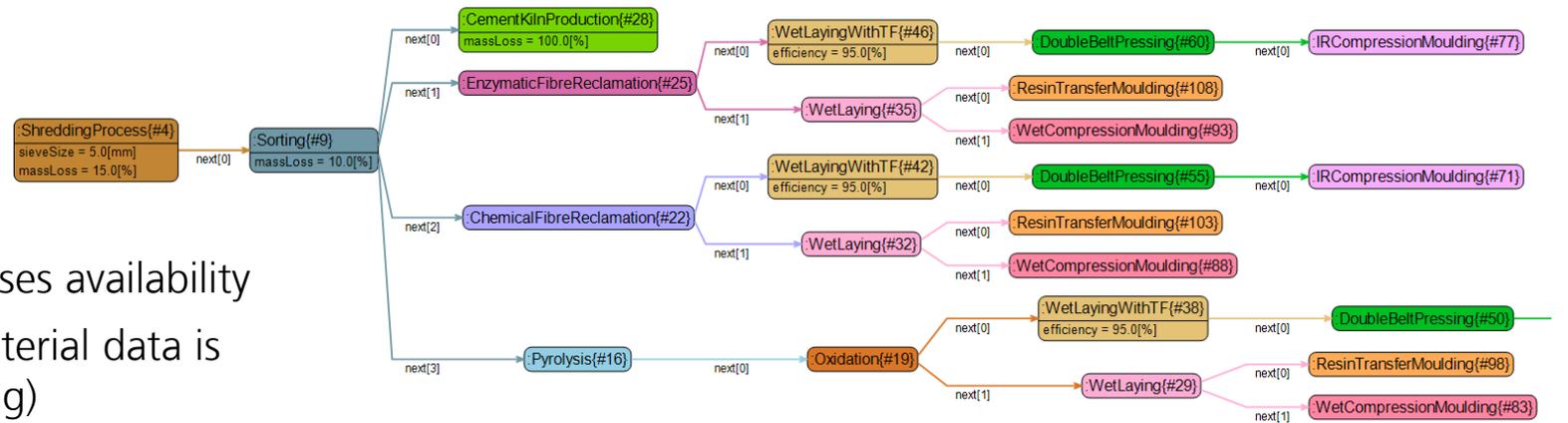
Atmospheric parameters



Digital circular economy

Challenges and potential

- Lack of information for recycling processes availability
 - Quality and quantity of recycled material data is missing (digital know-how modelling)
 - Transparency in available recycling processes
- Ontologies for recycling processes help to find the best suited and price effective recycling routes
- Digital Twins will help to disassemble parts, shred and sort multi-materials
- Including Design2Recycling within the design process of parts
- Adaptive and intelligent process control help with more fluctuating material input



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Prediction of the degradation behaviour

Characterisation and modelling of the ageing of reinforced and unreinforced plastics

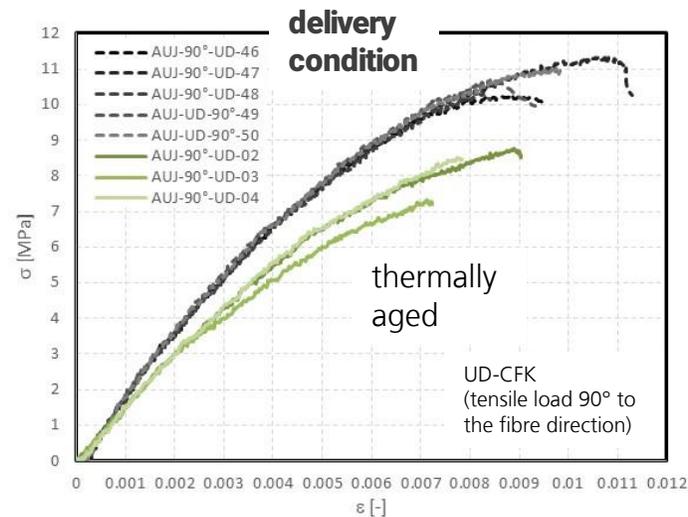
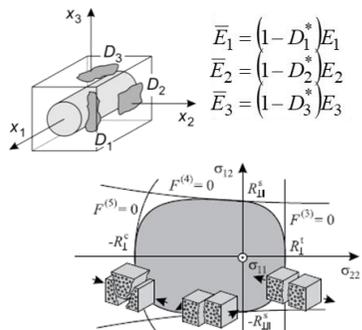
- Ageing due to
 - UV exposure and condensation
 - Constant or cyclical (long-term) temperature exposure
 - Constant or cyclical (long-term) moisture exposure
- Determination of resulting material characteristics
- Modelling for the prediction of ageing effects



Climate chamber



Weathering system



Circular products and resource-conserving (re)fabrication

reProd® - Example: From car roof to brake shield plate

1. Dismantling car roof



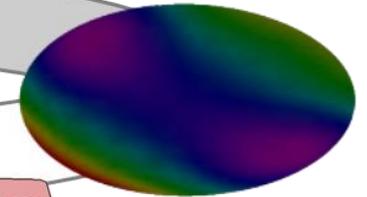
2. Inspection



3. Data provision using RFID



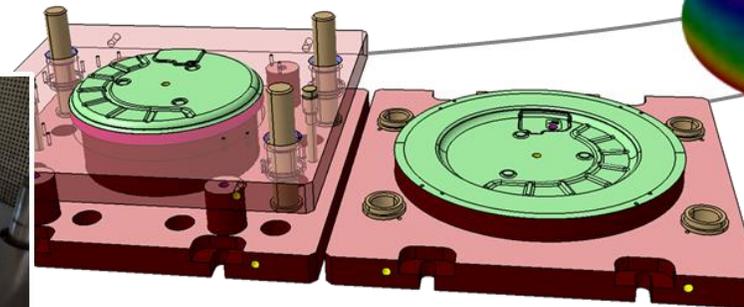
3. Cutting



5. Component brake shield plate



4. Remanufacturing





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Lightweight construction of battery-powered vehicles

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Design | Production | Suitability for use

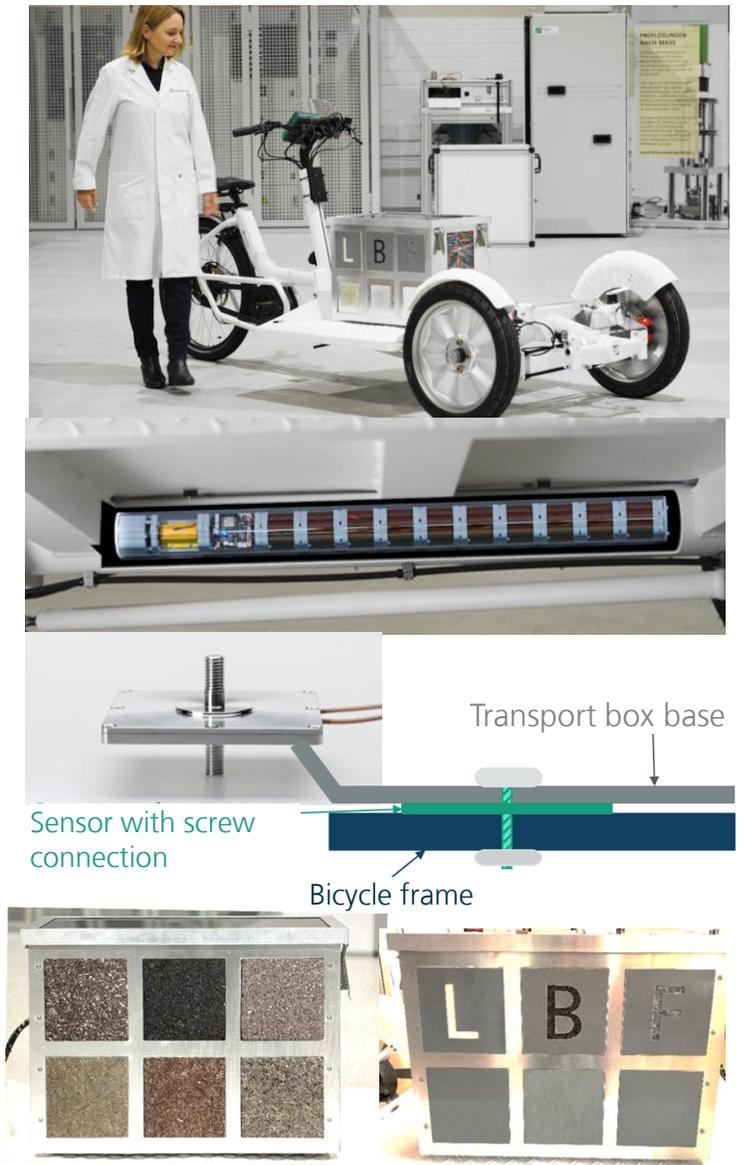
Functionally integrated lightweight construction

Lightweight cargo bike (L-LBF)

Redesign of the front end to realise the following advantages:

Mass reduction of approx. 40 %

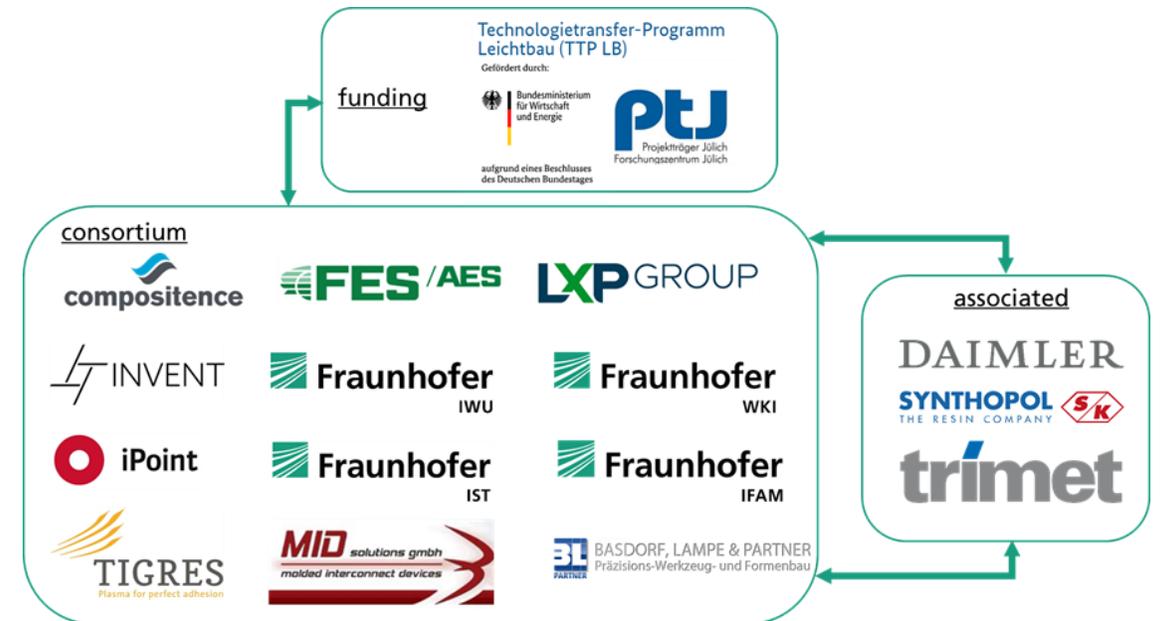
- Integration of a tubular battery system with double the capacity (1000 Wh) compared to the commercial system in the frame structure (weatherproof and theft-proof)
- Integration of sensory connecting elements between the frame and sustainable transport boxes, which are made from 100% organic materials or 100% recycled materials



CoolBat

CO2-SAVING LIGHTWEIGHT SOLUTIONS ON THE DEMONSTRATOR BATTERY HOUSING OF THE NEXT GENERATION

- **Finances**
- **Funding: BMWi: TTP Lightweight Construction Call for Proposals**
- **Total volume: approx. 4,600 T €**
- **Timetable: 01.05.2021 - 30.04.2024**
- **Focal points of the project:**
- **CO2 balancing**
- **LCA and LCC Materials, technologies and systems**
- **Development of internal support structures with integrated temperature control channels**
- **Development of functionally integrated external load-bearing structures**
- **Development of sustainable fire protection materials**
- **Development of load path-optimised covers**
- **Demonstrator development with proof of CO2 reduction**





Lightweight construction for Hydrogen technologies

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Production | Infrastructure | Material assessment

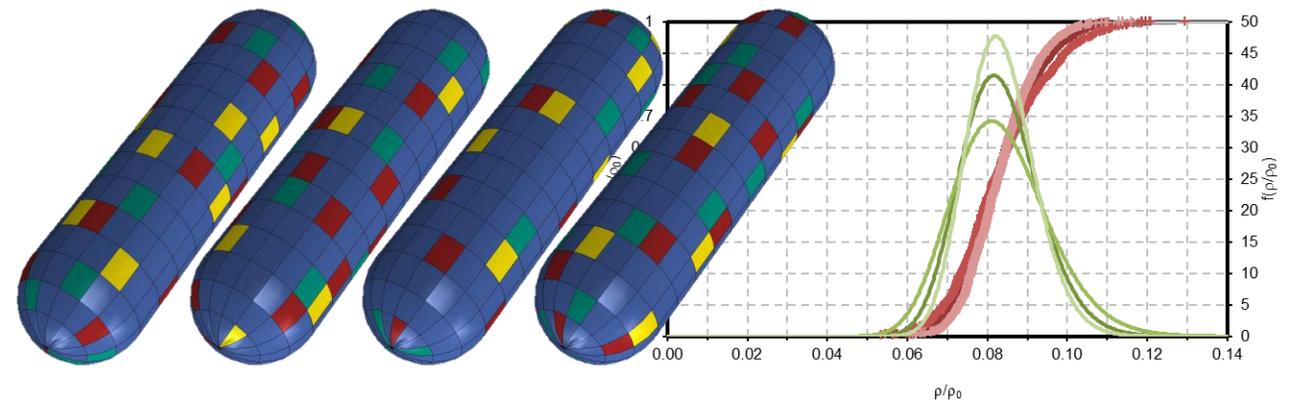
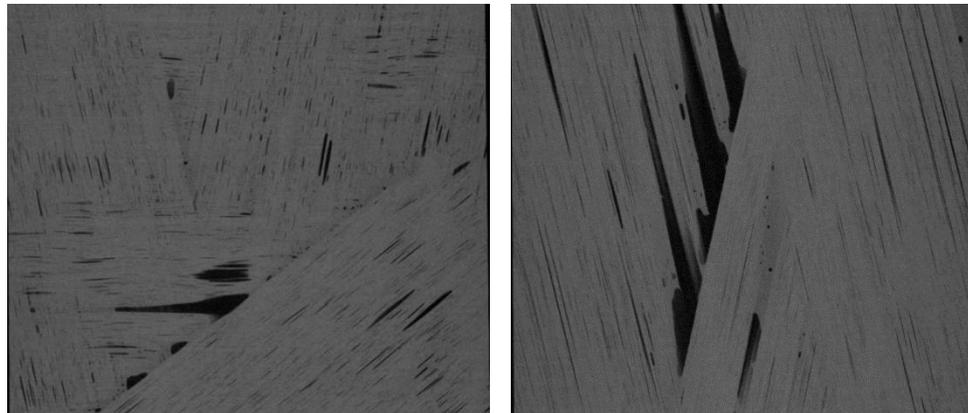
Probabilistic evaluation of high-pressure H2 tanks

Load limits, service life estimation

- Development of CFRP H2 high-pressure tanks (1000 bar)
- Problem
 - Inherent production-related imperfections in the CFRP shell
 - form starting points for failure
 - discontinuities stochastically distributed
- Solution: probabilistic evaluation concept



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LCA for Lightweight solutions

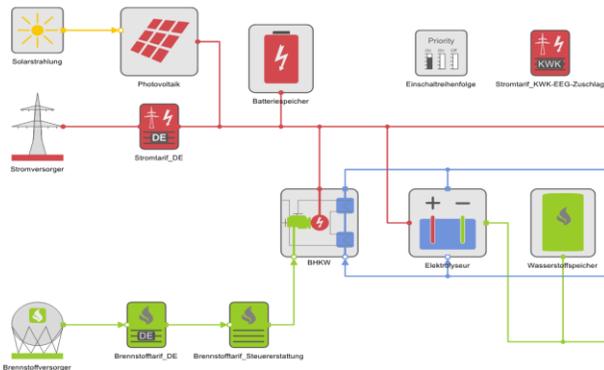
Resource efficiency | Sustainability assessment

Sustainable production systems

Main topics

Sustainable energy supply concepts

- Dimensioning of sustainable energy supply concepts
- Energy procurement, generation and suitable storage technologies
- Reliable information basis for **(short, medium and long-term) planning options** for investment decisions

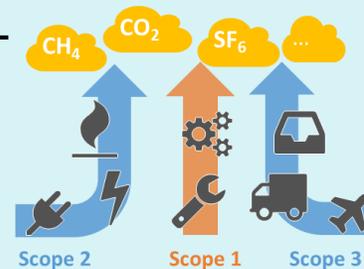


Sustainable production planning and control

- Sustainability-related value stream analysis
- Development of suitable key figure systems (energy costs, CO2-equiv., etc.) for a multi-criteria PPS
- Development of suitable operating strategies for holistic optimization
- **Integration** of additional control variables in commercially available **PPS software systems**

Product and company-related sustainability assessment

- **Creation of transparency** to identify key emitters, levers and selection of **optimal solutions** (e.g. energy supply, supply chains, use of materials, manufacturing processes)
- **Identification of product- & company-related environmental impacts** (e.g. CO2 footprint)



Activities in the field of LCA with a focus on the composites sector

Transparent data basis for rCFRP process chains from the [MAI ÖkoCap](#) and [Infinity](#) projects

- Guideline on the technical, economic and ecological potential of recycling and using rCF
- Web application on recycling and the use of rCF



Continuous expansion of the commercial supplementary database „[Extension database XXII: carbon composites](#)“

- Current scope of 182 data records, of which:
 - 50 data records Carbon fibre production
 - 20 data records for semi-finished products
 - 72 data records for individual production processes
 - 40 data records Production aggregated



Integration of holistic assessment into the development phases of composites

- Expansion of developments from [completed](#) projects in current and [future](#) projects
- Transfer to the industry



Ecological assessment of the bio-based production of carbon fibres and matrix materials

- Processing of publicly funded projects (e.g. GreenCarbon and Nature) and industrial projects



03



Further education programme

Composite Engineer

Course overview

Modular further training:

Qualification goal:

**Composite Engineer
certificate and diploma**

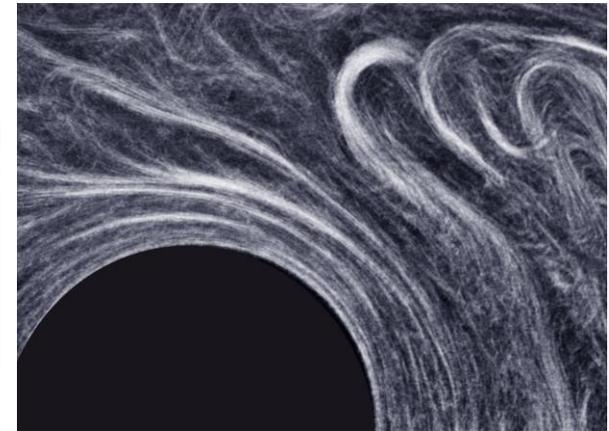
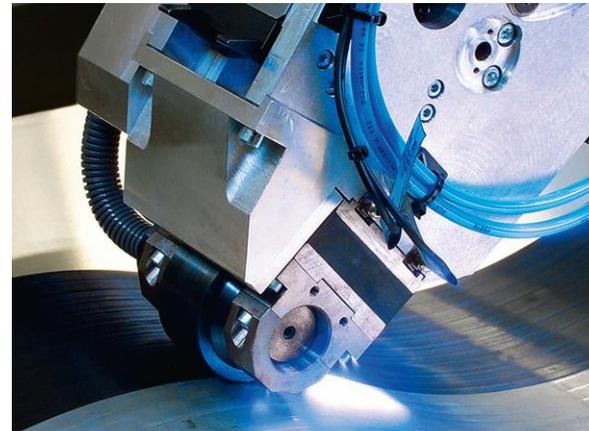
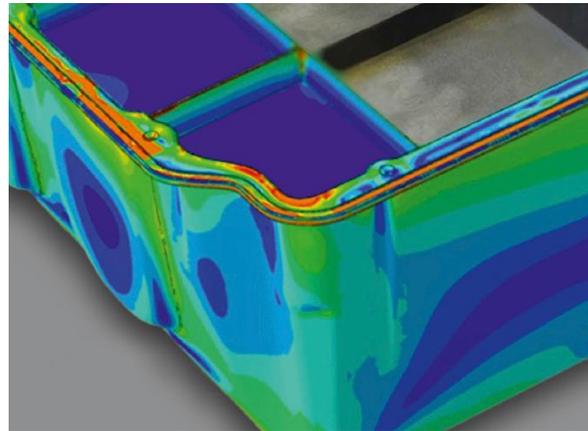
Target group:

1 Fundamental - 2 basic modules - 2 advanced modules - Final module

Professional support of a component made of fibre-reinforced materials over the entire product life cycle. Interdisciplinary thinking, evaluation, decision-making and action when using fibre-reinforced composite technology.

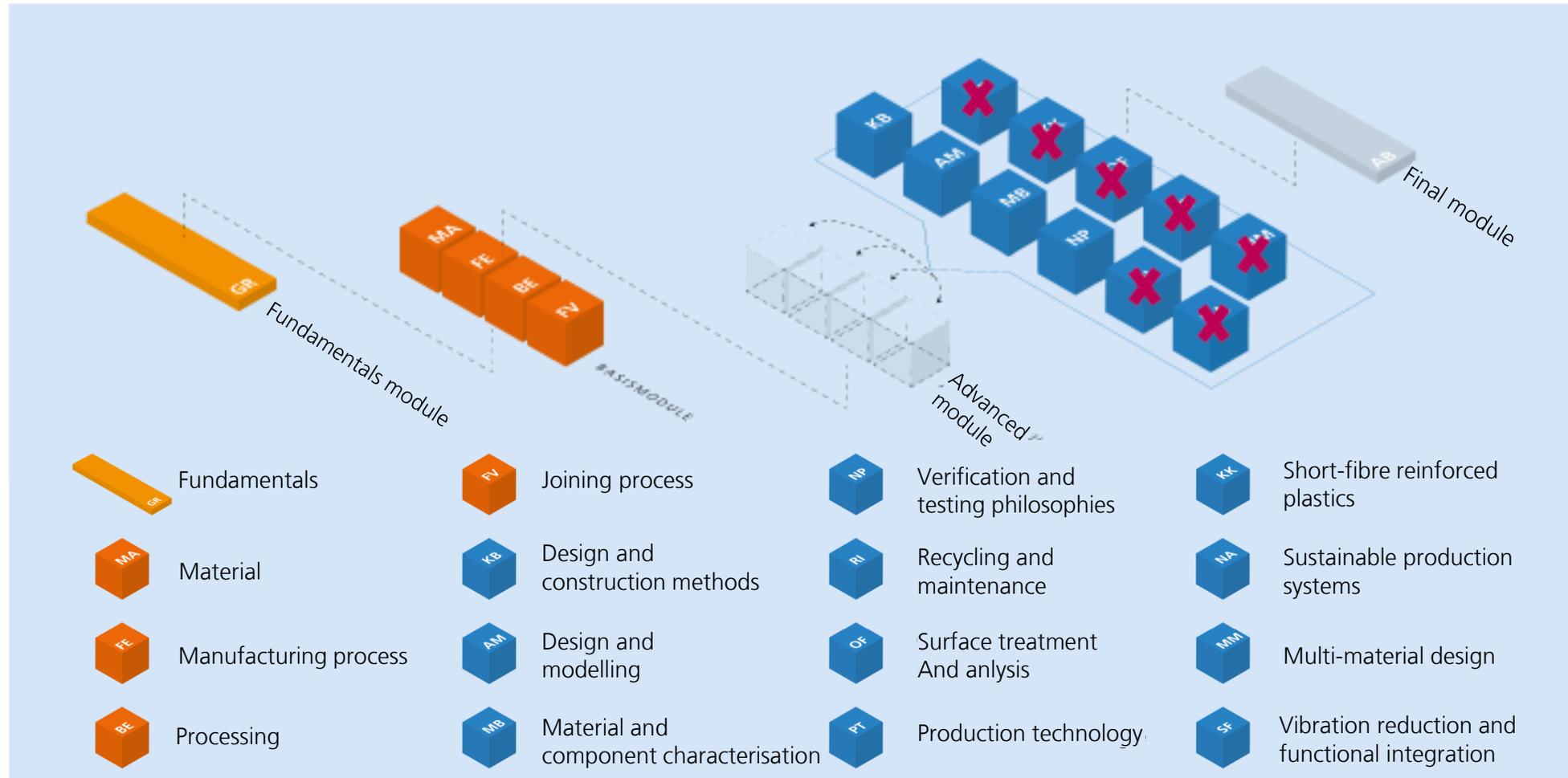
Issued by the Fraunhofer Personnel Certification Body
Requirements fulfilled according to DIN EN ISO / IEC 17024

Engineers, scientists and specialists with professional experience



Composite Engineer

Module overview



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Thank you for your attention

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