the future is composite

Annual Report 2025

Leibniz-Institut für Verbundwerkstoffe

Leibniz Gemeinschaft

Imprint

Publisher: Leibniz-Institut für Verbundwerkstoffe GmbH (IVW) Editors: Anke Kunze, Ariane McCauley

Layout: Laura Tiedge, Lilli Thomas

Photos: IVW, unless otherwise noted

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IVW at a Glance

2025

Core budget [m€]	6
Project funding [m€]	8.3
Projects	128
Publications in peer-reviewed journals	31
Lectures, laboratories	
▪ Summer term [h]	16
▪ Winter term [h]	32
New doctorates	4
Staff	
▪ Scientific staff*	60
▪ Scientific guests	13
▪ Technical staff and administration*	47
▪ Student assistants	21

**FTE*

As a member of the Leibniz Association, the institute receives institutional grants in accordance with the AV-WGL for the joint financial support of institutions by the federal and state governments (federal share 50%, share of the state of Rhineland-Palatinate and the entirety of the states 50%).

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Dear readers,

‘From Fibre to Future’ was the title of our international colloquium in 2025, and this heading also applies to the projects we present to you in the blue section of this annual report. This is due to the fact that fiber reinforced polymer composites are characterized by being lightweight, strong and sustainable, enabling them to address a whole range of the challenges we currently face. To achieve even greater lightweight design and thus better environmental compatibility, we are working on advanced solutions for highly stressed primary structures in aircraft and automotive engineering, for example in the German government's aviation research program “Luftfahrtforschung”, page 36. For CO2-free mobility, we are using polymer composites to develop particularly space-saving and functionally integrated containers for hydrogen, page 40. Sustainability is also the focus of environmental impact assessments during production. In a research project funded by the Ministry of Science of the State of Rhineland-Palatinate, we have established an ‘Industrial Internet of Things’ that we intend to develop further in order to optimize the quality of finished components in the future with the help of data obtained from production processes and suitable AI methods, see page 42 & 48. For the integration of individual composite parts, efficient alternatives to bolted joints are urgently needed. Therefore, we are investigating inductive welding processes. And in order to be able to reuse production waste or end of life components made of carbon fiber-reinforced polymers for high-quality applications in the future, we are developing the necessary knowledge for suitable process technology, page 37. A special area of application is the use of fiber reinforced polymer composite materials in healthcare; see page 21. We are also already working on the technologies of tomorrow, and to do so, we need to understand the fundamentals today. This applies, for example, to the field of vitrimers, a very special type of polymer. Read more about this on page 23.

We transfer the knowledge we generate in a variety of ways, not only in the form of scientific publications and lecturing, but also – provided it does not involve confidential industrial contract research – to the general public. On 13 September 2025, for example, we set a new world record in front of a large audience at the Mainz Science Market. Using the high-performance thermoplastic PEEK, we firmly bonded steel cylinders together and lifted a weight of 20.3 tons, significantly exceeding the previous record of 17.5 tons using a thermoset adhesive https://www.ivw.uni-kl.de/en/news/details/new-world-record-at-the-mainz-science-market-high-performance-adhesive-lifts-the-heaviest-weight .

We are also particularly committed to high school students, for whom we have once again held a series of events such as the Federal Ministry of Research, Technology and Space's Materials Holidays, demonstrations at the Kaiserslautern Garden Show and internships in our laboratories. Together with the RPTU, we also held a summer school for students from the Heinrich Heine Gymnasium in Kaiserslautern to inspire participants with the possibilities of science and technology in theory and practice. And we are planning special activities again for 2026: Starting in May, the Dynamikum in Pirmasens, an interactive museum for children and young people, will host our special exhibition entitled ‘Super light and super strong – discover the secret of fiber strength!’.

We hope you enjoy reading our latest annual report!

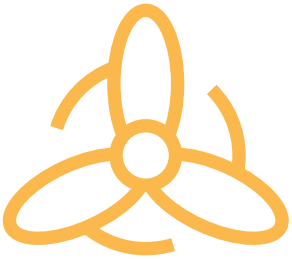
Yours sincerely,

Ulf Breuer & Pascal Sadaune

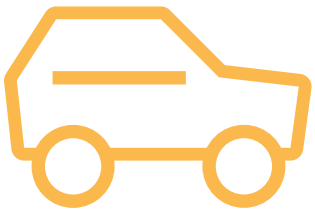
From Fundamental Research to Application

IVW is a non-profit research institution of the state of Rhineland-Palatinate and University of KaiserslauternLandau (RPTU). It researches fundamentals for future applications of composite materials, which are of great importance for the mobility of the future, the fields of energy, climate and environment, production technology as well as for health care. New materials, construction methods and manufacturing processes are investigated and - after the basic understanding has been developed - tailor-made for the respective requirements. The focus is on the entire process chain, from basic materials to characterization and simulation, from construction methods and production technology to component testing and recycling. New ideas and innovative concepts are not only an essential part of the research and further development of the institute, but also lead to spin-offs. Newly acquired knowledge is transferred, above all into science, but also into teaching, the interested public and industrial applications.

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Energy, Climate, Environment



Mobility



Production / Plants



Medical Engineering

from A to Z

IVW Develops Composites Using a Wide Variety of Technologies

- Coatings
- Component Testing & Simulation
- Design
- Development of Semi-Finished Materials
- Failure Behavior & Fatigue Analysis
- Filament Winding & Simulation
- Foam Injection Molding
- Forming Technology & Simulation
- Functionalized Matrix Systems
- Hybrid Materials & Structures
- Hybrid Processes
- Hydrogen Storage & Technologies
- Impact / Crash Behavior & Simulation
- Joining Technology
- Life Cycle Assessment
- Material Analytics
- Medical Technology
- Microstructrural Analysis
- Multi-Axial Material Testing
- Multifunctional Composites & Simulation
- Nanocomposites
- Nondestructive Material & Component Testing & Simulation
- Press Molding Technology & Simulation
- Resin Injection Technology & Simulation
- Standardization
- Smart Structures
- Stress Analysis
- Sustainable Materials & Processes
- Tape and Fiber Placement & Simulation
- Textile Preform Technology
- Tribology
- Vitrimers
- Welding & Simulation

for more info, please visit

Interview with Prof. Dr. rer. nat. Hatice Mutlu



Bercis Pektaş, Elio Böffel, Prof. Hatice Mutlu, Lukas Schäfer, Dr. Meryem Akdemir

With the new Program Area Polymer Chemistry led by Prof. Dr. Hatice Mutlu, IVW completes its program structure and strengthens its polymer chemistry profile at the interface of IVW and RPTU. As the first woman to lead a Program Area at IVW, she brings a clear scientific vision and new momentum.

1. You are taking over the new Program Area Polymer Chemistry, completing the IVW structure. What excites you most about this role?

What excites me most is the opportunity to redefine polymer chemistry as a strategic systems discipline within IVW. I see polymers not as final products, but as dynamic material systems linking molecular design, processing, interfaces, performance, and end-of-life pathways.

For me, the key question is not only what a polymer can do in its first life, but what it is designed to become afterwards. This Program Area is therefore a scientific statement: polymer chemistry as a driver for circular, high-performance material systems.

2. Which scientific priorities in polymer chemistry do you plan to strengthen at IVW in the coming years?

Innovation today is no longer only about maximizing performance. We need performance combined with circularity, scalability, and responsibility.

I want to strengthen circular polymer chemistry beyond passive recyclability, toward programmed transformation pathways: selective deconstruction, reuse, and functional upcycling, with chemical logic for the next life embedded into the polymer.

Precision polymer chemistry will be key, as control over architecture and functional placement enables both high performance and circular options, translated into real materials systems from composite matrices to functional interfaces.

3. You are the first woman to lead a Program Area at IVW. What does this mean to you personally, and what message do you hope it sends to women in science?

Being the first woman in this role is meaningful, but it should not define my work. What should define it is the science, the vision, and the impact we create.

Progress means normalizing diversity so it no longer requires a label. If my position sends a message, I hope it is this: do not stay in the box others define for you. Step beyond it and create space for others to do the same.

Read the full interview:

Fields of Competence

Materials Science

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Digitalization

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Data-Driven Methods 20

Materials Science

Tailored Thermosets & Biomaterials

The competence field develops high-performance multifunctional composites with thermoset matrix. As a bottom-up technology platform, an innovative “materials toolbox” is being developed and applied. New materials, preferably based on biogenic resources, and functional nano- and micro-reinforced materials as well as fibers are used to equip composites with tailored properties.

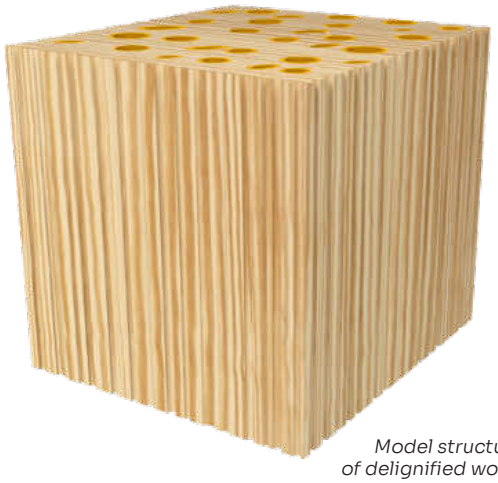
Particular attention is paid to their sustainability and durability, even in aggressive environments, as well as their (chemical) recyclability at the end of their life cycle. To this end, environmentally friendly, scalable manufacturing and recycling processes are being developed and liquid materials are being processed from laboratory scale to quantities of 200 kg on an industrial scale.

The aim is to develop material innovations based on a mechanistic understanding and correlation of processes, structures and properties. State-of-the-art analytical techniques from the spectrum of engineering, chemical and physical methods are used, such as fracture mechanics in media, atomic force microscopy with IR mapping and temperature-modulated optical refractometry.

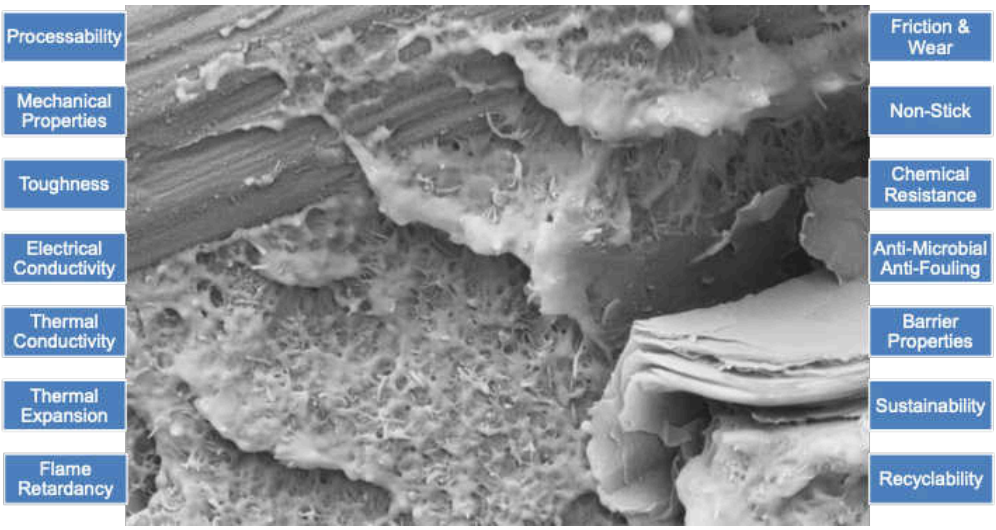


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Model structure of delignified wood



Multifunctional properties of polymer composites

Typical Materials

- Reactive systems
- Biobased materials
- Micro-/nanofillers
- Wood
- Fibers

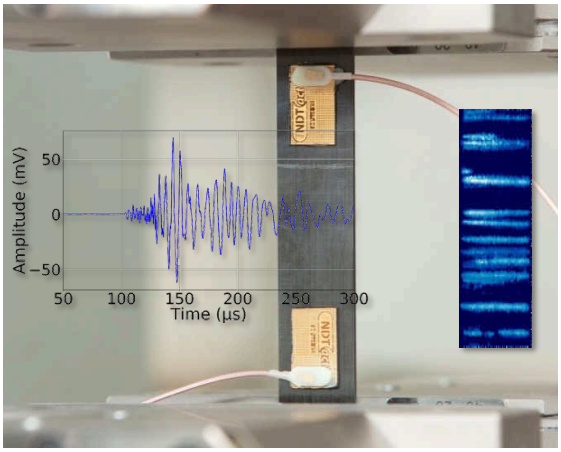
Special Expertise

- Broad expertise in material selection, processing and characterization
- Development of thermoset composites with tailored and multifunctional properties
- Scalable processing technologies and methods according to industrial standards
- Further development of characterization methods

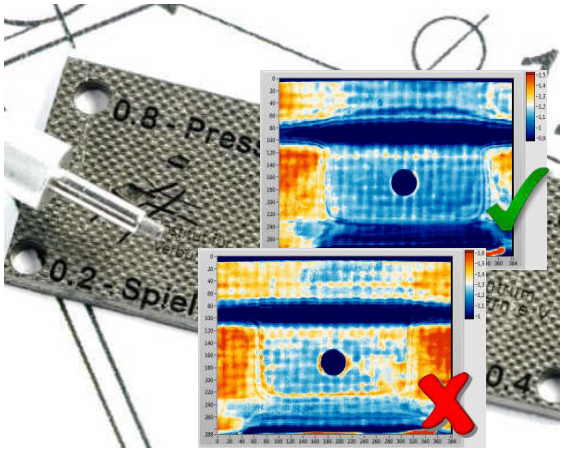
Typical Questions

- How can properties and processability of thermosets be improved without increase of costs?
- Which thermosets are resistant against strong alkaline media in order to reach high durability in applications?
- Which equivalent or better material can substitute a material no longer available on the market?

Smart Composite & Nondestructive Testing



Combination of IR-thermography and acoustic emission for nondestructive evaluation of material and components



Quality control and monitoring with IR-thermography



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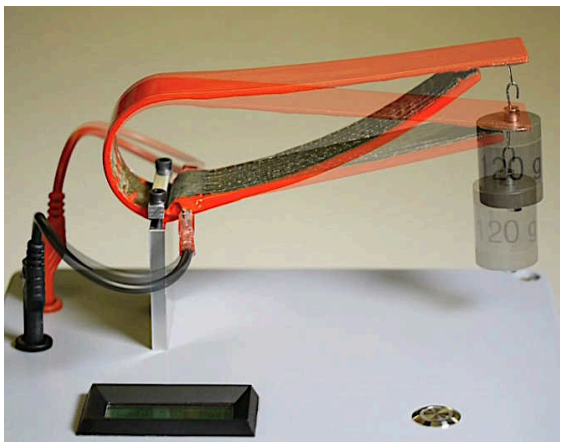
From multifunctional material to system - composite materials allow a variety of functional prop- erties to be combined with optimal structural performance. This makes them a key element of mechatronics and adaptronics, a rapidly advancing field of research today. The main challenge is to mas- ter the complex property profile of these materials along the entire development chain from design and production to system integration and testing of the finished component. This is where the research activities of the competence field Tailored & Smart Composites start:The focus is on understanding the relationships between structure, process, and the resulting properties of multifunctional composites. We are working on the development of new methods for non-destructive testing of composite materials and we integrate sensors or actuators in fiber-reinforced components so that they can adaptively adjust to their environment. After their design by finite element methods, we can produce such materials using standard methods, process them into components or semi-finished products and comprehen- si- vely characterize both the material properties and the special functions.

Typical Materials

- Composites
- Piezo ceramics
- Shape memory alloys

Special Expertise

- „One Stop Shop“: design - simulation - realization - testing
- Combination of composite know-how with smart materials expertise
- Hybrid composites based on various material combinations



Active hybrid composites for shape change

Typical Questions and challenges on the way from material to system are ...

- the effcient theoretical and experimental description of the complex property profiles of multifunctional materials
- the development of suitable measuring and testing equipment and associated methods for multiphysical material characterization
- the development of complexity-adapted, cross-scale material models for processing and component design

Tribology

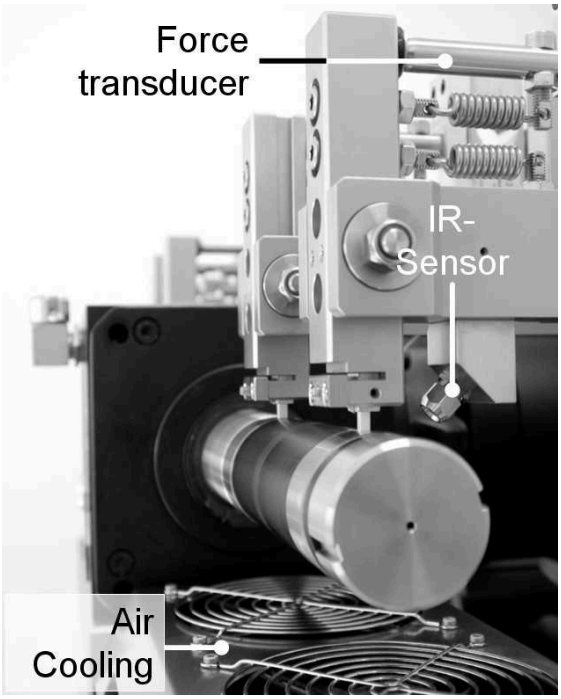
In the field of Tribology, our specialty lies in the development of innovative composite materials that possess outstanding thermal stability and low friction coefficients. These properties allow for prolonged service life even in the most demanding applications. Our approach involves a comprehensive analysis of the specific technical requirements or research questions, coupled with our extensive expertise gained from fundamental scientific research.

When creating new materials, we employ custom-designed tribometers fitted with high-precision sensors and employ pioneering testing procedures. These tools and methods help us gain a deep understanding of the intricate interaction between friction and wear, as weil as the relationships between material composition, material processing, material microstructure, and tribological properties.



Bernd Wetzel

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Block-on-Ring Tribometer

Typical Materials

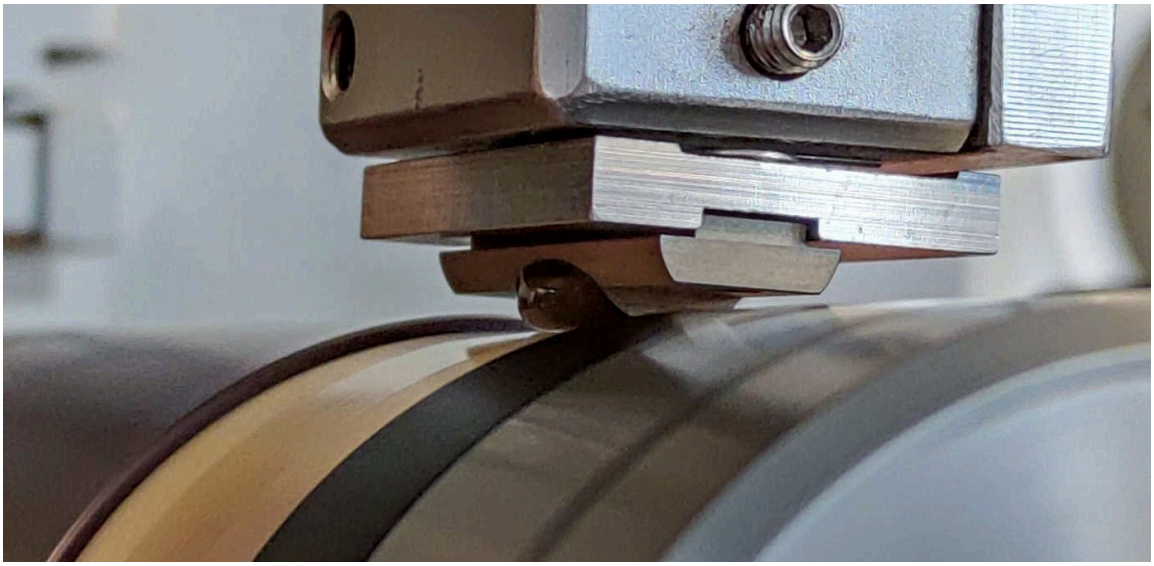
- Thermosets, thermoplastics, elastomers
- Glass/carbon/aramid fibers
- Micro and nanoparticles, solid lubricants

Special Expertise

- Application-oriented customized development of composite materials and manufacturing processes, tribological testing procedures and methodology, component testing

Typical Questions

- How does the material composition influence the stability of transfer films?
- How can tribological model tests be designed so that they can replace plain bearing tests?
- How must laboratory information systems be designed so that they best represent tribological material tests?

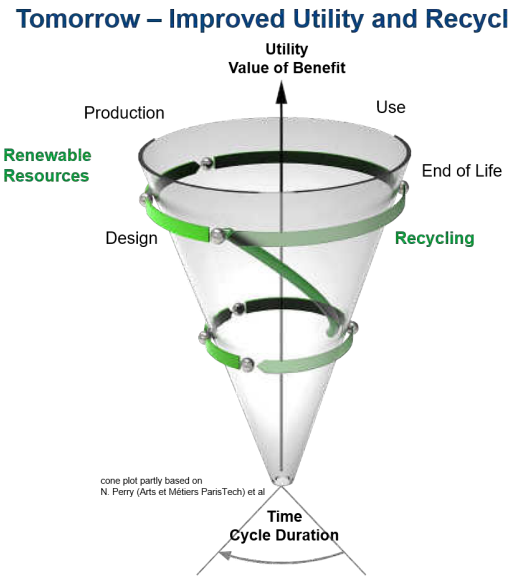


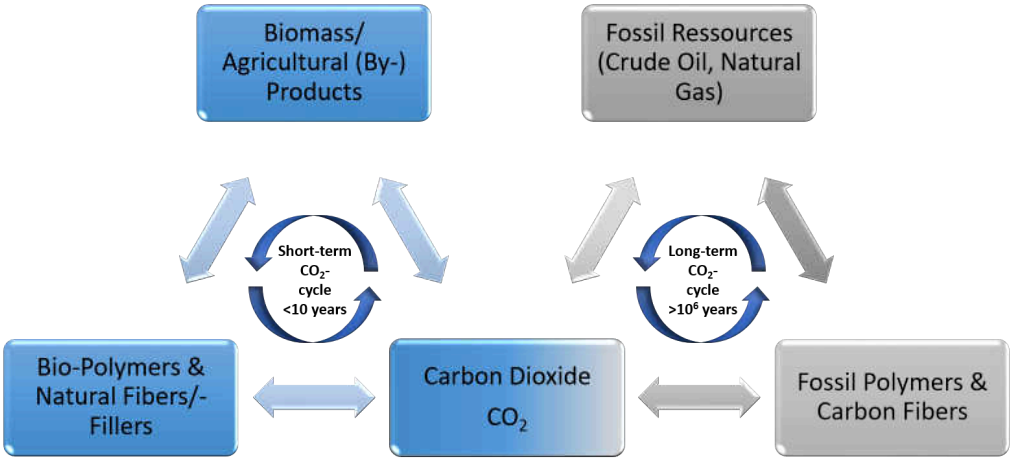
Oil film on a polymeric ring during a gear substitute test

Material Cycles

This research group focuses on fundamental issues related to the use of materials in a closed carbon cycle. Particular attention is paid to the use of renewable raw materials, such as natural fibers or biopolymers from renewable sources. The second focus is on the recycling of materials and components made of composites, and especially those with carbon fibers, since it is another important aspect in the optimal use of raw materials.

Across topics, thermal resistance and surface properties for best possible fiber-matrix bonding and high-performance use are key issues. Naturally occurring structures in natural fibers can, if used in a targeted manner, add value through additional functionality. Understanding this fundamentally is also the subject of research in this competence field.







Barbara Güttler
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Special Expertise

- Circularity of polymers, fibers and composite materials
- Renewable and recycled material streams for composite development
- Modern testing facilities with coupling options for material properties such as thermal behavior, high resolution structural analysis, surface properties as well as influences of weathering and oxygen

Typical Materials

- Polymers, fibers and additives from renewable resources
- Recycled fibers and polymers
- Materials from their end-of-life phase

Typical Questions

- How can materials from end-of-life components be brought into new high-performance applications with consistent quality?
- How can sustainable materials be used and add value to composite applications?
- How do properties of natural fiber influence the behavior of composite materials?

Component Development

Design of Composite Structures

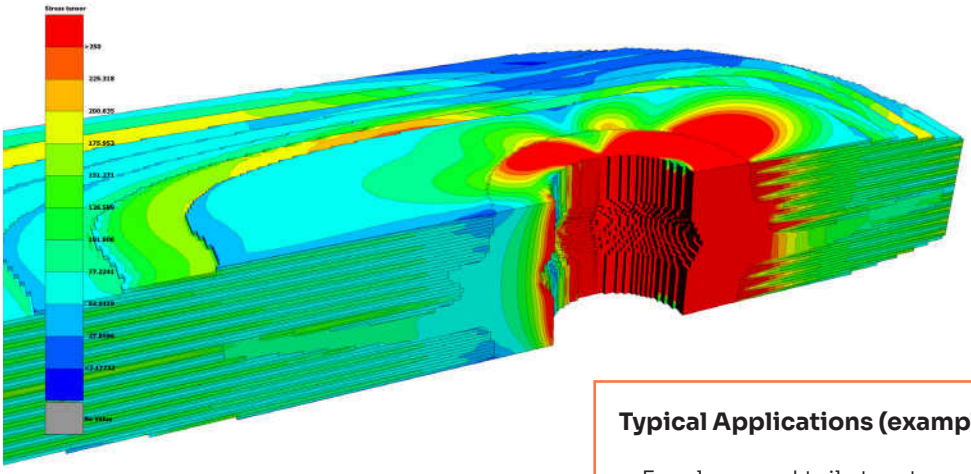
The area Design of Composite Structures covers the development of optimized lightweight structures of fiber reinforced polymer composites (FRPC) for new applications as weil as the substitution of existing designs made of other materials. Finite element program systems (e.g. ABAQUS, ANSYS) with specialized meshing and CAD programs (ANSA, SolidWorks), optimization tools (e.g. TOSCA, lsight) and in-house developed subroutines for modeling, fiber alignment optimization and description of strength and failure mechanisms of FRPC (strength criteria, degradation, non-linear material models, unit cell modeling) are applied.





Nicole Motsch-Eichmann

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Special Expertise

- Lightweight pressure vessel design for optimal use of installation space
- Development of complex, integral FRP-structures
- FEA unit ce/1 model for prediction of stiffness and strength of 3D-reinforced laminates
- Algorithm for flber angle determination from CT-measurement
- Mapping of flber orientation from CT measurement or material simulation to FE model
- Expertise concerning load application in thick-walled FRP-components
- Combination of flber angle- and topology optimization
- Validation of structural design and analysis by experimental testing
- Topology optimization

Typical Applications (examples)

- Fuselage and tail structures, high lift components
- Body-in-white and undercarriage structures
- Highly accelerated machine parts
- Bicycle frames and -parts
- X-ray transparent implants, orthosis
- Pressure vessels, hydrogen storage systems, rotor shafts

Typical Questions

- Can structural components with good mechanical properties be produced by using recycled flbers?
- Is a high level of lightweight design quality achievable even for complex component geometries by cleverly combining continuous fiber-reinforced and short fiber-reinforced areas?
- How can lightweight FRP hydrogen tanks and pipelines be designed for a safe operation?

Mechanical Characterization & Modeling

This field of competence covers the experimental and simulative analysis of materials, structures and joints, especially influenced by strain rate and temperature. Key aspects are the evaluation of material properties (parameters, stress-strain-curves, ...) and the transfer of this behavior into validated material models for FE-simulation. Within these activities, testing procedures are newly developed or optimized. The improvement of energy absorption and structural integrity in tension and bending loaded composite structures and joints is an additional focus in this competence field.



Typical Materials

- CFRP, GFRP, AFRP
- Continuous and discontinuous fiber reinforcement
- Hybrid materials

Special Expertise

- Mechanical characterization of materials using modern high performance measurement equipment
- Validation of FE-models for composites
- FE-modeling by ABAQUS and LS-Dyna
- Modem testing equipment and technologies:
  - » 2 high speed tension machines: material characterization
  - » up to 160 kN testing force at velocities of 0.1 mm/s to 20 m/s and temperatures from -100°C to 250°C
  - » Crash rig up to 22 kJ impact energy for testing of substructures
  - » Drop tower for impact tests up to 3 kJ impact energy
  - » Local optical deformation measurement (DIC) for evaluating of material properties and validating of simulations
  - » 3O-ultra-high-speed pictures up to 1 million Hz frames per second
  - » 3O-ultra-high-resolution pictures up to 40 MPix



Typical Questions

- Will you support us in creating FE-parameter sets for FE-simulations or with validating simulation results?
- Are you able to test materials and structures also under the influence of temperature and varying test velocities?
- How can structures made of FRP absorb energy effectively and show a good structural integrity even under tension?

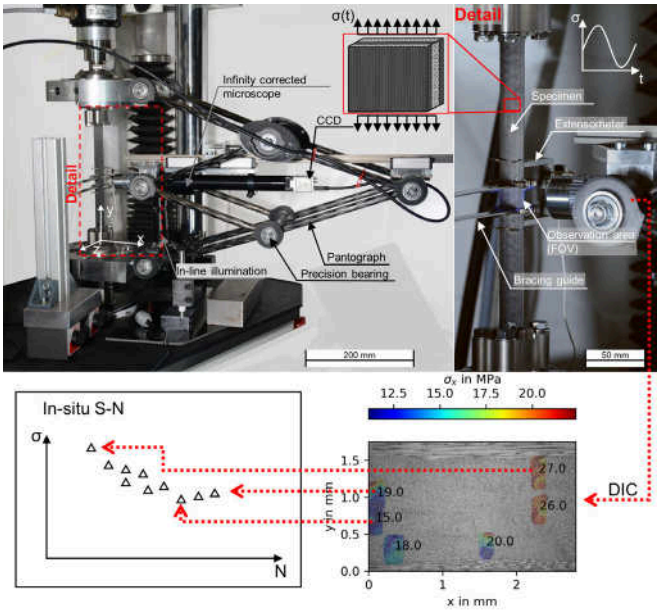


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Fatigue & Life Time Prediction

In the competence field Fatigue & Life Time Prediction research is being carried out on experimental characterization and modeling of the fatigue behavior of fiber reinforced polymers, the identification of input parameters for the fatigue life analysis (fatigue strength, decrease of residual strength, stiffness degradation), and the detection of damage mechanisms i.e. of short fiber reinforced thermoplastics and their influence on life time. The development of sophisticated testing methods and data analysis is used for reliable lifetime prediction with least testing effort. A further topic is the experimental fatigue life testing under environmental conditions.





Joachim Hausmann

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Typical Questions

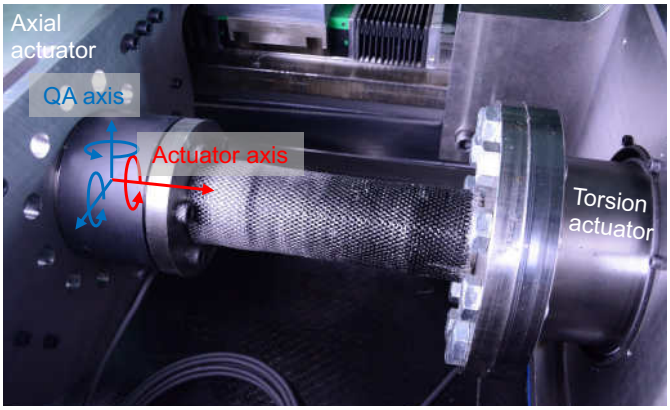
- Are micro damages detectable which determine the life time behavior?
- How are fiber and matrix material influencing the fatigue properties?
- What is the effect of temperature and humidity on the fatigue behavior of fiber reinforced polymers and adhesive joints?

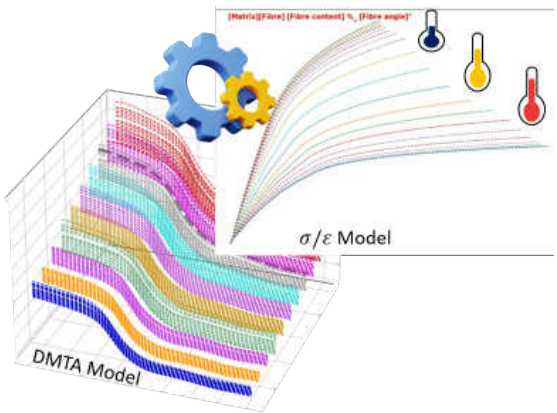
Typical Materials

- GFRP
- CFRP
- Continuously and discontinuously reinforced polymer composites
- Thermoplastic and thermoset matrix systems

Special Expertise

- Life time simulation
- Multiple test facilities and measurement methods
- Component test rig with 6 channel control
- Cyclic testing in climate chamber and at high and low temperatures
- Uni- and multi-axial materials characterization
- High frequency test rig
- 3D optical strain and deformation measurement
- Linking to structural FEA
- Acoustic emission and thermography measurement equipment

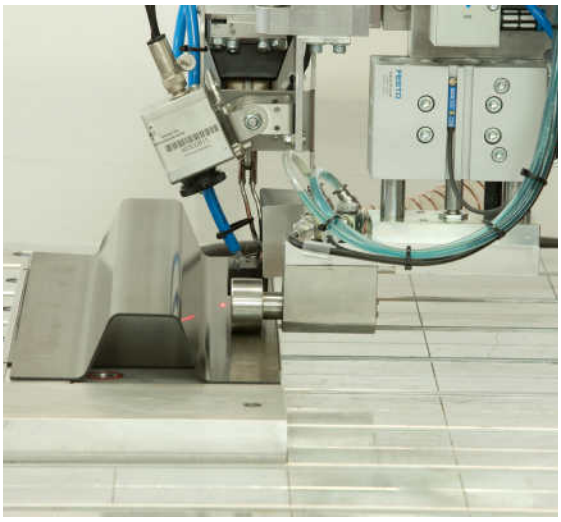




Molding & Joining Technologies

This field of competence focuses on thermoforming of thermoplastic composites, combination technologies with injection molding, thermoplastic foams, LCM processes as well as welding technology. A particular emphasis lies on the production of highly integrated hybrid components, especially those based on high-performance thermoplastics, also combining continuous and discontinuous reinforcements. To maximize lightweight potential and minimize material usage, the application of cellular materials is of particular interest. In this context, approaches to produce geometrically complex, recyclable monomaterial sandwich structures based on thermoplastic composite materials are developed. This also includes the use of thermoplastic foam injection molding. Another key focus is the development of efficient joining technologies for thermoplastic FRPC and metal-FRPC hybrid materials, mainly based on induction welding.







Thomas Neumeyer
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Typical Questions

- How can highly integrated and recyclable composite parts be produced at minimal cycle time?
- How can thermoplastic sandwich structures contribute to electro mobility?
- How can the fusion quality of welded joints be predicted?

Special Expertise

- Combination of continuous / discontinuous fiber reinforcement
- Development of special profile shapes – open and closed – in
- Continuous compression molding (CCM) technology
- Industrial scale equipment:
  - » Continuous compression molding press
  - » Injection overmolding of composites
  - » Resin Transfer Molding (thermoset and thermoplastic)
  - » Several parallel controlled presses with up to 2,500 t press force and mounting table size of up to 2 m x 3 m, IR field and integrated injection molding unit for hybrid thermoforming and compression overmolding
  - » Welding robot
  - » Different test rigs for induction welding
- Foam core materials for thermoplastic sandwich structures
- LCM-one-stop-shop: Tool design, material selection, manufacturing, testing
- In-line and off-line process monitoring
- Digital mapping of process chains

Roving & Tape Processing

Research goal is the development of more efficient manufacturing processes by filament winding, tape laying and 3D-printing with continuous fiber-reinforced thermosetting and thermoplastic matrices including process specific tooling and novel manufacturing equipment solutions. Research focuses on quality management, process control, process optimization and process automation such as in-line direct impregnation, ring winding technology, "out-of-autoclave" process by in-situ consolidation or the extension of additive manufacturing technologies (3D printing).



Jens Schlimbach

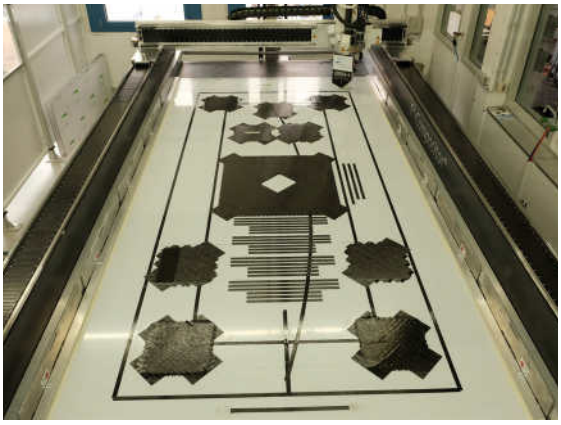
jens.schlimbach@leibniz-ivw.de

Typical Questions

- How can the filament winding process be upgraded for large-scale production?
- How can the quality of unidirectionally reinforced thermoplastic semi-finished products be determined?
- For which applications can the siphon technology be used efficiently?

Special Expertise

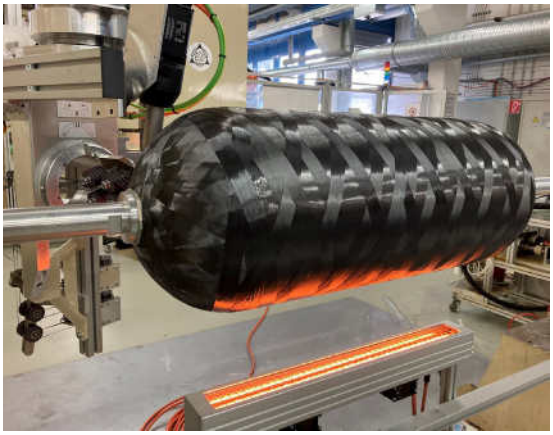
- Industrial scale equipment:
  - » Ultra high speed tape laying gantry system (3.5m x 1.5m layup area, up to 4 m/s layup speed)
  - » Industrial robot with tape laying head (Innovation Award) and external rotation axis (robot winding)
  - » 7-axis winding machine for conventional wet winding, thermoplastic winding and towpreg winding
  - » Ring winding head with 48 rovings for increased throughput (JEC Innovation Award)
  - » Siphon impregnation technology
- Development of procedures specifically for large quantities
- Special tape-laying developments (TP tapes, TS tapes, binder tapes, towpregs)
- Autoclave with inert gas environment (up to 30 bar)
- 3D-printers also with endless fiber reinforcement



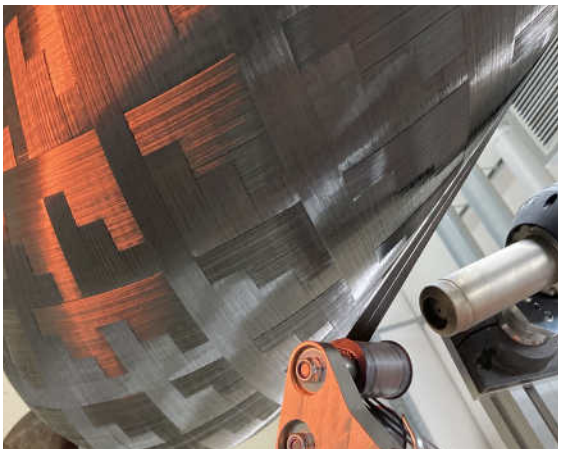
Ultra-fast multiaxial tape laying machine

Typical Materials

- GFRP, CFRP, rovings, tapes (virgin and recycled), prepregs, epoxy resin, polyester resin, PP, PA, PPS, PEI, PEEK, LM-PAEK etc...



TowPreg winding of H2 pressure vessels



TowPreg winding process

Remanufacturing & Repair

This competence field focuses on technologies for the recycling and cascade use of FRPs as well as on the development of strategies for the repair of FRP components. Furthermore, the use of renewable raw materials as matrix fillers, bio-based matrix systems or in the form of natural fibers ("biocomposites") in SMC materials and tape production, is further developed. In terms of recycling a major focus is drawn on the development of staple fiber technology for tape production and subsequent deposition into organic sheets, including their processing into components in the thermoforming process. In order to quantify the environmental impact of processes and products, sustainability assessments (LCA) are carried out.

Typical Materials

- GFRP, CFRP, NFRP
- UP-/EP-resin systems, biopolymers, vitrimers
- Recycled & pyrolized reinforcement materials
- Carbon fiber staple fiber yarns
- Continuously and discontinuously FRP



Florian Gortner

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Typical Questions

- Can recycled materials reach same mechanical properties as virgin materials?
- Is it possible to provide an alternative to virgin material by using materials in a cascade approach including appropriate processing methods?
- Is it possible to use bio-based materials instead of crude-oil based ones?
- can you determine on a case-by-case basis whether recycling is economically and ecologically reasonable?

Special Expertise

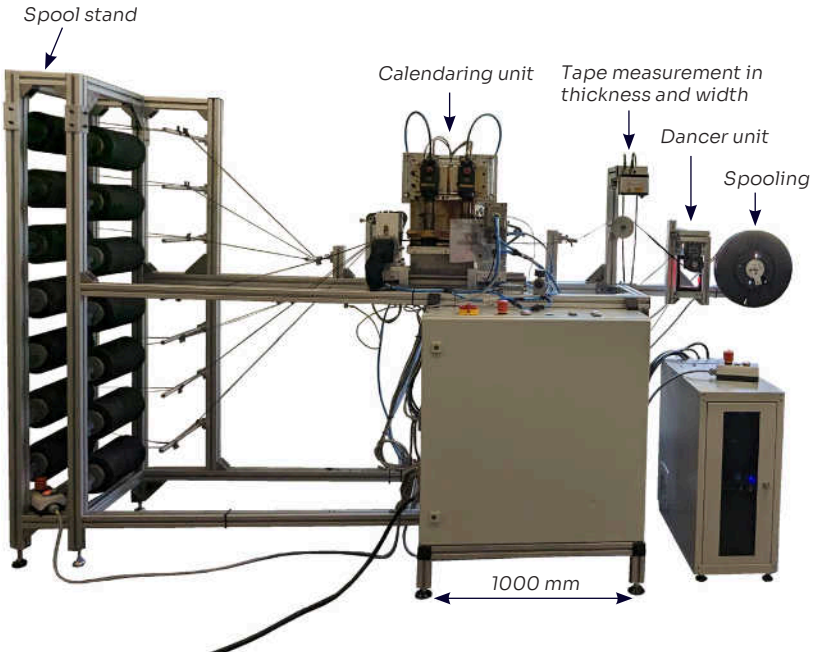
- Processing of recycled carbon staple fiber yarns
- Tape development based on recycled materials
- SMC production
- Tape placement
- Characterization of pseudo-plastic deformation behavior
- Sustainability assessments (LCA)

Industrial scale equipment

- SMC production line



SMC laboratory line



Digitalization

Process Simulation

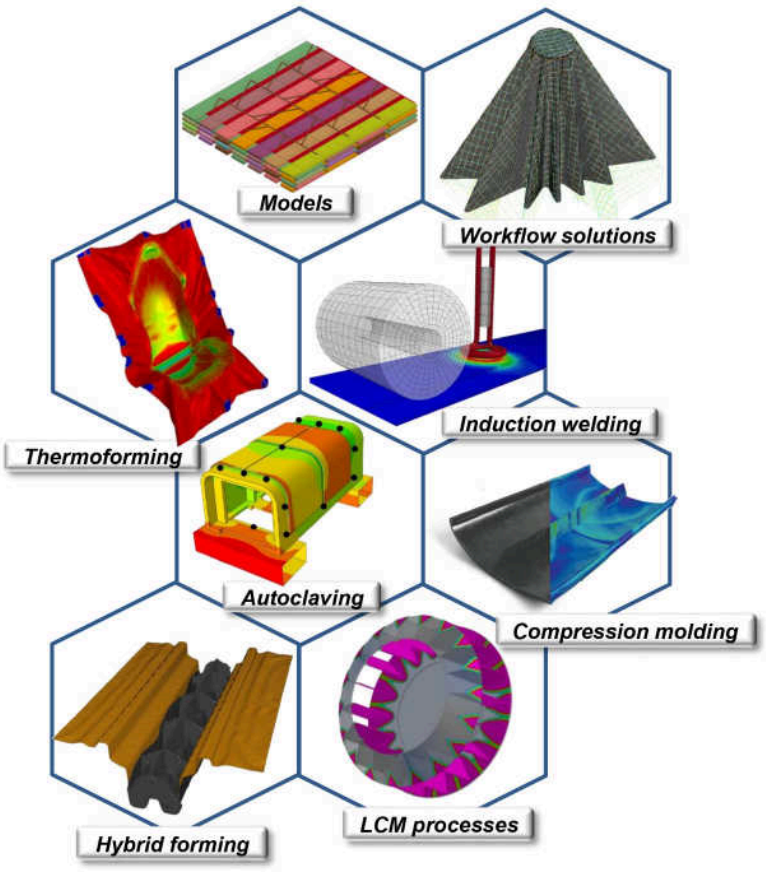
Process modelling and simulation is the cornerstone of Digitalization and Industry 4.0. In this competence field the focus lies on the development of simulation methods, CAE-workflows and material models for the systematic optimization of all manufacturing processes used to create fiber reinforced polymer composite parts.

Application-specific implementation of simulation tools based on commercial and/or open source CAE software are used to carry out systematic studies for optimizing process parameters, tools, component design, sensor positioning and semi-finished product selection. Furthermore, software tools are developed for data transfer within consistent simulation chains, e.g. transfer of process simulation results into mechanical component simulations. Finally, the validation of individual material models based on self-developed experimental and Process simulation for the production of fiber reinforced polymer composites



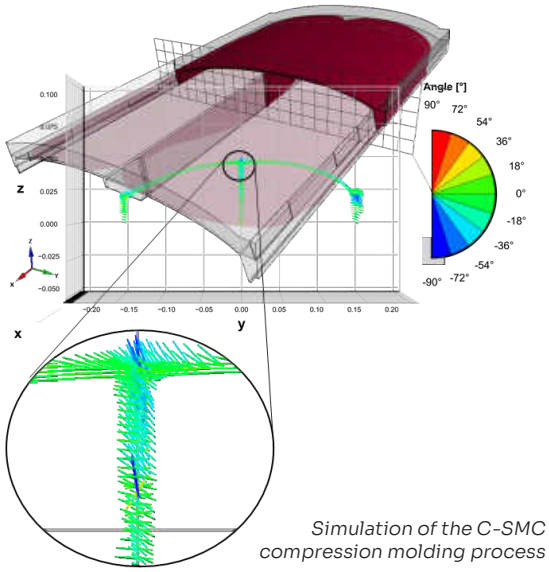
Miro Duhovic

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Process simulation for the production of fiber reinforced polymer composites

Process Simulation & Post Analysis



Simulation of the C-SMC compression molding process

Current Research Topics

- Faster process simulations through model order reduction and machine learning
- Thermoforming simulation for customized preforms made from unidirectional reinforced materials
- Material models for C-SMC with very high fiber volume fraction

Typical Questions

- How do different semi-finished products behave during the pressing process?
- How can fiber orientations and wrinkling be predicted during thermoforming of organic sheets?
- How can the filling time in LCM processes be optimized by adapting gating scenarios?

Special Expertise

- Latest commercial and open source software packages
- Automatable scripts for data transfer and parameter studies
- Modular shell and beam element material model for accurate prediction of fiber orientation
- Material model for C-SMC materials

Digitalized Process & Material Development

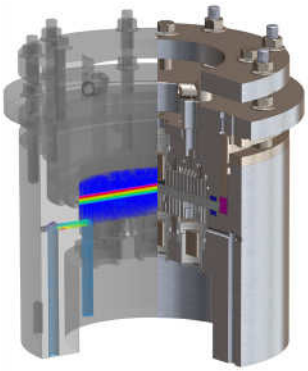
Digitalization forms the basis for efficient product development. Our focus is on the corresponding hardware and software based digitalization "tools" themselves.

Following the principle of"the right sensor at the right place'; application-specific concepts for data acquisition are developed and realized, whereas virtual studies with process simulation models make it possible to minimize data acquisition effort and to maximize information value at the same time. This research area includes micro-scale material simulation for predic- tions of material behavior during processing and application. To build up the necessary material understanding, validate models and generate input data, innovative experimental methods for characterizing the processing behavior of semi-finished products are developed. In all areas, machine learning methods are applied for effective data analysis.

All technologies are developed for the entire spectrum of composite process chains and materials. A special focus, however, is on liquid composite molding (LCM) processes.

Current Research Topics

- Workflows for computer generation of realistic textile models
- Machine vision based on polarization imaging for fiber recognition
- AI-based quality assurance for thermoplastic profile production
- RT storage-stable thermoset prepregs based on solid resins





Andreas Gebhard

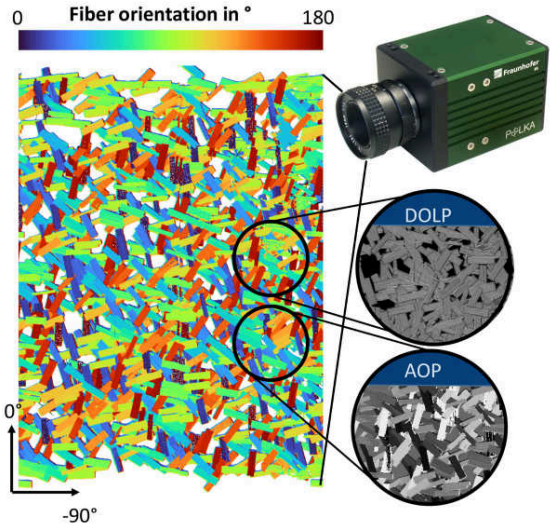
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Typical Questions

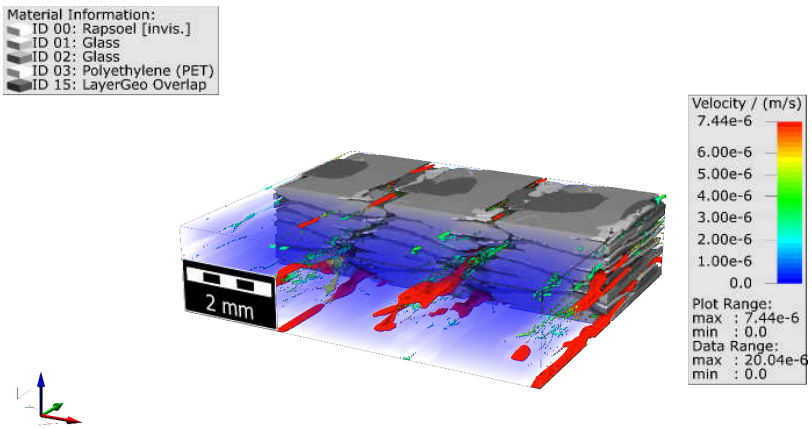
- Which sensor types and positions provide the most meaningful process data?
- How can machine learning methods be used for quality assurance?
- Which liquid impregnation process is suitable for my application?

Special Expertise

- Patented measuring systems, e.g. for textile permeability and organo sheet shearing
- Software packages for material simulation
- LCM-one-stop-shop: Tool design, material selection, manufacturing, testing
- Caprolactam-based Thermoplastic Resin Transfer Molding



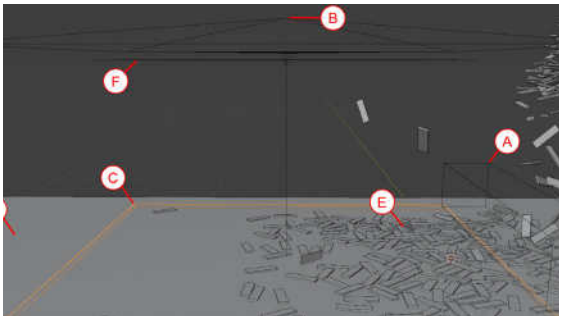
Machine Vision based on polarization imaging



Flow simulation throught a textile model

Digitalization

Data-Driven Methods



Simulation of the cut fiber scattering process in SMC manufacturing to generate training data for AI-powered tracking of cut fibers

Current Research Topics

- *Workflows for data synthesis of composite materials and their manufacturing processes*
- *Machine vision based on polarization imaging for fibre recognition*
- *AI-based quality assurance for thermoplastic profile production*



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When traditional simulation methods reach their limits - for example due to high computing costs or unknown cause-and-effect relationships - data-driven approaches offer a powerful alternative. In this area of expertise, machine learning and statistical methods are used to gain usable knowledge from large, heterogeneous data sets.

One research focus is on surrogate models, which significantly accelerate complex physical simulations through data-based approximations. Modern learning methods also enable the recognition of high-dimensional patterns, for example to predict material behaviour, evaluate material compositions and structures or optimize processes. Other fields of research include data-based quality assurance in production - for example through learning-based anomaly detection - and active process control using artificial intelligence. In addition, the generation of synthetic data through generative models is being researched in order to be able to use data-hungry processes even with limited data availability, to explicitly integrate domain-specific knowledge into data modeling or to carry out targeted variation experiments virtually.

Typical Questions

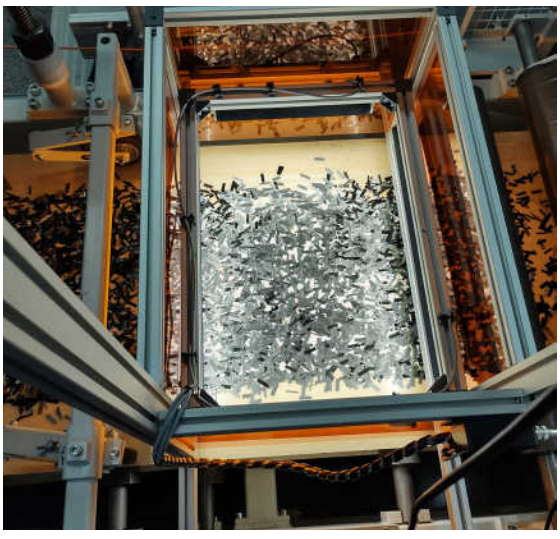
- How can complex, high-dimensional relationships between process parameters and product properties be reliably mapped using surrogate models and used for optimization?
- Which machine learning methods are suitable for the robust prediction of quality and error probability under real process conditions with noisy or incomplete data?
- How can the availability of meaningful training data be improved through data synthesis (e.g. with generative models), especially in scenarios with scarce, sensitive or difficult-to-acquire real measurement data?
- How can data-driven models be combined with domain-specific knowledge (e.g. physical constraints) to improve both generalizability and interpretability?

Special Expertise

- Pattern recognition in materials research
- Machine vision in the quality assurance of FRP
- Surrogate models for the simulation of FRP processes

Typical Materials

- Liquid and solid resins, acrylic resin, reactive PA6
- Glass/carbon fiber-based rovings and textiles, new and recycled
- Thermoset and thermoplastic binder materials



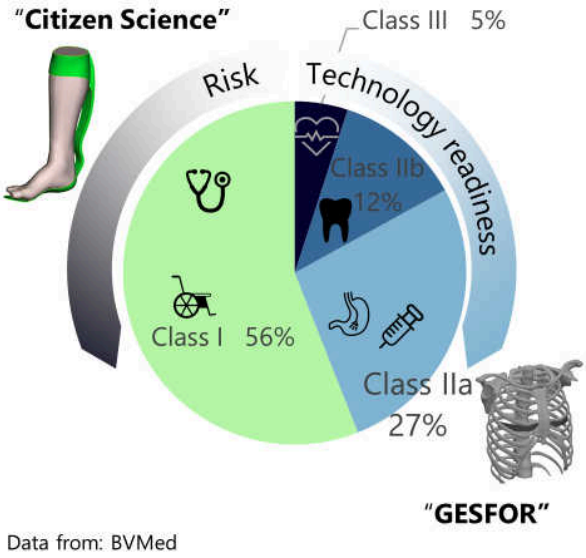
Surface inspection to determine the fiber orientation distribution in C-SMC manufacturing based on polarization imaging

Tailored Composite Solutions

The demographic development and risk factors like diseases of affluence are increasing demands on healthcare and society. Composites can contribute to innovative methods to mitigate some of the consequences. IVW has been transferring its expertise in composites manufacturing and design into the area of medical devices, for over a decade. Past projects like HySpine, 3DPrint2Fiber and FIXTER have shown that composites can be a viable alternative or enabler for new solutions of orthoses and implants. Unlike conventional materials, fibre composites offer a high degree of freedom when it comes to adjusting or customising stiffness. In the case of implants, radiolucency can prove to be advantageous. At the same time, all projects underscored the importance of interdisciplinary dialogue and developing a common understanding across the fields: It is estimated that half of all new product ideas come from doctors and nurses[1]. This is why collaboration with the right partners is especially important. Fortunately, Rhineland-Palatinate possesses a broad community of small and medium sized companies in the health sector but also strong medical research at various institutes and universities. Furthermore, local initiatives like the Health+Innovation Hub (HIH) and the Leibniz Health Technology Research Alliance promote cooperation of highly skilled partners.

An important framework guiding many activities in the medical device sector is the medical device regulation. Acknowledging this, IVW has fitted its activities and the associated aims to the risk classification. A great number of products is classified as class I low risk products, which are supplied in large quantities via small and medium sized companies. Here the focus is on a high technology readiness level and knowledge transfer from established composite domains like aviation and automotive, for example in the Citizen Science project on page 50. In stark contrast Class III products like specific implants require exceptional qualification procedures frequently reserved for large entities. In this case the focus of IVW is on basic research in close collaboration with medical researchers. One currently ongoing project is the GesFor project focusing on implants for a funnel chest.

Our vision is to make a meaningful difference for patients by enabling new solutions with composites. This ambition led us to expand our team in 2025 and to strengthen our engagement across multiple initiatives. Dr. Andreas Baumann took over our activities in this field from Dr. Janna Krummenacker mid of this year, bringing in his strong background in composite fatigue. With this core competence, which is crucial for many applications, IVW will be able to provide even better support to partners and customers in the future, from the initial idea to the finished product for medical applications.



Market entries in 2012 by risk class[1] and along with IVW research activities by TRL



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HEALTH + INNOVATION HUB

LEIBNIZ HEALTH TECHNOLOGIES

[1] *[1] BVMed - Bundesverband Medizintechnologie e.V., "Der lange Weg eines Medizinprodukts von der Idee zum Patienten," BVMed. Accessed: Oct. 09, 2025. [Online]. Available: https://www.bvmed.de/verband/publikationen/medizinprodukte-inforeihe*

Cross-Cutting Technologies

Understanding Interactions of Microstructure, Processing and Properties

Composite materials have long been indispensable in numerous technically relevant industries – from the automotive and aviation industries to the energy sector and healthcare. However, with the ever-increasing complexity of new applications, the demands on the materials themselves and their manufacturing processes are also growing. Because the properties of structures, especially those made of high-performance fiber composites, do not depend solely on the raw materials, it is crucial to develop a comprehensive understanding of the entire value chain – from material analysis to manufacturing and performance evaluation to recycling.

IVW pursues an integrative research approach that links all the key aspects. In order to understand the behavior of composite materials, findings must be brought together across different scales – from structures in the nano and micro range to the macroscopic component level. Linking these scales enables a deep understanding of the underlying mechanisms and forms the basis for the targeted development and optimization of forward-looking materials and processes.

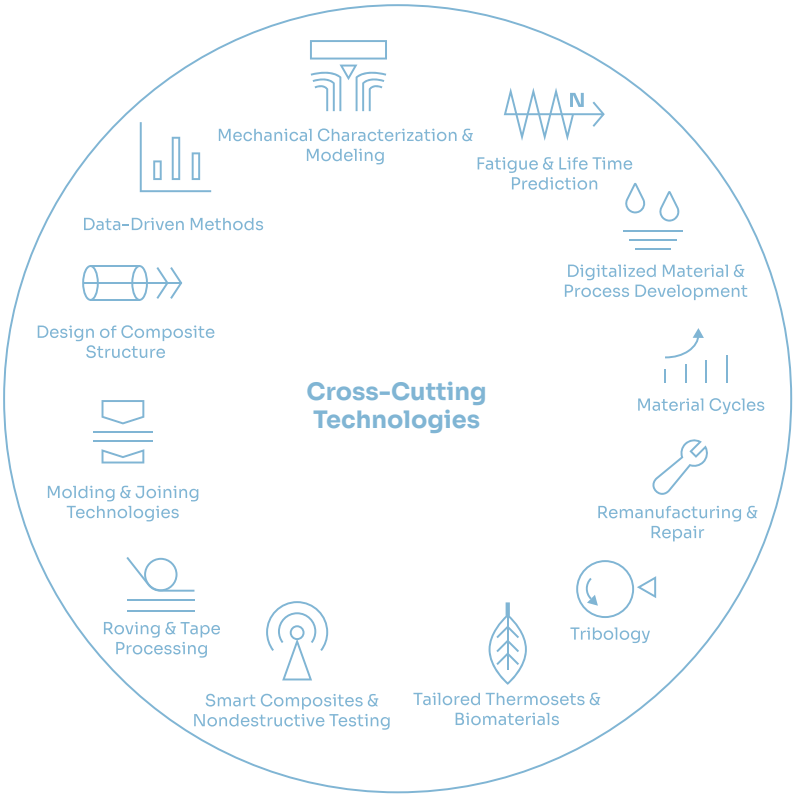
Even though individual disciplines continue to become more specialized, many issues along the value chain are of great importance across disciplinary boundaries. These so-called cross-cutting issues are specifically identified, analysed and addressed in an interdisciplinary manner in the Cross-Cutting Technologies competence area. Perspectives and expertise from materials science, manufacturing technology, simulation, characterization and sustainability research are incorporated into this process.

The aim of this future field of competence is to use this holistic approach to focus on and analytically deepen common core research interests. This creates new synergies and innovative approaches to take the composite materials of the future to an even higher level of performance – more efficient, more sustainable and optimally tailored to the requirements of new applications.



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Vitrimers

New Types of Polymer Matrices for Advanced Fibre Reinforced Composites

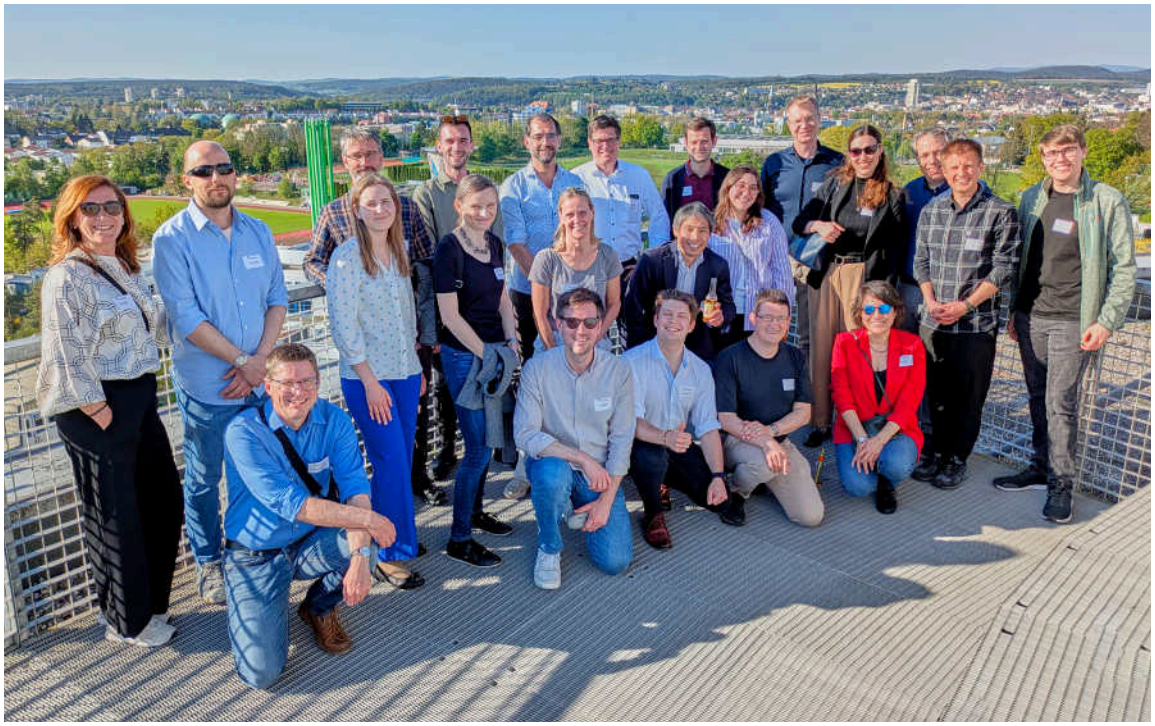
Today, materials scientists and engineers face the challenge of pushing their polymer composite developments to new performance limits while simultaneously meeting the sustainability demands set by national and European authorities. This affects both eco-efficient manufacturing processes and the closing of material cycles. In this framework, vitrimers are promising candidates for the next generation of sustainable and high-performance polymer composite matrices.

Vitrimers are a subclass of dynamic covalent polymer networks, formed through polymerisation of a low viscous resin system, similar to thermosets. Upon an external stimulus, such as e.g., temperature or UV light (cf. Project Repairtecture, page 54), dynamic molecular bond exchange processes enable vitrimers in the cured state to undergo a phase change from a thermoset phase to a flowable phase, and vice versa. This means that vitrimers can be applied as polymer matrices, but can additionally be remanufactured, repaired (even in service), and disassembled.

The objective within this field of emerging technologies is to deepen the understanding of vitrimers from an interdisciplinary physics- and engineering-based perspective, in order to lay the foundation for their possible future use as matrix materials in fibre reinforced polymer composites. This means foremost understanding the thermo-mechanical behaviour of vitrimers in the solid, viscoelastic, and flowable phases, as well as their transition behavior between those phases. This thematic focus has been addressed within a DFG-funded Walter-Benjamin project. Building on this foundation, particular attention is now given to vitrimer composites in order to elucidate the interaction between dynamic molecular bond exchange and fibres or (nano)particles. Finally, the research within this field extends beyond classical vitrimers, seeking new classes of adaptive polymer matrices for reprocessable and multifunctional polymer composites.



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Mini-Symposium: "Vitrimers Connect – From Physics & Chemistry to Engineering" April 29th, 2025, concluding event of the DFG-funded Walter-Benjamin project

Projects Overview

In 2025, a total of **128** projects were processed. **57** projects were funded by public funding authorities such as

- **the German Research Foundation (DFG)**
- **the European Union (EU)**
- **the Federal Ministry of Research, Technology and Space (BMFTR)**
- **the Federal Ministry for Economic Affairs and Energy (BMWE)**
- **the Ministry of Science and Health of Rhineland-Palatinate (MWG)**
- **the Industrial Cooperative Research (IGF)**
- **the Central Innovation Programme for SMEs (ZIM)**
- **the Leibniz Association foundations**

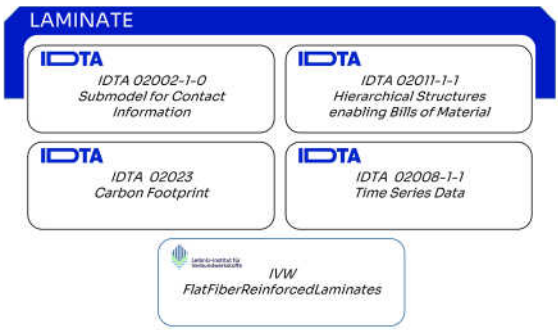
and others.

71 of these projects were bilateral research projects with industrial partners, with the greatest demand from the mobility sector, followed by the energy, climate and environment segment.

The following pages highlight a selection of our projects, presented in alphabetical order, with detailed descriptions provided for each.

AAS4ATL

Asset Administration Shells for Automated Tape Laying & Thermoforming



Schematic overview of the data model for laminates produced on the IVWs F2-Compositor automated tape laying machine as presented on the ICCM24 in Baltimore

Motivation

Efforts to collect, structure, and harmonize data on composite production are steadily increasing, yet standardized data frameworks remain limited. Established nomenclatures and data modeling practices already provide a solid foundation to build upon.

Objectives

The objective is to define common, machine-readable data structures for continuous fiber–reinforced laminates, leveraging established industrial digital twin models while remaining closely aligned with familiar and trusted terminology and relationships.

Approach

The proposed solution is based on the IDTA's Asset Administration Shell, which offers a neutral and open framework. Its structure centers on flat fiber-reinforced laminates composed of unidirectionally reinforced layers, reflecting the well-known concepts of classical laminate theory.

Results

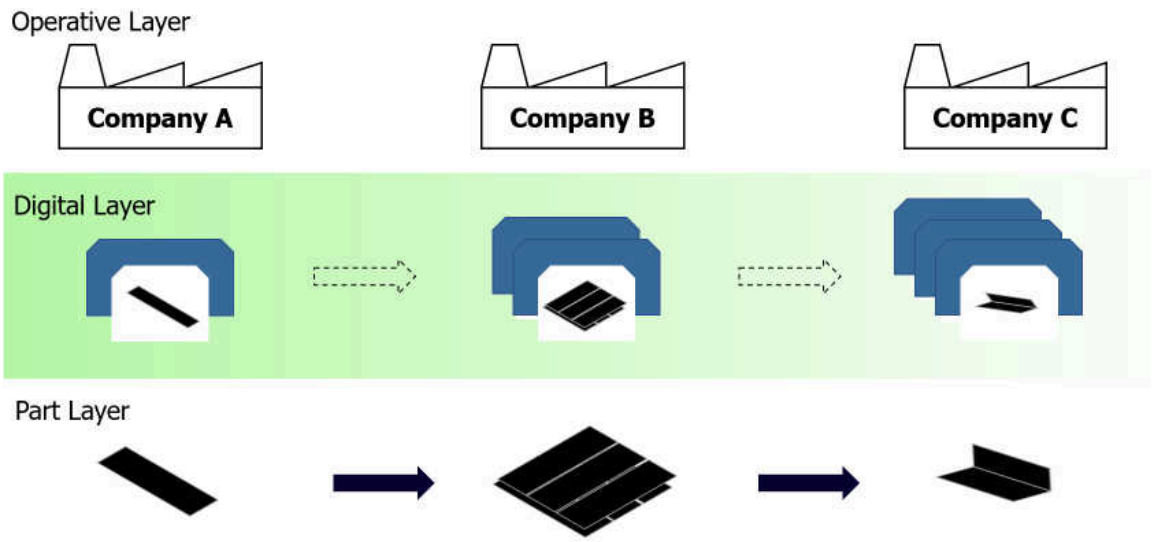
The data model has been developed to capture data collected through IVW's Industrial Internet of Things (IIoT) platform for a production-ready Automated Tape Laying process and is integrated into a generalized framework alongside models describing product relationships and product carbon footprints. Self-hosted instances of the model have been created and prepared for external provisioning, and the modeling approach has been presented to the academic community at the 24th International Conference on Composite Materials.



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The Asset Administration Shell (AAS) provides a standardized model for exchanging information along process chains that may include multiple manufacturers

This project was funded by the Ministry of Science and Health of Rhineland-Palatinate

RheinlandPfalz
MINISTERIUM FÜR WISSENSCHAFT UND GESUNDHEIT

Partner FOTOVERBUND GLAS MARL

AdaptiveS

Development of Plant Technology for the Production of Continuous Fiber-Reinforced Polymers



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Motivation

A range of established processes is currently available for the production of fiber-reinforced polymer composites (FRPC). In terms of achievable part quality, autoclave technology remains the benchmark, as it enables the production of high-performance composites through the combination of vacuum and pressure. This approach, however, also involves certain limitations, including long cycle times, high energy consumption, and complex process preparation. To efficiently meet the growing demand for large-scale FRPC components, innovative manufacturing approaches are required that can overcome these drawbacks.

Objectives

The objective of the AdaptiveS project was to develop an innovative manufacturing technology for the thickness-adaptive production of continuous fiber-reinforced polymer composite structures.

Approach

In collaboration with the project partner Fotoverbundglas Marl GmbH, a modular manufacturing unit has been designed and constructed based on the targeted processing parameters. The prototype is capable of reaching processing temperatures of at least 250 °C and a process pressure of 3 bar. With a usable area of 1.5 × 1.5 m², the system is suitable for the production of multiple or large-area

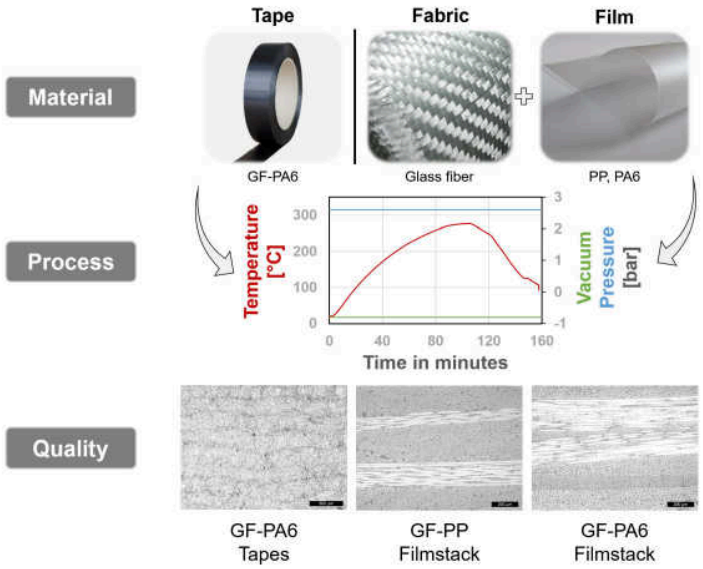


AdaptiveS Prototype for manufacturing FRP-structures
© Fotoverbund Glas Marl

semi-finished components. In addition to the technical development, a simulation model was created to enable material-dependent determination of process parameters.

Results

The realized and tested prototype confirms that the plant concept offers significant potential for the processing of fiber-reinforced polymer composites. This technology enables the production of semi-finished components with varying dimensions — in terms of both surface area and thickness — within a single process step. As a result, a high throughput can be achieved, which can be further increased and flexibly adapted to specific customer requirements thanks to the system's modular scalability.



Manufacturing of FRP based on different materials

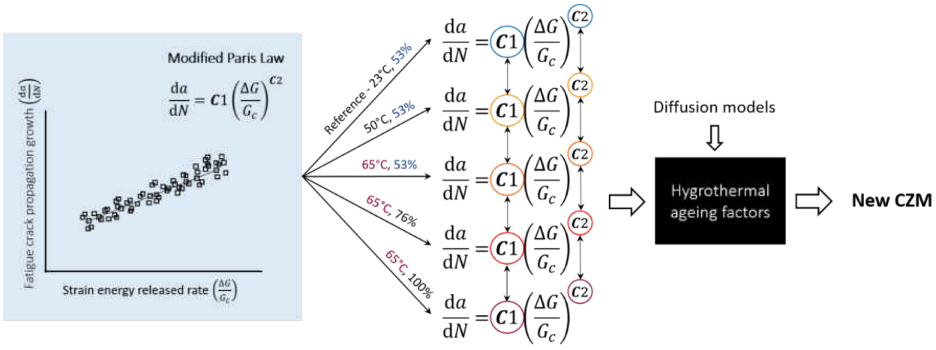
Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the Federal Ministry for Economic Affairs and Energy (BMWE) based on a decision by the German Bundestag (funding code KK5003709KU3).

Partner U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Adhesive Joints

Hygrothermal Effect on the Fracture/Fatigue Behavior of Adhesively Bonded Repairs



Schematic representation of the procedure to obtain the hygrothermal ageing factors under fatigue loading

Motivation

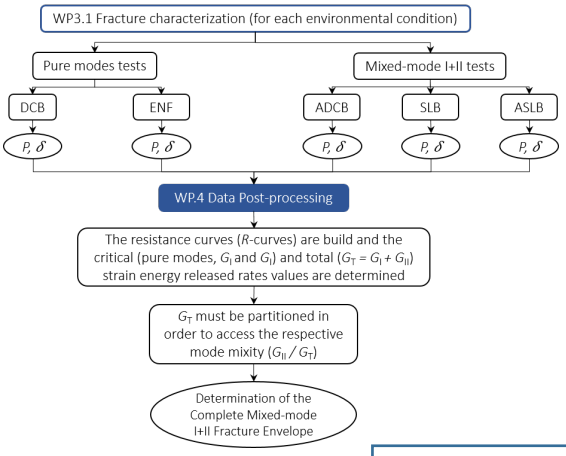
Aeronautic structures are exposed to a great variety of temperatures and humid environments during service. Nowadays, it is known that the combined influence of moisture and temperature induces further detrimental effects on the fatigue behavior of bonded joints when compared to the influence of each isolated condition. Currently, the majority of numerical works are semi-empirical in the sense that they only apply to specific cases and they require extensive experimental testing to fine-tune the proposed models. Moreover, the application of such models in the context of repairs of composite components is missing. In addition, it is also worth highlighting that most works evaluating the environmental effects on the fatigue performance of bonded joints focus mainly on pure loading modes. In fact, there is currently no standard procedure to evaluate the behavior of joints under mixed-mode I+II loading. Therefore, firstly, this project intends to contribute with a detailed procedure to analyse the effects of different hygrothermal environments in the mixed-mode I+II fracture and fatigue behaviour. Furthermore, the final goal is to develop a more generalized predictive numerical tool for bonded repairs.

Objectives

The goals of the project are: (1) develop a careful design of an experimental procedure to evaluate the combined effect of moisture and temperature on adhesive bonded joints and (2) develop a numerical model to predict the quasi-static and fatigue performance of composite adhesive repairs under different adverse hygrothermal conditions.

Approach

The project includes the quasi-static fracture and fatigue/fracture characterization of carbon-fiber reinforced polymer (CFRP) laminates and CFRP bonded joints. This characterization will be conducted on coupon specimens exposed to different hygrothermal conditions. To analyse the influence of the environment on the fatigue behavior, the fracture law describing the quasi-static (QS) mixed-mode I+II fracture envelope will be obtained first. Then, fatigue tests will be conducted considering the same specimen's configurations and environmental conditions. Crack growth curves (da/dN) as a function of strain energy release rate (G) will be obtained using the modified Paris law (da/dN = C1*(ΔG/Gc)C2). The idea is to find the coefficients (C1 and C2) of such a law for each environmental condition. After obtaining the laws, a relationship between the diffusion coefficients and the fracture and fatigue properties for all the environmental conditions will be derived. Finally, a suitable approach enabling fatigue and hygrothermal degradation effects (ageing factors) will be implemented in the cohesive zone model already developed by our research partner.



Scheme of quasi-static tests and their data post-processing



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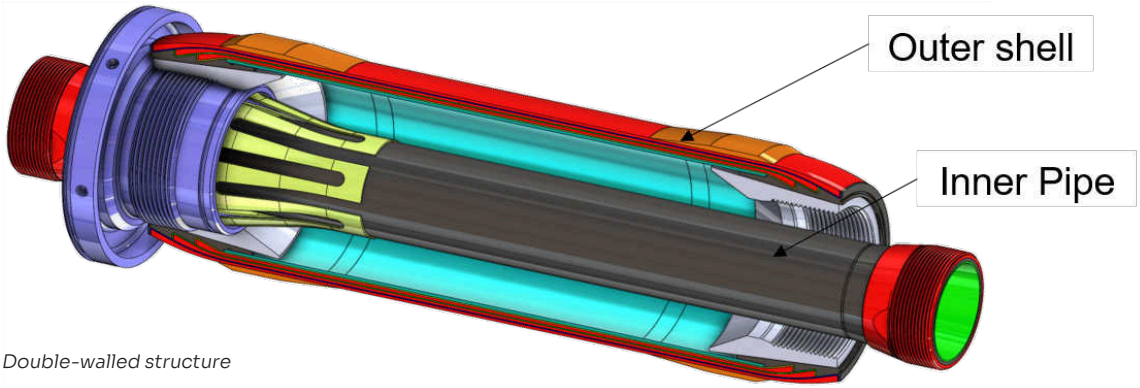
Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation

This project was funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG). Project number: 529660074.

Partner AIRBUS

CF-Hydro

Development of an Integrated, CFRP-Based Hydrogen Distribution System for Aviation



Double-walled structure



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Motivation

The substitution of fossil fuels with green hydrogen can significantly reduce the climate-damaging impact of aviation. However, the storage and distribution of hydrogen in aircraft can only be operated efficiently if lightweight-optimized designs (e.g., using fiber-reinforced plastics (FRP)) produced through efficient manufacturing processes are available.

Objectives

The objective of the research project CF-Hydro is therefore the development of a lightweight design and manufacturing processes for the production of CFRP (carbon-fiber-reinforced plastic) pipelines for hydrogen distribution in aircraft. The project targets the development of a system for transcritical (cryo-compressed) and liquid hydrogen distribution.
To improve the lightweight efficiency of the hydrogen system, the pipelines will be designed to additionally bear structural loads. This enables certain structural stiffeners to be replaced by the pipelines themselves. Through this dual functionality, the number of components can be reduced, leading to savings in both cost and mass.
In addition to the structural design, the development of an efficient manufacturing process is also planned. A key feature of the intended process is the ability to produce cylindrical CFRP components with an almost freely selectable diameter to enable optimal use of the available installation space.

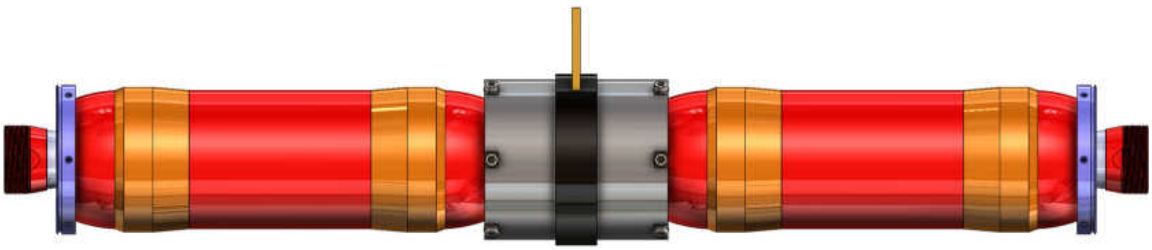
Approach

To maintain the hydrogen at the required temperature of well below –200°C, the pipeline will be constructed as a double-walled CFRP structure. The inner pressure cylinder serves to transport the hydrogen and withstands the internal pressure. The outer shell of the double-wall system provides thermal insulation and integration into the surrounding structure. The pressure cylinder and outer shell are mechanically decoupled.
This design allows the outer shell of the pipeline to function as a load-bearing structural component, enabling the replacement of existing structural elements such as stiffening profiles in the future.



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Tube connector

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the German Federal Ministry for Economic Affairs and Energy (funding reference: 20E2103).

C-SMC Benchmark

First European Benchmark Exercise on Squeeze Flow Testing of High-performance C-SMCs

Motivation

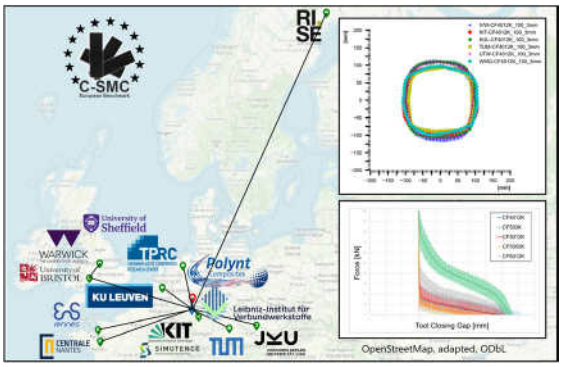
High-performance carbon fiber sheet molding compounds (C-SMCs) are widely used in lightweight, high-strength applications, where accurate prediction of part quality is crucial. Although squeeze flow testing is commonly used to characterize C-SMC rheology, the lack of standardized procedures and the complex behavior of high-performance C-SMCs result in low reliability and reproducibility of experimental data.

Objectives

The project aims to identify sources of variability, improve test repeatability, and generate reliable datasets that support both understanding of material behavior and the development of simulation models to support efficient C-SMC manufacturing.

Approach

Under the joint leadership of the Leibniz Institute for Composite Materials and the University of Sheffield, the benchmark involves 12 research institutes across 10 testing facilities in 7 countries. A total of 500 kg of C-SMC material was donated by Polynt Composites Germany GmbH. Five different material recipes are investigated during a 5-day testing campaign, with each participant testing up to 120 specimens. This coordinated effort allows systematic evaluation of intra- and inter-laboratory repeatability, while also assessing the influence of material variations on test reproducibility.



C-SMC project European consortium

Results

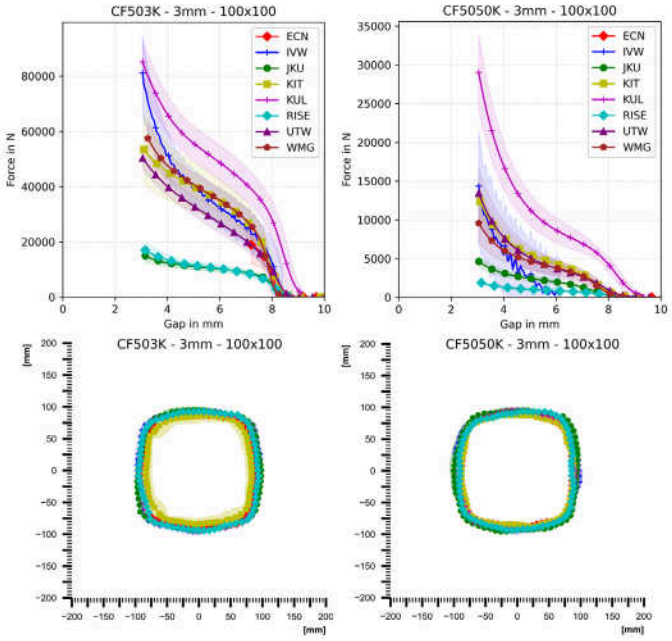
All partners successfully followed the standardized plate squeeze-flow procedure developed by the consortium despite having different equipment. Initial results indicate that comparable compression curves were obtained for each material, showing good reproducibility. Preliminary analyses show that a 3K tow size generates the highest press forces, while a 50K tow size requires 3 times lower forces for a C-SMC material at the same fiber content. In addition, increasing the fiber content raises the required press force for a given tow size.



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Partners

Polynt Composites Germany GmbH, Germany
University of Sheffield, England
Karlsruhe Institute of Technology, Germany
University of Twente, Netherlands
Katholieke Universiteit Leuven, Belgium
École Centrale de Nantes, France
University of Warwick, England
Johannes Kepler University, Austria
University of Bristol, England
Research Institutes of Sweden, Sweden
Technical University of Munich, Germany

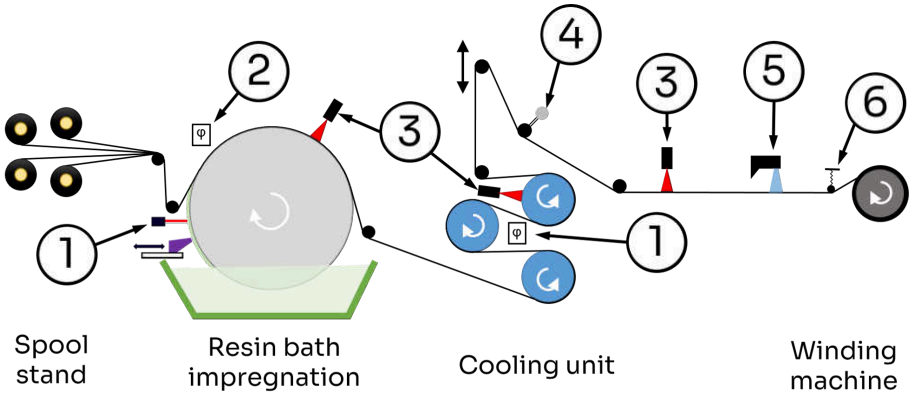


C-SMC material force-displacement and flow-front development curves

This project is driven by shared scientific motivation and has been conducted without third-party funding.

DigiTain

Digitalization for Sustainability



1. Resin film thickness (confocal sensor)
2. Relative humidity
3. Temperature (pyrometer)
4. Speed (encoder)
5. Geometry (laser profiler)
6. Tension (load cells)

Schematic representation of the digitized SpeedPreg-process



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Motivation

Hydrogen mobility offers great potential for a sustainable future of the transportation sector. Composite pressure vessels - manufactured in filament winding - represent a lightweight and high-performance solution for hydrogen storage. A new direct towpreg winding process was developed in a previous project to overcome low cycle times of wet winding and high material costs of towpreg winding. This so-called SpeedPreg-process is based on inline impregnation followed by cooling to achieve towpreg-like roving behavior. It is currently available in laboratory scale.

Objectives

The objective is to advance the novel winding process to industrial scale. Digitalization reveals potential for process improvements, enables closed-loop quality control and thus increases product quality.

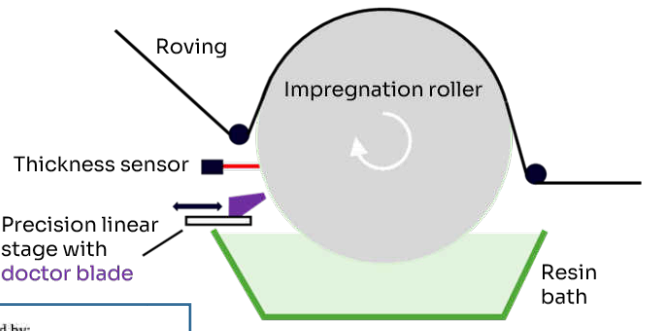
Approach

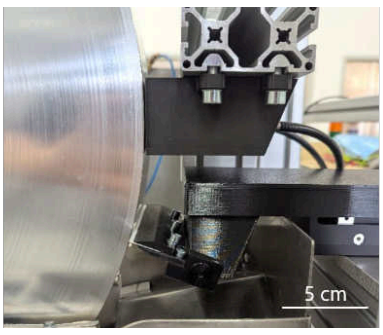
Various sensors were evaluated concerning their ability to monitor key process parameters. They include roving related factors such as tension, speed, geometry, and fiber damage. Resin film thickness, temperature and humidity measurements give insights into impregnation behavior. The sensor data was used to deepen understanding of the process, make iterative adjustments, and derive requirements for the production system. Winding and analyzing test specimens at different process parameters serves for validation.

Results

Thickness measurements showed fluctuations in resin film, leading to deviating fiber volume contents. To address this, a resin film thickness control system was developed and integrated. Fiber tension measurements revealed the necessity to tension each roving individually and to ensure higher dynamic performance of dancer and cooling unit. The insights obtained were incorporated into the design of the prototype system, which is currently being manufactured and will be established at Hexagon Purus GmbH.

Partners:





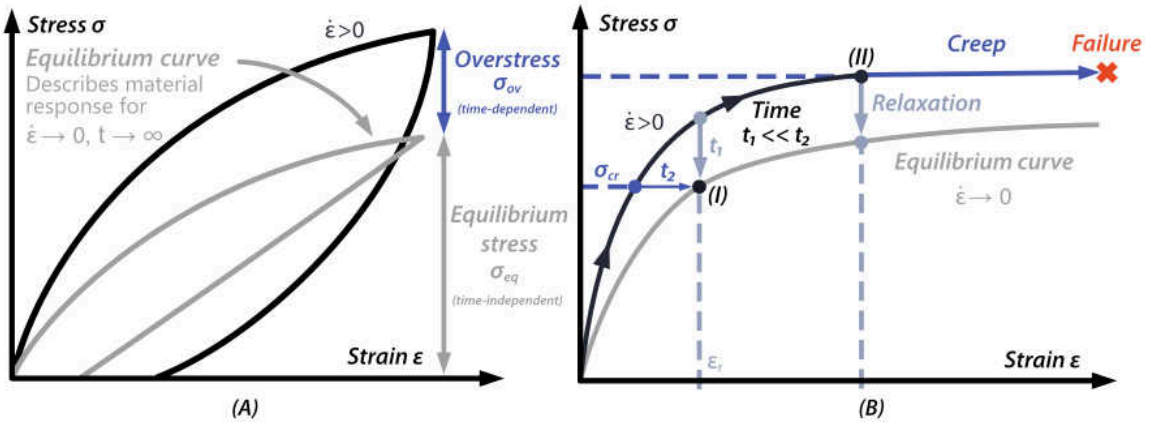
Resin film thickness control system

Funded by the European Union
NextGenerationEU

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the European Union and the German Federal Ministry for Economic Affairs and Energy within the framework of the economic stimulus package no. 35c in module b on the basis of a decision by the German Bundestag, funding reference: 19S22006P.

Efficient Mechanical Characterization and Modeling of Short Fiber-Reinforced Thermoplastics



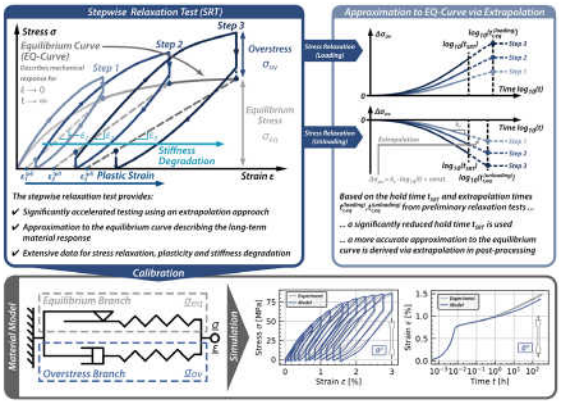
(A): Equilibrium curve concept for the comprehensive separation of the material response, (B): Approximation of the equilibrium curve via creep or relaxation experiments

Motivation

Short fiber-reinforced thermoplastics (sFRTP) exhibit a highly nonlinear material response: Besides damage and plasticity, especially pronounced time-dependent effects such as creep and stress relaxation are of concern. For effective component design, it is essential to be able to represent this material behavior in the calculation. Extensive testing programs are currently being carried out to determine material properties, which are extremely time-consuming and costly. In addition, commercial material models are unable to adequately represent the complex material behavior.

Objectives

The objective was to provide an integral, efficient approach for the efficient characterization and modeling of sFRTP.



Developed workflow for the efficient characterization and modeling of short fiber-reinforced thermoplastics

Approach

The approach is based on the theoretical concept of an equilibrium curve, which can be understood as a mechanical description of the long-term material response. Therefore, the equilibrium curve describes a limiting state that is reached in creep or relaxation experiments after sufficient time. Based on this concept, a novel stepwise relaxation test (SRT) has been developed at IVW that derives an approximation to the equilibrium curve in an accelerated manner. In SRT, the holding times for the individual stages are reduced to a few hours and the measured behavior is extrapolated to longer times, resulting in a significant increase in efficiency. The SRT evaluation provides comprehensive material properties with regard to stress relaxation, degradation of stiffness due to damage effects, and plastic strain. Furthermore, a corresponding material model has been developed that can be fully calibrated using the SRT data – an important aspect for practical use.

doi: 10.1016/j.compositesb.2023.110734
doi: 10.1016/j.compstruct.2026.120178

Results

The developed approach has been successfully validated for an application-relevant PBT-GF30. Due to the generic concept of the developed methodology, it can be generalized to other material systems.



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This project was funded by Forschungsvereinigung Antriebstechnik e.V. (FVA) (funding reference 1008 I).

Fiber-Reinforced Bipolar Plates

Fiber-Reinforced Compound Foil Bipolar Plates for Compact Fuel Cells



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Motivation

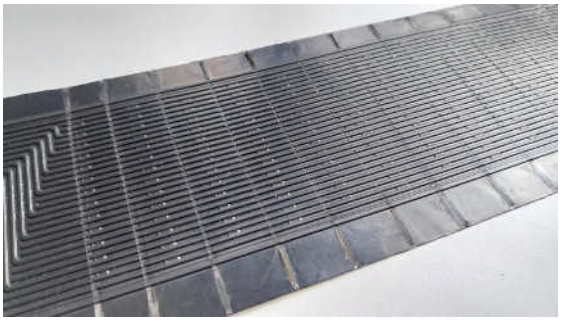
Hydrogen fuel cells are seen as one approach to fossil fuel substitution, e.g., in the automotive industry. Fuel cells consist of multiple bipolar plates, which, due to their complex requirements, are made of either specifically coated metals or polymers filled with graphite, so-called graphite polymer compounds. For metallic bipolar plates, the specific coating causes major costs and the compound bipolar plates, due to their mechanical properties, require high wall thicknesses, increasing the volume and decreasing the power density of the fuel cell.

Objectives

By reinforcing the compound bipolar foils with fibers, it was intended to drastically reduce the required wall thicknesses, mitigating the mentioned drawbacks while keeping costs lower than metallic bipolar plates.

Approach

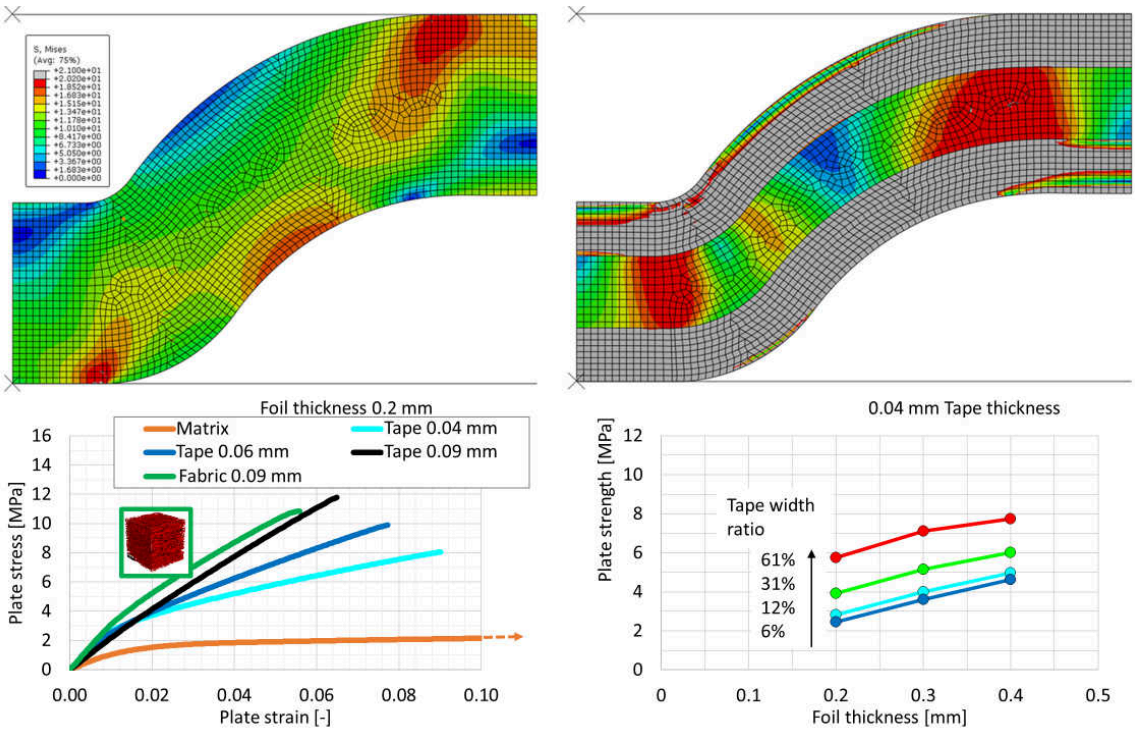
For the sake of reinforcement, carbon fibers were incorporated into the surface layers of the compound foils via variothermal press processes. A comprehensive characterization was performed to investigate the influence on mechanical performance, the essential electrical conductivity and the impermeability regarding hydrogen. The mechanical characterization was accompanied by an FEM analysis, also accessing the effects on the fuel cell.



Formed fiber-reinforced bipolar plate from a compound foil. Active area of the plate: approx. 200 x 50 mm²

Results

Compound foils were successfully reinforced with fibers in the form of tapes and formed into bipolar plates. The characterization approved the concept of fiber reinforcement and FEM analysis highlighted the opportunity of a further wall thickness reduction, showing the potential for compound bipolar plates to go beyond the automotive sector and be considered in aerospace applications.



FEM simulation calculating the mechanical influence of fiber reinforcement on stress and strength of bipolar foils

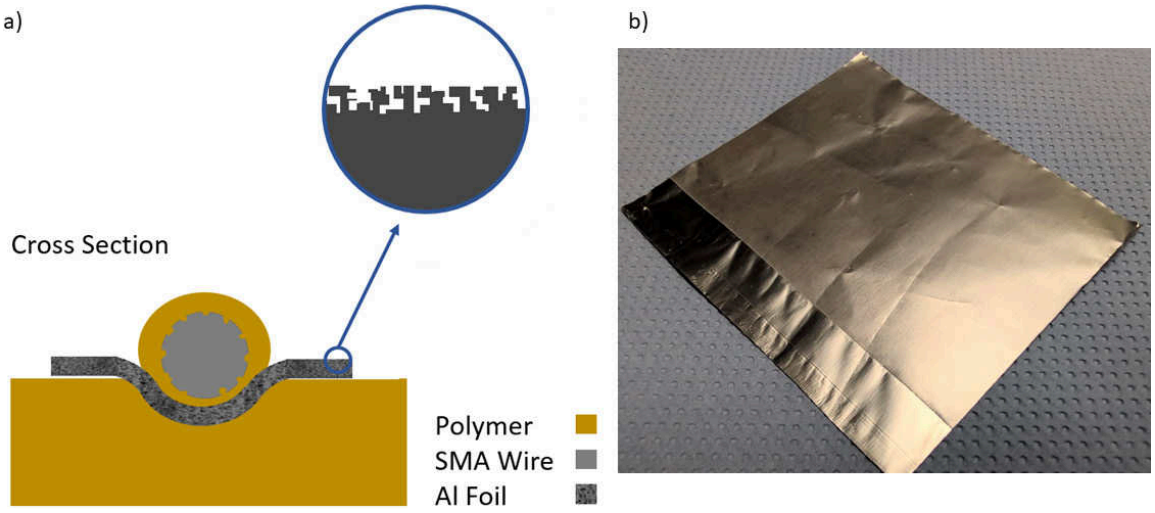
Supported by
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag (funding reference 22342 N).

Partner CAU Kiel University Christian-Albrechts-Universität zu Kiel

Functional Hybrid Composites

Active Hybrid Composite with Metallic Layer for Rapid Activation and Load Transfer



Schematic of the intended design of an optimized HC in cross section in a). Both polymer matrix layers are connected with the sculptured Al-foil. b) The sculpted surface with the characteristic hooking structure on the Al-foil surface is shown

Motivation

Active hybrid composites, consisting of shape memory alloys (SMA) and fiber-reinforced polymers (FRP) have become indispensable in numerous industrial and medical applications. Their use ranges from medical instruments to adaptively shape-changing components in transportation and lightweight actuators in automation.
However, a key challenge in realizing such active hybrid composites lies in embedding SMA wires into the polymer matrix without additional macroscopic anchoring, while ensuring efficient heat and load transfer at the material level. Addressing this problem is crucial to improving the durability, activation speed, and integration capability of these materials.

Objectives

The objective was to develop an active hybrid composite with a metallic surface layer that enables efficient thermal and mechanical coupling for rapid activation. The main goals were:

1. **Enhancing the thermo-mechanical resilience of the SMA polymer interface through optimized surface treatment of the SMA wires.**
2. **Adjusting the heat transfer and mechanical properties of the polymer matrix by integrating nanoscale, anisotropically structured functional aluminum foils.**
3. **Studying how geometrical anisotropy of the metallic layer affects vertical thermal diffusivity while maintaining lateral flexibility.**

Approach

The project applies a multi-scale material design strategy combining experimental and analytical methods:

- Surface modification: SMA wires are selectively etched to create microstructured surfaces that improve mechanical interlocking and thermal coupling within the polymer matrix.
- Functional metal integration: A nanoscale-structured aluminum foil is embedded to tailor the composite's heat conduction pathways.
- Characterization and modeling: The influence of anisotropic foil geometries on heat diffusion and mechanical flexibility is analyzed to achieve a controlled decoupling of thermal and mechanical modification.

Results

Initial investigations show that selectively etched SMA surfaces exhibit improved adhesion in the polymer matrix. The integration of anisotropically structured aluminum foils enables increased vertical heat conduction while maintaining flexibility. Ongoing work focuses on optimizing the foil geometry and validating the thermo-mechanical properties using prototypes.



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This project was funded by the German Research Foundation (DFG), funding reference: 698206.

Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation

Partner KVS

GIRO

Green Internal Release Options for Composite Manufacturing



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Motivation

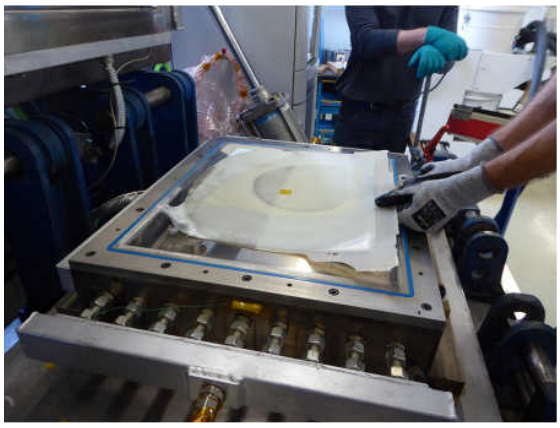
The demand for sustainable thermoset resin systems as composite matrices is increasing across industries. In parallel, bio-based alternatives are being explored not only for the resin itself but also for common additives such as fillers, diluents, toughheners, or flame retardants. Internal mold release agents (IMRs) are essential additives in high-volume production of fiber-reinforced thermoset polymers, facilitating demolding by migrating to the mold-part interface during curing and forming a lubricating film. Accurate evaluation of IMR performance is critical, but conventional assessment methods are largely qualitative, relying on manual demolding and subjective scoring.

Objectives

GIRO aimed to contribute to sustainable composite manufacturing by developing bio-based IMRs to replace petroleum-based raw materials.

Approach

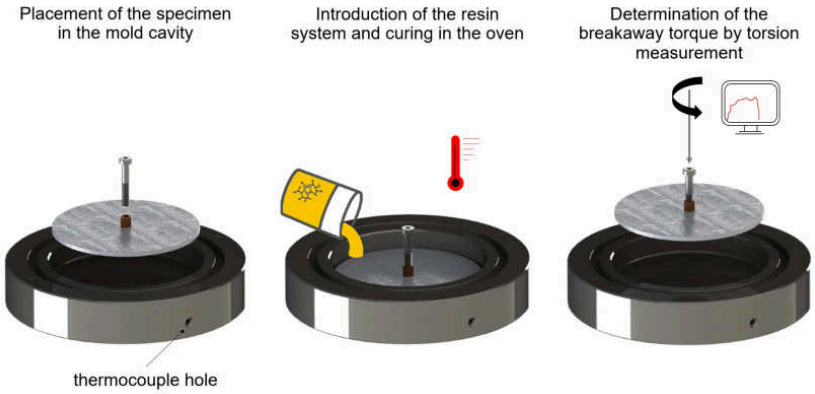
The development of bio-based IMRs followed a structured workflow: candidate formulations were designed using green precursors, guided by knowledge of resin chemistry and curing kinetics. Initial screening was performed in a small-scale laboratory mold to assess release performance. Promising formulations were then validated in a pilot-scale RTM device, allowing evaluation under realistic processing conditions. Multiple iterative optimization cycles were conducted, adjusting formulation components, concentrations, and process parameters based on quantitative demolding performance. In parallel, a novel torque-driven extraction setup at IVW enables reproducible measurement of demolding forces, providing objective data for optimization.



Qualitative assessment of release force during manual demolding of an RTM component

Results

Using this structured approach, the project successfully developed a bio-based IMR based on green precursors, demonstrating reliable demolding performance under both laboratory and pilot-scale conditions. The combination of iterative formulation development and quantitative testing provides a robust framework for optimizing IMR performance for industrial application.



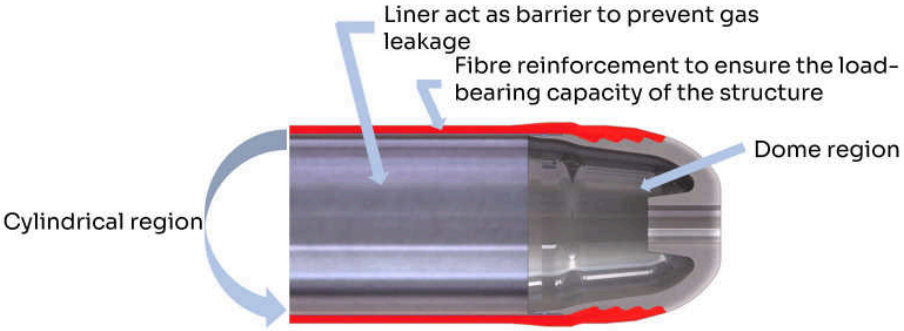
Quantitative measurement of release force using a torque-driven extraction device

This project was funded by the Federal Ministry for Economic Affairs and Energy — on the basis of a resolution of the German Bundestag (funding reference: KK5003710EB3).

Partners

H2Flex

Plant Development for the Production of CFRP-Pressure Tanks made of Bio-Based Epoxy Resin



Design and demonstrator of type 3 hydrogen tank (left) and flexible lightweight-hydrogen-pressure-tank (right)

Motivation

Green hydrogen fuel represents a pivotal solution to the accelerating rise in global temperatures. This project focuses on developing the sustainable transportation, zero emissions, efficient, and high-performance geometrically flexible hydrogen pressure tank. It stands out as one of the most promising options for achieving large-scale decarbonization and bridging the gap between sustainability and technological advancement.

Use of green hydrogen not only eliminates CO_2 emission but can also reduce non-CO_2 climate effects, such as contrail formation, when managed properly. Hydrogen possesses the highest specific energy content of any known renewable and available fuel, approximately 142 MJ/kg; nearly three times that of gasoline. It can be stored either as compressed gas at high-pressure (350-700 bar) and ambient temperature as well as cryogenic liquid at pressure typically (1-10 bar) and temperature of (-253 °C). Hydrogen reacts with oxygen to produce energy and water vapor, with no carbon dioxide emissions. This makes hydrogen one of the cleanest energy carriers available.

Objectives

The objective is to develop processes and equipment for the large-scale production of a novel, cost-effective, and geometrically highly flexible lightweight hydrogen pressure vessel using carbon fibers and a bio-based resin system that can withstand extreme temperature and pressure conditions without compromising performance, for applications in the automotive and aerospace industries. This has resulted in weight minimization while maintaining high strength and sustainability.

Approach

This project includes design of lightweight hydrogen pressure tank, surface optimization, determination of suitable materials, surface treatment and manufacturing of the metallic parts (aluminum-/-aluminum), development of manufacturing process, plant development and development of bio-based epoxy resin system.

The design and automated manufacturing process of a new type of lightweight-hydrogen-pressure tank is developed and manufacturing trials have been performed at IVW on TRL-3. The proposed configuration consists of a cylindrical pressure vessel with axial and circumferentially wound fiber layers to optimize the load distribution and structural performance. The composite layup is approximately axial (0°) and circumferential (90°) wound fibers. The plant development is done by the project partner Automation Steeg and Hoffmeyer GmbH focused on the automated filament winding for mass production to ensure high reproducibility and cost efficiency. The project also emphasizes the incorporation of sustainable epoxy resin systems, developed in collaboration with Schill+Seilacher “Struktol” GmbH. The project partner Karl Wolf Präzision³ e.K. has determined the optimal metallic interface parameters and surface was treated to enhance bonding between dissimilar materials used (aluminum-/-aluminum, aluminum-/-FRP). The load is transferred layer by layer from the axial layers in the cylindrical area of the pressure vessel by using the "IVW force introduction" patented at IVW. The cyclic loads acting on the tank during operation generate a tribological load on the joints between the materials used (aluminum-/-aluminum, aluminum-/-FRP), which is investigated experimentally and surface optimization has improved between metallic parts at IVW.



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This project was funded by the Federal Ministry for Economic Affairs and Energy — on the basis of a resolution of the German Bundestag (funding reference: 03LB3100E).

HERA

Sustainable High-Rate Processes for Aircraft Rear Structures

Motivation

Fiber reinforced plastics have high potential to contribute to significant weight savings and reduction in fuel consumption of modern commercial aircrafts when manufacturing processes for each component are specifically selected and optimized. The focus of the work at IVW in the HERA joint project is on the further development of process chains and process combinations as well as the integration of process digitalization concepts for the production of rear-end structures for a future single-aisle aircraft.

Objectives

The goal of the project is to increase the economic efficiency and the associated technological maturity of the investigated manufacturing processes, taking into account the industrial requirements of the aerospace sector.

The focus is on the one hand the production of small components, where the economic efficiency and high-rate capability of selected processes are investigated. On the other hand, thermoplastic high-speed tape laying applied in preform production for thermoforming will be optimized for high production rates.

At the same time, digital methods will advance the analysis of sensor data. This data is employed for deriving relationships between process parameters and manufacturing quality as well as for creating process simulation models.

Approach

The manufacturing process for small components can be optimized with flexible toolings for taking advantage of part families and smart part design adaptions. For the automated fiber placement process, the actual lay-up rate can be increased by higher process speed, software-supported optimization of lay-up path planning as well as adaptation of component design and lay-up scheme.

Results

The project officially started on July 1st, 2025. By the end of 2025, first trade-off investigations on different manufacturing processes for small parts were completed and strategies for high rate tape laying were defined.

Partners

Airbus Aerostructures GmbH
Airbus Operations GmbH
Cevotec GmbH
DLR e.V.
Fraunhofer ICT
Fraunhofer IFAM
Fraunhofer IGCV
Xelis GmbH



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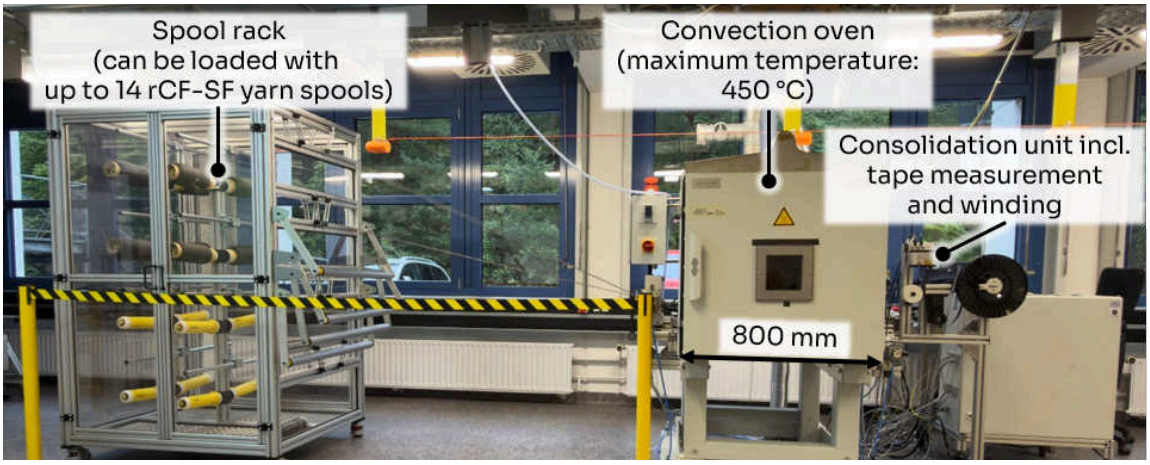
Multifunctional Fuselage Demonstrator (Credit: DLR (CC BY-NC-ND 3.0))

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the Federal Ministry for Economic Affairs and Energy (BMWE) on the basis of a resolution passed by the German Bundestag (funding reference 20W2405D).

HESTIA

Sustainable Thermoplastic Window Frame Concept – Overmolded rCF Inserts



Optimized tape manufacturing line for the requirements of high-temperature thermoplastic processing

Motivation

The thermoplastic window frame concept enables the use of recycled carbon fibers and thus demonstrates approaches for the circular utilization of high-performance composite materials in aviation.

Objectives

The aim of the project is to develop an aircraft window frame manufactured by combining a thermoformed insert made of staple fiber-reinforced low-melt PAEK in combination with an injection overmolding process. The focus is on the entire process chain, from the production of the staple fiber tape to the frame design, part manufacturing and testing of the finished component.

Approach

In the current project phase, an impregnation and consolidation plant adapted to high-temperature thermoplastic processing at IVW is being used to determine the process parameters for optimizing tape quality and material throughput. A finite element model (FEM) is established to determine the optimal layer structure of the tape preform and the positioning of the stiffening ribs.

Partners

Airbus Operations GmbH

Deutsches Zentrum für Luft- und Raumfahrt e.V.

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung

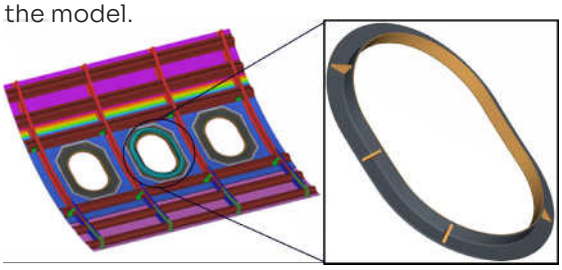
Airbus Aerostructures GmbH

Albany International Corp.

The load path-oriented alignment of the staple fibers according to FEM results allows for a significant improvement in mechanical properties compared to a quasi-isotropic fiber orientation. Based on this model, the next step is the near-net-shape production of a preform by automated tape laying.

The tape laying head, which has been extended to include a preheating section, is used for the targeted pre-tempering of the tapes in order to enable wave-free deposition, even with tight radii. The temperature of the preheating section, the deposition speed, and the burner volume flow are systematically varied and optimized in order to derive optimized processing parameters for production of the window frame preforms.

These preforms are then converted into the final insert geometry using a thermoforming process and are subsequently overmolded to shape the stiffening ribs. Finally, the concepts developed in FEM are tested on the prototypes to assess their feasibility and consistency with the model.



Section of the aircraft fuselage as the basis for the FEM simulation and FEM model of the window frame made of rCFRP (gray) and injection molding (orange)



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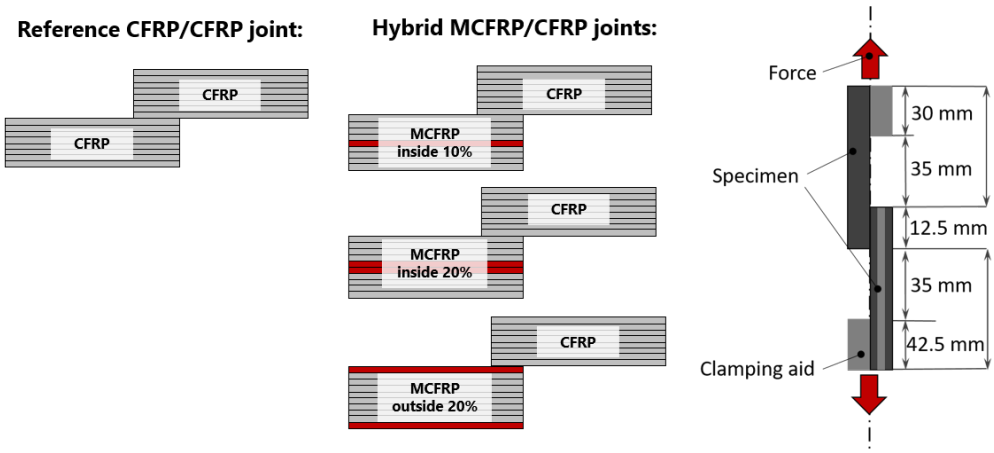
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This project was funded by the Federal Ministry for Economic Affairs and Energy (BMWE) on the basis of a resolution passed by the German Bundestag (funding reference 20W2203E).

Partners AIRBUS Fraunhofer Technische Universität Braunschweig

HYBATS

Hybrid Ice Protection on Advanced Natural Laminar Slat



Left: Representation of the different configurations of induction-welded joints
Right: Schematic lap shear test setup



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Motivation

Carbon fiber reinforced plastics (CFRP) dominate the aerospace industry due to their low density, high stiffness, and excellent strength. They offer significant potential for lightweight structural applications. Despite these advantages, CFRP is characterized by brittle failure behavior which limits its energy absorption capacity. In addition, it offers only restricted electrical functionalities compared to metallic materials. The integration of steel fibers into CFRP to form metal-fiber reinforced composites (MCFRP) addresses these limitations by improving energy absorption while enabling multifunctional properties such as electrical conductivity for signal transmission and lightning protection.

Objectives

The HYBATS project focuses on the development of a thermoplastic-based MCFRP concept for aircraft wing leading edges, where resistance to bird impact and lightning strike is essential.

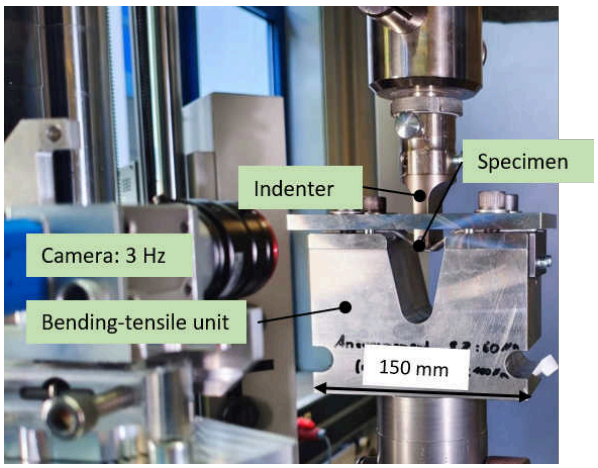
Approach

The scope of work includes the establishment of reproducible manufacturing routes, structural–mechanical design, and experimental characterization. Compared to thermoset-based MCFRP, thermoplastic MCFRP also provide improved impact tolerance, recyclability, and compatibility with a range of joining techniques.

Results

The thermoplastic MCFRP was mechanically tested in a classic tensile test and in a realistic bending-tensile test developed at IVW. The latter simulates the superimposition of bending and tensile loads that occur predominantly in reality. The mass-specific energy absorption capacity of the tested laminates was increased by up to 80% compared to the CF-PEEK reference.

Furthermore, as part of the project, the feasibility of induction welding for hybrid MCFRP/CFRP joints is investigated and benchmarked against conventional CFRP/CFRP reference joints. The different heating behavior of carbon and steel fibers constitutes one of the main challenges. Lap-shear tests on hybrid joints show that the best laminate configuration achieves results similar to those of CFRP/CFRP reference joints (40.7 MPa and 40.5 MPa, respectively).



Setup of the bending-tensile test

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

This project was funded by the Federal Ministry of Economic and Climate Action (BMWK) on the basis of a decision by the German Bundestag (funding reference 20Y2204E).

HybridSolver

Multiscale Simulation with Numerical Solvers and Physically-Informed Neural Networks

Motivation

The simulation of fiber-reinforced plastic composites (FRPCs) poses major challenges due to their inherently multiscale nature, ranging from micrometer-scale fiber structures to meter-scale components. Conventional physics-based solvers often reach their limits in computational cost and model size.

Objectives

The goal of HybridSolver, a joint effort of WIAS, KAIST and IVW, is to enable efficient and accurate multiscale simulations for complex materials such as fiber-reinforced plastics by combining established numerical methods with physics-informed neural networks (PINNs). The approach targets reduced computational time, improved scalability, and robustness against imperfect training data. The project focuses on permeability prediction in reinforcement structures while laying the groundwork for further applications in material and process development.

Approach

Within the project, two spatial scales are coupled: At the microscale, PINNs approximate partial differential equations, while at the mesoscale, conventional numerical solvers are applied. The two are connected through multiscale modeling techniques and formulated as a non-standard optimal control problem. Efficient parallelization and domain decomposition strategies ensure scalable performance. The method is designed to be flexible for use with various multiscale problems and integrates input from academic and industrial partners to guarantee practical relevance.

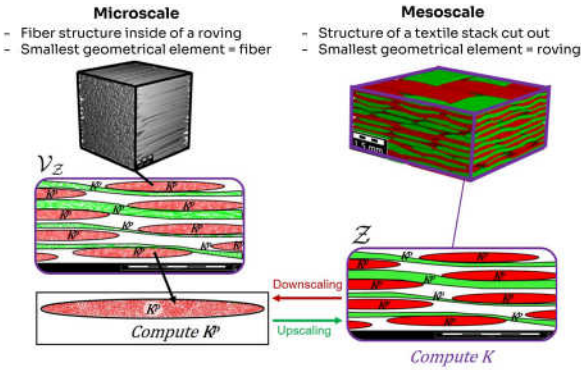


Illustration of the up/downscaling procedure of permeabilities K between micro- and mesoscale

Results

Initial work focuses on scaling Physics-Informed Neural Networks (PINNs) to realistic microscale configurations with randomized fiber structures, showing promising progress. Finite Basis PINNs (FBPINNs) are used for domain decomposition to capture high-frequency flow features, enhanced by Fourier feature embeddings for improved spectral accuracy. Combined with hard constraints via signed distance functions (SDFs), these methods accelerate convergence, reduce errors, and achieve stability where standard PINNs often fail.

Partners

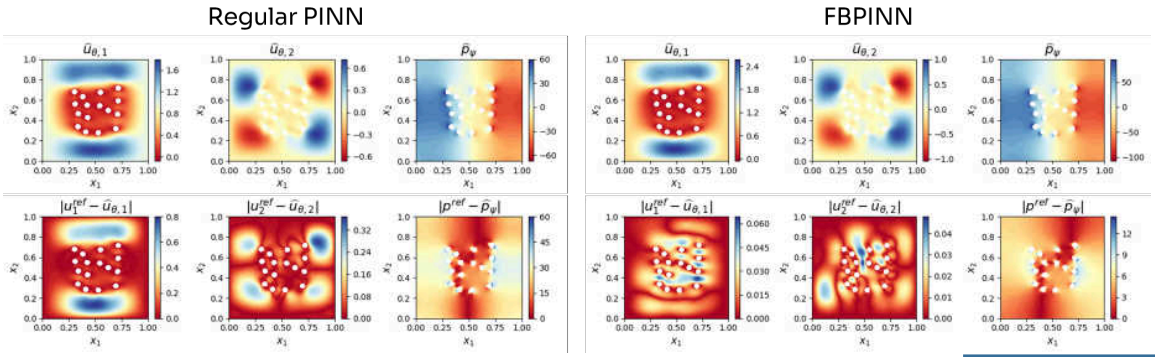
Weierstrass Institute for Applied Analysis and Stochastics (WIAS) - Leader

Chair for Scientific Computing – University of Kaiserslautern-Landau (SciComp)

Korea Advanced Institute of Science and Technology (KAIST) – supporting partner

Bosch

Comsol



Prediction of the velocity and pressure field using PINNs (left) and FBPINNs (right)
Top panels: predicted fields, bottom panels: absolute pointwise error



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With funding from the:
Federal Ministry of Research, Technology and Space

This project was funded by the Federal Ministry of Research, Technology and Space (funding code: 01IS24081B).

HydroBear

Partner SWINBURNE UNIVERSITY OF TECHNOLOGY | AIR Hub

Load-Bearing Type-V Hydrogen Pressure Tanks

Motivation

The aviation industry faces the major challenge of developing climate-neutral propulsion systems. Hydrogen is considered a promising energy source, but its bulky and heavy pressure tanks have so far made it difficult to integrate into small aircraft and drones. This is where the HydroBear project comes in: It aims to integrate the tanks into the wings not as an additional load, but as load-bearing structural elements. This results in an innovative lightweight construction concept that makes efficient use of installation space, reduces aerodynamic disadvantages and paves the way for sustainable, hydrogen-based aviation propulsion systems.

Objectives

The aim of the HydroBear project is to develop a novel wing concept that enables the integration of hydrogen pressure tanks in small aircraft and drones. The tanks are not only intended to serve as energy storage, but also to act as a load-bearing spar structure.

Approach

The HydroBear project combines digital and experimental approaches to integrate hydrogen pressure tanks into wings. First, the structure is designed using modern CAD methods and evaluated in terms of stress using numerical simulations. Based on this, experimental tests are carried out on prototypes to validate the calculations and verify damage tolerance under real operating conditions.

Results

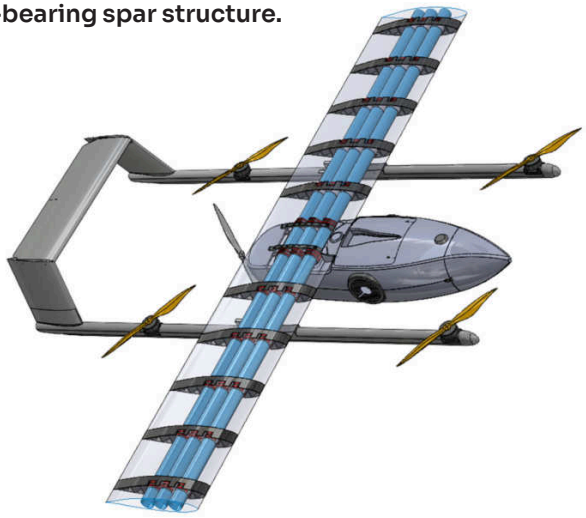
The HydroBear project demonstrated that integrating hydrogen pressure tanks into the wings of small aircraft is technically feasible. A new wing profile was developed that creates sufficient installation space for the tanks without significantly impairing the aerodynamic properties. Initial tests with additively manufactured ribs and locally inserted continuous fibers prove that the mechanical stability of the structure can be significantly improved.

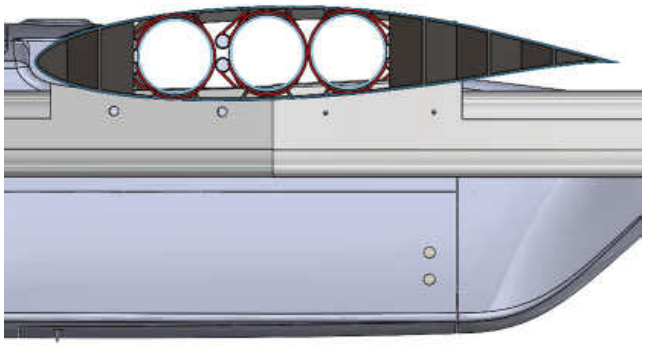


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UAV (Ghostdrone Airhub) with integrated IVW H2-pressure vessels in the wing

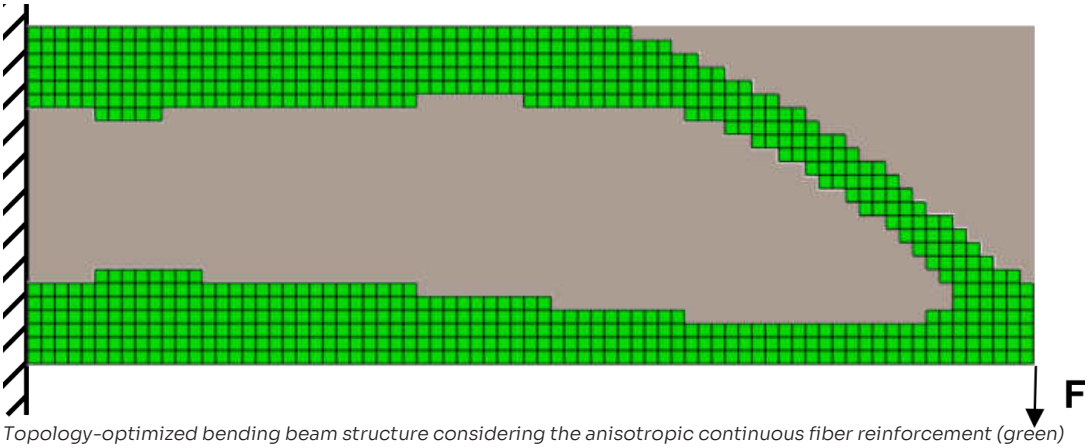
RheinlandPfalz
MINISTERIUM FÜR WISSENSCHAFT UND GESUNDHEIT

This project was funded by the Ministerium für Wissenschaft und Gesundheit (funding reference: 1501 15403).

Partner HS PF AKRO COMPOUNDS

HyTO3D

Hybrid Manufacturing & Topology Optimization of Overmolded 3D-Wound Structures



Topology-optimized bending beam structure considering the anisotropic continuous fiber reinforcement (green) and the properties of the short fiber-reinforced injection molding material (gray)



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Motivation

Fiber-reinforced polymers range from injection-molded short fiber composites to unidirectional continuous fiber-reinforced materials. The former enable highly automated, cost-efficient production but offer limited mechanical performance. The latter achieve high specific stiffness and strength, yet are expensive to manufacture and thus restricted in broad industrial use.



3D robotic winding system at Pforzheim University for manufacturing three-dimensional, load-path-optimized reinforcement structures.

Objectives

The HyTO3D project aims to combine injection molding with local continuous fiber reinforcement. Thermoplastic injection-molded parts are locally reinforced with robot-wound structures made of thermoset TowPregs. The topology and fiber orientation of these reinforcements are defined using an optimization algorithm developed at IVW, which accounts for the anisotropy of continuous fibers as well as the properties of the short fiber base material.

Approach

A robot-based winding process for the continuous fiber-reinforcements is being developed. In parallel, a topology optimization framework tailored to the applied materials and processes ensures efficient design of the local reinforcements. This combination enables optimal reinforcement strategies that balance performance and costs.

Results

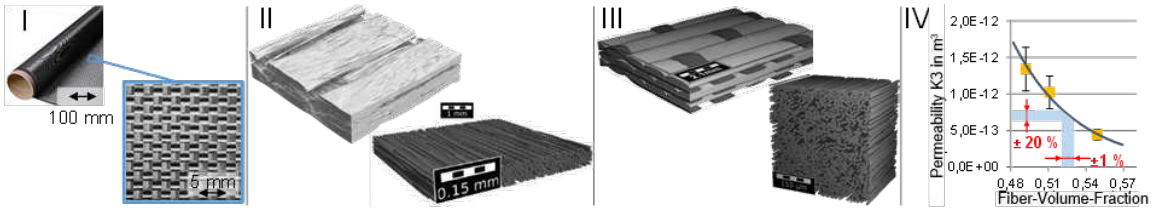
The work carried out to date includes the characterization of the materials intended for use in the project. In addition, PA66 GF and PA66 CF are being conditioned in order to investigate the influence of moisture on material behavior. At the same time, interface treatments are being analyzed to improve the adhesion between injection molded material and thermoset reinforcement. Initial hybrid structures are being manufactured manually, optimized and insights gained for their simulative consideration, and the optimization algorithm is being further developed and adapted to the new findings.

This project was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – project number: 550248900.

Partner MATH 2 MARKET

KI4MaterialModeling

AI for Generating Simulation Models for Material Development from CT Data



Typ. Carbon fiber fabric for FRP production (I), X-CT images of a fabric structure (II, top) & a fiber bundle section (II, bottom), computer-generated models (III) and diagram showing the dependence of the permeability of the fabric on the fiber volume fraction (IV)



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Motivation

The development of advanced materials requires accurate knowledge of their microstructural properties to predict key characteristics such as stiffness, strength, and thermal conductivity. Digital material models enable efficient optimization by reducing experimental effort, energy consumption, and development time. For composite materials, especially fiber-reinforced plastics, precise differentiation of microscopic constituents is critical to achieving reliable simulations.

Approach

The project will enhance X-CT imaging methods to achieve precise visualization and phase separation of microscopic constituents over large volumes. By digitally reconstructing the fiber architecture of FRPs, accurate input data will be generated for multiscale material models. This enables end-to-end simulation chains, linking microstructure to macroscopic processing properties for improved predictive accuracy.

Objectives

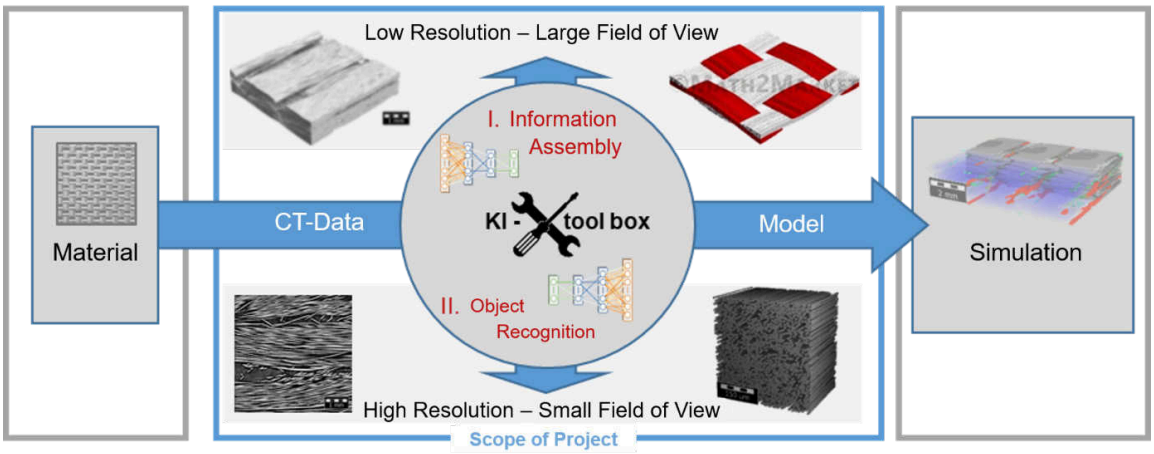
The project aims to extend high-resolution 3D imaging using X-ray computed tomography (X-CT) to capture the microstructure of fiber-reinforced plastic composites across the largest possible volume. A key goal is to reliably image and segment reinforcing fibers with micrometer-scale diameters from surrounding polymer matrix to predict relevant processing properties, such as the permeability of semi-finished textile products.

Results

On twill weave textile based composites, classifier-based and gradient-based segmentation approaches have been successfully evaluated and were found to yield similar results and were presented to a broad audience on the 14. international conference on industrial computed tomography iCT in Antwerp.



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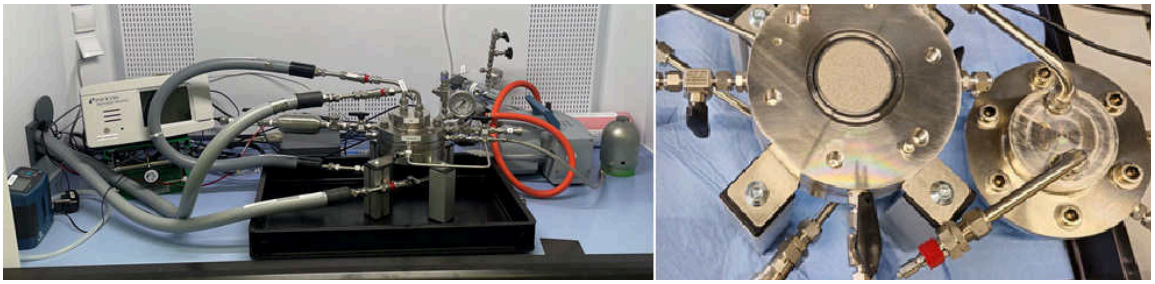
Visualization of the envisaged workflow from the material sample to the simulation model

With funding from the:
Federal Ministry of Research, Technology and Space

This project was funded by the German Federal Ministry of Research, Technology and Space (funding reference: 01IS23054B).

LH2-Flatlight

Hydrogen Permeation Measurement in Composite Materials



Overview picture of hydrogen laboratory and close view of the permeation test cell

Motivation

A cleaner energy future requires new technologies and materials that can safely handle hydrogen as an energy carrier. Hydrogen offers up to four times higher energy efficiency per unit volume than comparable fossil fuels in its gaseous form, and even higher when liquefied. Moreover, its only by-product during use is water, making it an attractive alternative for sustainable energy systems.

Objectives

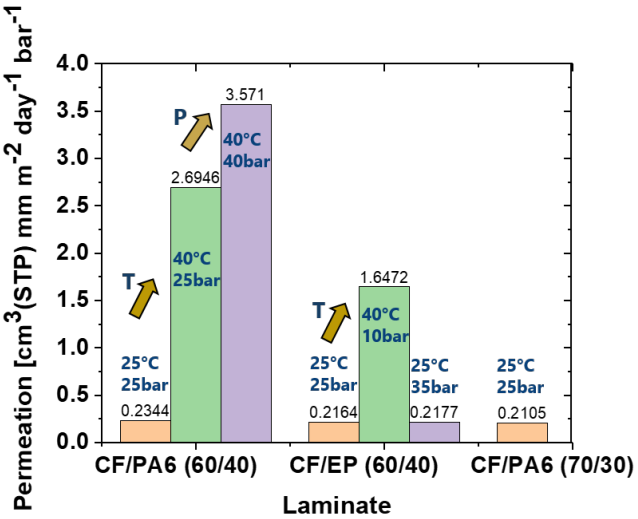
Working with hydrogen poses unique material challenges. The extremely small hydrogen molecules can diffuse through solid materials such as fiber-reinforced plastics (FRP), leading to absorption and desorption processes—known as permeation. This process depends on time, pressure, and temperature. To ensure long-term safety and functionality, a detailed understanding of permeation behavior in composite materials is essential.

Approach

In the LH2-Flatlight project, hydrogen permeation is systematically investigated in various fiber composites under different environmental conditions, manufacturing processes, and material combinations. Using IVW's advanced hydrogen laboratory and dedicated permeability testing facility, diffusion capacity and permeability of FRPs are determined via concentration and pressure-difference methods.

Results

The experimental data reveal clear trends: higher temperature and pressure increase permeation, but material composition significantly affects this behavior. For instance, epoxy matrices show lower pressure sensitivity compared to PA6, while higher fiber volume fractions reduce hydrogen permeation. These findings provide the basis for designing safe and lightweight components for future hydrogen systems.



Permeation values of different materials at different testing atmosphere. Comparative data showing the influence of parameters on properties



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This project was funded by the state of Rhineland-Palatinate via the Ministry of Science and Health (funding reference 724-0027#2023/0003-1501 15404).

RheinlandPfalz
MINISTERIUM FÜR WISSENSCHAFT UND GESUNDHEIT

Partner ENGEL GK CONCEPT

Light & Sustainable

New Equipment for Thermoplastic Foam Injection Molding



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Motivation

To minimize resource consumption, the production of foamed components in large quantities with reproducible quality is becoming increasingly important in polymer processing. Thermoplastic foam injection molding offers not only component-related advantages – such as reduced density, lower material consumption, higher specific bending stiffness, minimized warpage, and recyclability – but also significant process-related benefits: lower melt viscosity leads to reduced cavity pressures, enabling lower clamping forces and even the elimination of the holding-pressure phase. These benefits contribute to efficient, energy- and material-saving manufacturing, making the technology particularly relevant for sustainable lightweight solutions.

Objectives

The project aimed to expand the research infrastructure at IVW by integrating thermoplastic foam injection molding technology for enabling the development and production of sustainable lightweight parts and sandwich structures.

Approach

The existing injection molding machine with a clamping force of 400 tons was upgraded with a specialized plasticizing unit and connected to a gas-metering station. A dedicated test tool with interchangeable inserts was developed to reproduce key component complexities on a 3D demonstration part, making it ideal for detailed material and process studies. All relevant process parameters for foam injection molding can be recorded and analyzed within the production cell to support process and component development.

Results

The investment has expanded the research infrastructure at IVW with a forward-looking technology for manufacturing sustainable, lightweight, and recyclable thermoplastic components. The new setup enables comprehensive studies on materials, processes, and automated production of thermoplastic sandwich structures.

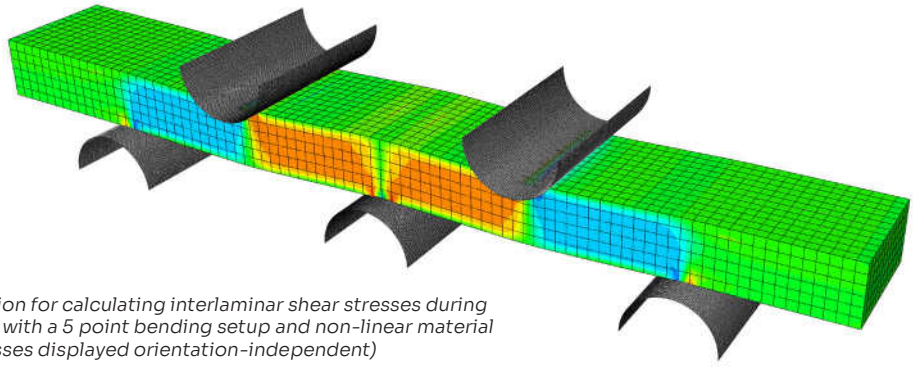


Production cell for injection molding of thermoplastic lightweight structures, equipped with physical foam injection molding

RheinlandPfalz
MINISTERIUM FÜR WISSENSCHAFT UND GESUNDHEIT

This project was funded by the state of Rhineland-Palatinate, Ministry of Science and Health, within the program "Equipment for Top Researchers."

cFRTP in Automobile Application



FEM simulation for calculating interlaminar shear stresses during ILSS testing with a 5 point bending setup and non-linear material model (stresses displayed orientation-independent)

Motivation

Continuous fiber reinforced thermoplastics (cFRTP) are characterized by their enormous lightweight potential and are predestined for large-scale series (e.g. in the automobile industry) because of their material properties. Since these materials are relatively young, their special attributes and requirements are sometimes not fully considered in current standards.

Objectives

To address this issue, testing methods for continuous fiber reinforced thermoplastics are refined to become more accessible and robust, thereby strengthening the trust in these materials by a reliable base of material properties. In doing so, test methods developed for thermoset composites are also checked for their applicability towards thermoplastic composites and are extended or modified accordingly.

Approach

Industry relevant topics in materials testing are identified (e.g., back out method or ILSS), comprehensively studied and documented, assisted by the industrial partners. In preparation of standardization, international round robin tests are conceptualized and performed.

Partners

AVK – Industrievereinigung Verstärkte Kunststoffe e. V.

Industrial partners:

Arkema

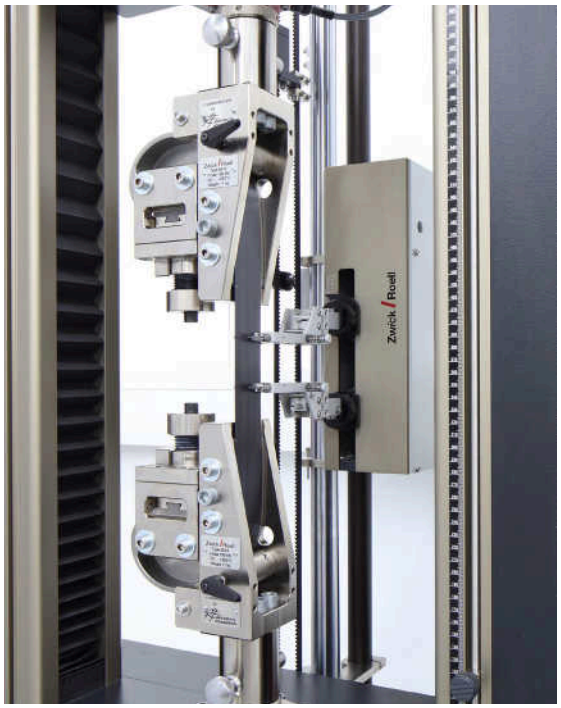
Envalior

Mitsui Chemicals

Syensqo

Results

So far, a newly developed tensile specimen geometry (integrated in ISO 527-4) as well as a complete test plan emerged from this strategy. The test plan consistently defines the minimal set of necessary material properties, test conditions and test methods (available for many materials in CAMPUS database). Through a cooperation with the testing machine manufacturer ZwickRoell, a tape testing fixture was developed, which has been commercially available since 2024. Since the performance of tape tensile tests has not yet been standardized, a new ISO standard is being worked on.



New tape testing fixture in cooperation with ZwickRoell GmbH & Co. KG



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This project was funded by the industrial partners Arkema, Envalior, Mitsui Chemicals, Syensqo and the Industrievereinigung Verstärkte Kunststoffe e. V. (AVK).

Modular Axial Tribometer with IIoT Expertise



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Motivation

Standard tribological tasks such as measuring the coefficient of friction or wear rate have traditionally been carried out manually, in small quantities and highly knowledge-based. Many processes are based on empirical knowledge and can only be automated to a limited extent. To overcome this barrier and enable reproducible, digitally integrated testing processes, IVW and ASH have jointly developed a new, modern axial tribometer.

Objectives

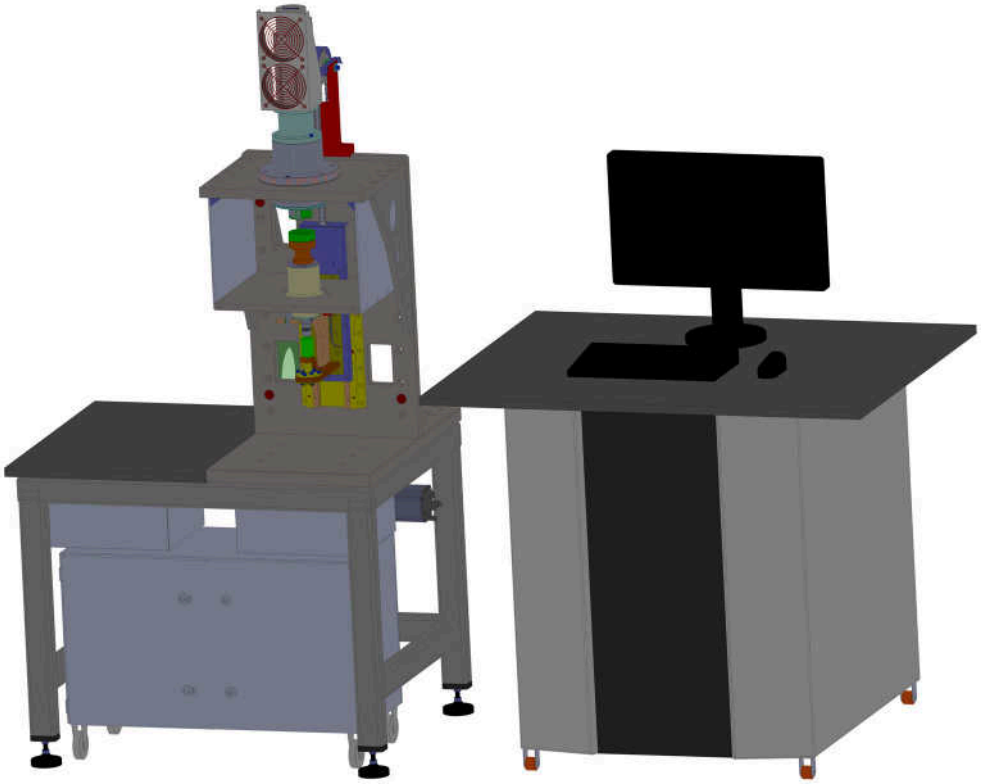
The aim was to develop a modular tribometer with flexible measuring point architecture and a new software platform that is fully connected to IVW's Industrial Internet of Things (IIoT). This is intended to standardize and automate tribological tests and lay the foundation for ambitious research tasks.

Approach

The tribometer is based on a variably configurable measuring point concept that can be adapted to different materials and loads. The test bench software developed at IVW forms the technological core: it integrates control, data acquisition and IIoT communication, enabling adaptive and digitally supported test processes.

Results

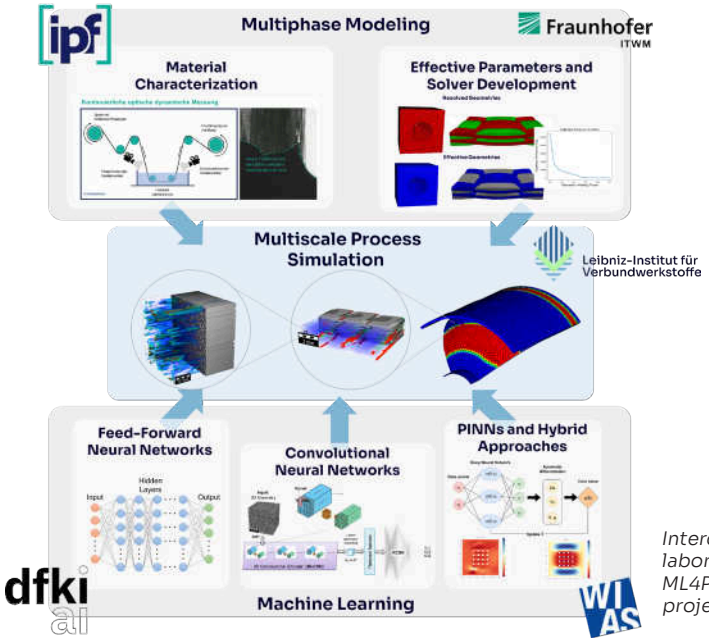
The combination of the new tribometer and IIoT-enabled software constitutes the technological basis for important advances in tribological testing technology. This includes, for example, the validation of plain bearing designs using hardware-in-the-loop methods and the elucidation of the interaction between material composition, transfer film formation and adhesion - and furthermore the dynamic, data and machine learning (ML) supported control of multi-stage test programs with automatically adjusted load segments. The system thus creates the basis for reproducible, automated and adaptive tribological testing processes.



Modular axial tribometer for ambitious research and development tasks. Equipped with variable number of measuring sites, new software platform and full integration into the IVW-IIoT

This project originated from IVW's internal research initiatives and ongoing scientific development.

Machine Learning for Process Simulation



Interdisciplinary collaboration within the ML4ProcessSimulation project



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Motivation

Simulation methods are essential for developing materials, components, and manufacturing processes. Fiber-reinforced polymer composites (FRPCs) pose particular challenges due to their multiscale and heterogeneous structure. Accurate simulations require coupling from fiber-level microstructures to macroscopic components. Traditional multiscale approaches often trade accuracy for computational efficiency through homogenization.

Objectives

The ML4ProcessSimulation project aimed to improve both accuracy and efficiency of FRPC process simulations by embedding machine learning into multiscale workflows, with a focus on Liquid Composite Molding (LCM) and virtual permeability prediction.

Approach

Machine learning models were integrated at multiple stages of the multiscale LCM workflow. Fast feed-forward neural networks enabled micro-to-meso upscaling (IVW + DFKI), while 3D convolutional neural networks captured full fiber geometry for improved permeability predictions. IVW developed a 3D CNN-based velocity field predictor to accelerate solver convergence. Material characterization was conducted by IPF, coupled with solver development at ITWM. Physics-informed neural networks were applied to 2D flow simulations at WIAS, providing a foundation for the HybridSolver follow-up project.

Results

Integrating machine learning enhanced both predictive accuracy and computational efficiency of multiscale FRPC simulations. 3D CNNs yielded robust permeability predictions and improved solver initialization, while physics-informed networks demonstrated potential for efficient coupled simulations. The collaboration among IVW, DFKI, ITWM, IPF, and WIAS illustrates the value of combining expertise in multiscale simulation, scientific machine learning, and materials science.



Partner

This project was funded by the Leibniz Association within the Leibniz Collaborative Excellence funding program (funding reference: K377/2021)

MVCC

Partners Fraunhofer ITWM and a consortium of 20 further industry partners

Machine Vision for Carbon Composites

Motivation

The correct alignment of carbon fibers is crucial for ensuring stiffness, strength and lightweight potential of CFRPs, but with current processes, fiber alignment during manufacturing cannot be observed fast enough to adjust process parameters, resulting in waste and loss of production efficiency.

Objectives

MVCC aims to develop cost-effective and user-friendly tools for fiber alignment process monitoring and quality assurance during the production of carbon fiber composites using polarization imaging.

Approach

Generalized machine-vision applications for industrial cameras equipped with on-chip polarizers have been developed for composite manufacturing. By converting raw image data into carbon-fiber–specific information in real time, key insights are extracted for interpretation by users or automated systems. This provides a highly adaptable foundation for detecting deviations and enabling process adjustments during ongoing production.

Results

Polarization imaging has been successfully applied to several use cases at IVW, demonstrating its potential and versatility. Disruptive effects have been identified and are being systematically addressed. An interactive graphical user interface (GUI) for visualizing and exporting key image information is currently under development for integration into Industrial Internet of Things (IIoT) environments.



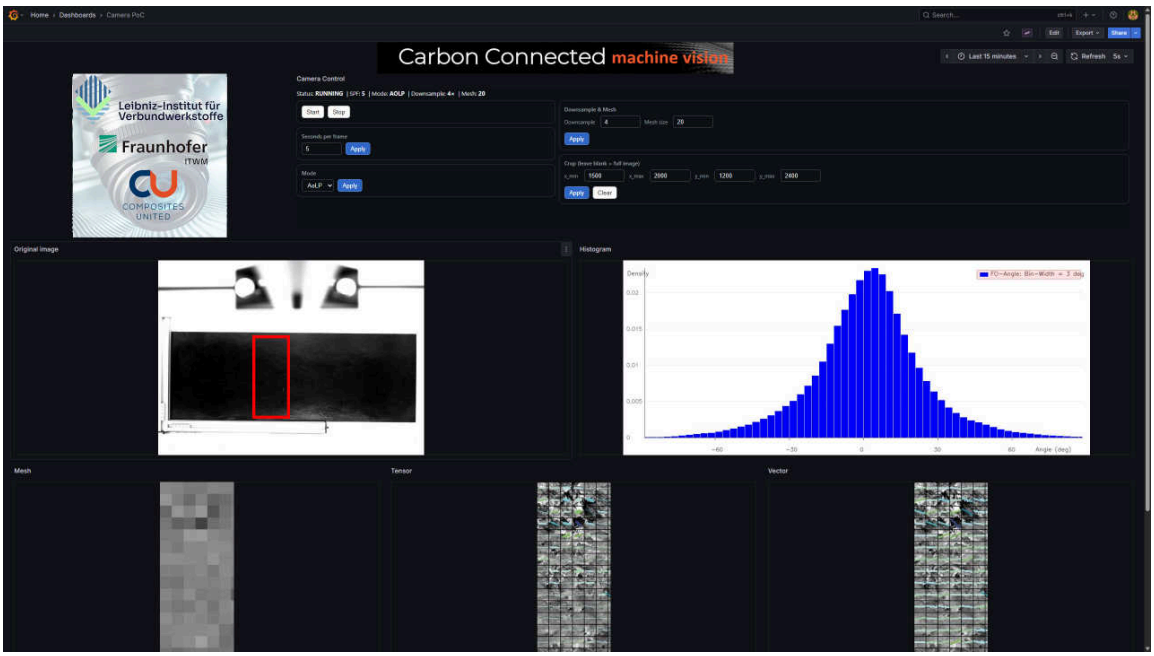
Machine vision for carbon composites project consortium



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Interactive graphical user interface developed for the project

This project is being carried out in partnership with the Fraunhofer Institute for Industrial Mathematics (ITWM) within the joint industrial research program (IGF) (funding code: 01IF23230N) under the supervision of the Composites United research association.

Partners INVENT UNIVERSITÄT BAYREUTH cmt

NewPreg

New Concepts for Processing Bio-Based Solid Resins Outside the Autoclave

Motivation

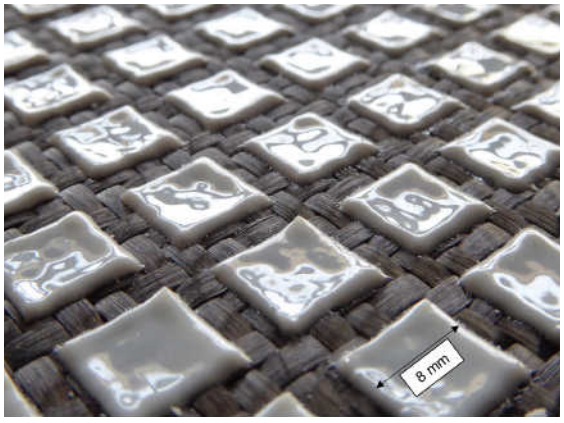
The project tackles the high energy demand of conventional prepregs, which require energy-intensive frozen storage and autoclave processing, thereby addressing a key sustainability challenge in the aviation sector.

Objectives

The aim of the project is developing a sustainable, bio-based and flame-retardant prepreg based on solid epoxy resins for application in the aviation sector. The prepregs enable significant energy savings through cooling-free storage at room temperature, as well as processing outside the autoclave, thereby increasing sustainability. Furthermore, the possibility of controlling the draping properties of these prepregs by applying the resin in a pattern form is being investigated at IVW.

Approach

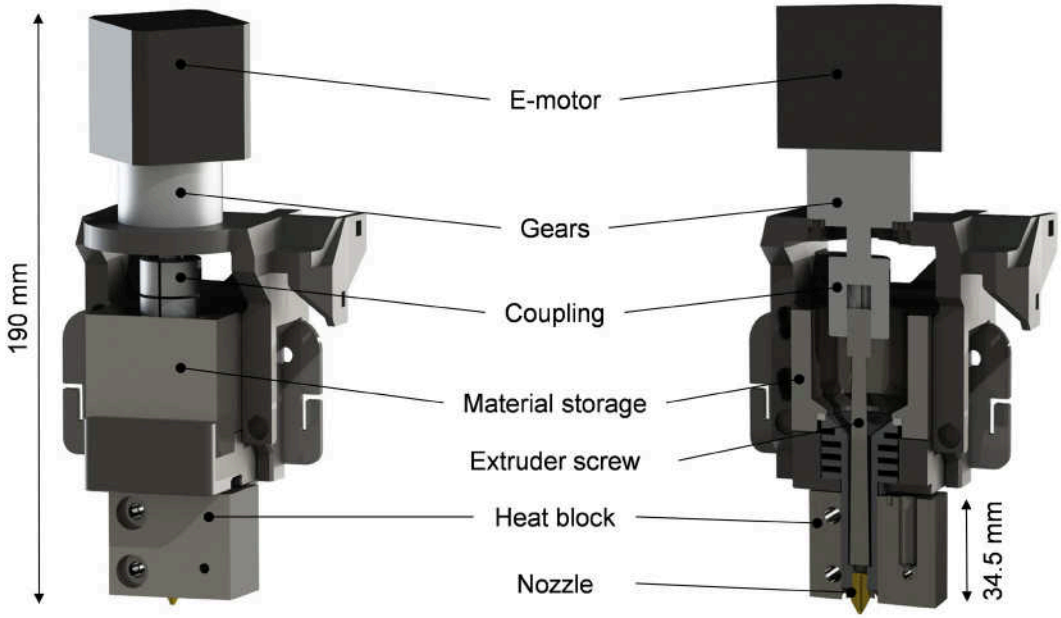
Within the project, IVW applies a novel patterned impregnation approach using solid epoxy resins, combined with the development of a suitable technology for resin application — a robot arm equipped with a granulate extruder — to directly print resin patterns onto dry textiles. In addition, suitable preforming concepts and an out-of-autoclave (OoA) process design are being developed in collaboration with the project partners.



Manufactured solid resin prepreg with a squared pattern

Results

The preforming and OoA processes for the resins supplied by the project parner have been successfully designed, and a lab-scale 3D printer has been implemented that enables the production of prepregs with a pattern impregnation. Furthermore, we investigated the draping behavior of the prepregs and found that bending is mainly influenced by the size of the pattern elements in bending direction, while shearing is primarily affected by the pattern coverage.



Developed extruder unit of the labscale 3D-printer (left) and its sectional view (right)



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This project was funded by the Federal Ministry of Economic Affairs and Energy on the basis of a resolution of the German Bundestag (funding reference 20Q2227B).

OD Pfalz II - Citizen Science

Partners RPTU Rheinland-Pfälzische Technische Universität Kaiserslautern Landau

offene digitalisierungsallianz pfalz

Everyday Medical Aids for and with Citizens

Motivation

The „BewegungsForscher“ (Movement Researcher) project of the “Open Digitalisation Alliance Palatinate” (OD Pfalz) was developed to expand the science communication with citizens in a workshop setting. There citizens were asked to suggest products in the field of health improvement that they would like to develop. The resulting topic was a stiffness adaptable ankle-foot orthoses made of fiber-reinforced plastic.



Presentation of the project at the „Nacht, die Wissen schafft“

Objectives

Many users of ankle-foot orthoses suffer from a neural damage of the nerves in their leg or foot, caused by a stroke or multiple sclerosis. The range of motion and sensation typically changes over the course of the illness. It is therefore mandatory to adjust the stiffness of the orthosis to maintain the mobility and reduce the risk of falling. Adjustments can sometimes be necessary on a day to day basis. As this is impractical and costly, the participants identified the need for a cost-effective orthosis that meets patients' needs better.

Approach

Over the course of the project, the participants took part in multiple workshops becoming familiar with the working principles of composite materials and the criteria for selecting the optimal material configuration for specific applications. Following a design-thinking workshop in which the citizens developed multiple concepts of a stiffness adaptable mechanism, they developed an evaluation matrix and voted for their favourite model. Using a virtual FE model and its 3D print, they were able to gain insights into the principles of FE-simulation in the development process and use this to test the mechanism of their model. In the further course of the project, this model will be refined and turned into a prototype.



Cedric Fuchs

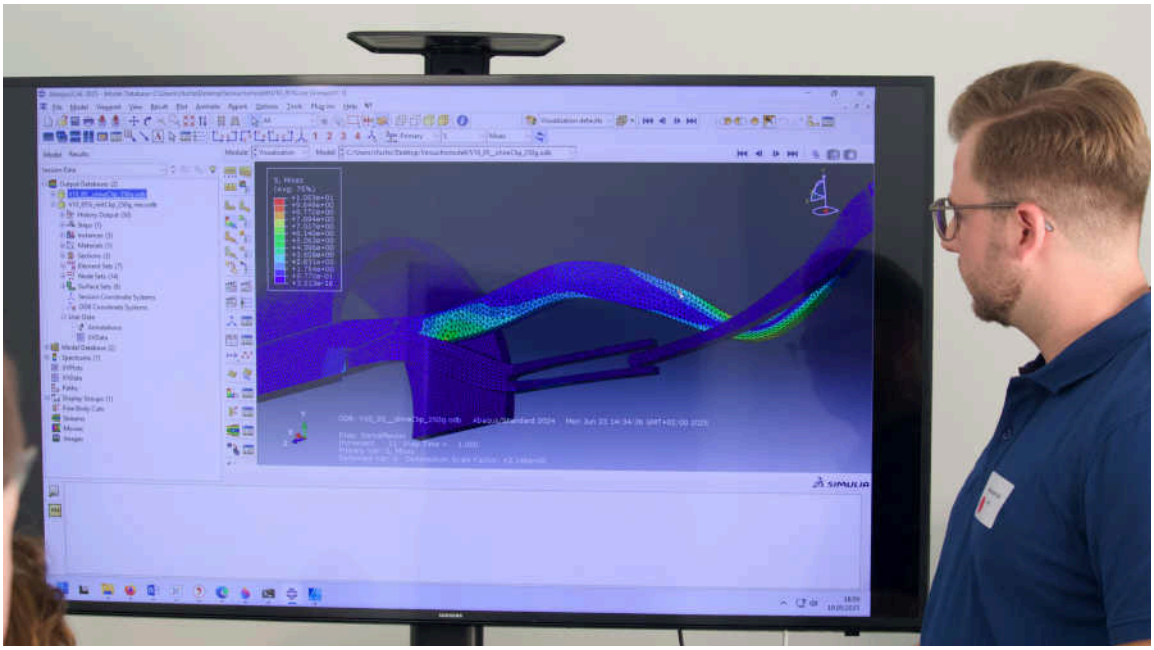
cedric.fuchs@leibniz-iww.de



Andreas Baumann

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Scan to learn more



FE-simulation of the stiffness mechanism

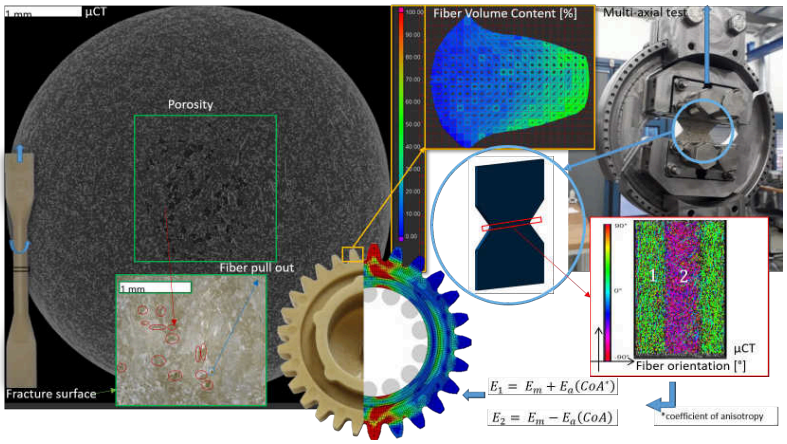
With funding from the Federal Ministry of Research, Technology and Space

This project was funded by the Federal Ministry of Research, Technology and Space (BMFTR) within the Federal-State Initiative “Innovative Hochschule”, based on a decision of the German Bundestag (funding reference: 03IHS254D).

Partners

Plastic Gears II

Design of Plastic Gears with Consideration of Cyclic Loading and Time-Dependent Deformations



Incorporation of microstructure properties for the element based simulation



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Motivation

Short fiber-reinforced plastic gears are gaining importance in mechanical drive technology due to their low weight and cost-efficient production. However, they show time-dependent behavior and creep, which limit load capacity and complicate lifetime prediction. Improved modeling and design methods are therefore required.

Objectives

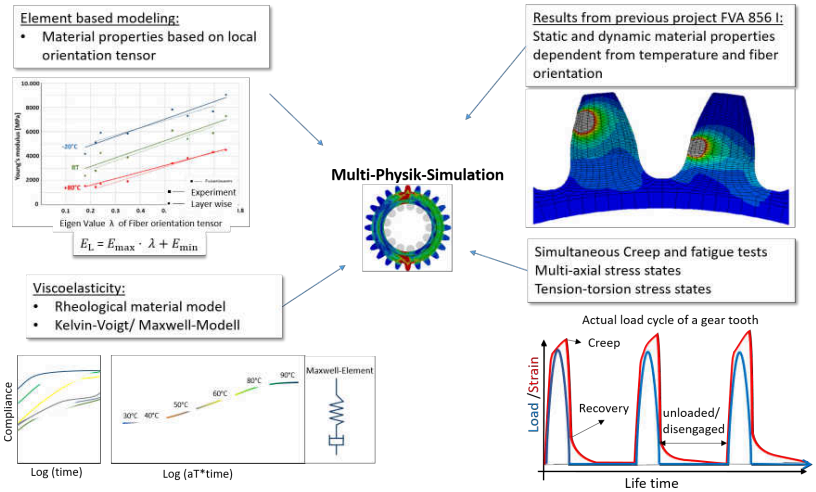
The project aims to develop standard methods and guidelines for designing plastic gears that consider functional, material, and process-related aspects. Element-based modeling is used to describe how fiber and matrix properties influence gear performance under cyclic loading.

Approach

A cyclic loading test plan is created to simulate realistic gear tooth stresses combining fatigue and creep. Quasi-static and cyclic multi-axial tests on specimen level help capture the interaction of creep, relaxation, and fatigue. Based on these results, rheological material models are developed and implemented in a multi-physics simulation by MEGT at RPTU Kaiserslautern-Landau. The findings are validated through static and running tests.

Results

The material used is short glass fiber-reinforced polyamide (PA46-GF30). Test specimens and injection-molded gears were produced to investigate multi-axial stress and fatigue behavior. A time–temperature superposition master curve enables long-term creep prediction. The fiber orientation and microstructure were characterized by computed tomography, and failure mechanisms analyzed microscopically to support reliable simulation models.

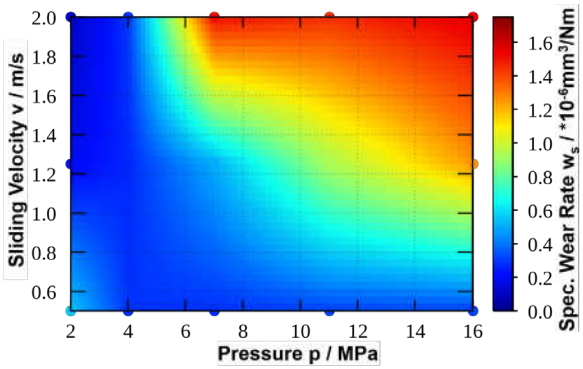


Overview of the project

This project was funded by the Federal Ministry for Economic Affairs and Energy as part of the "Industrial Collaborative Research" program based on a resolution of the German Bundestag (funding reference: 23244N).

PredicTrib

Predictive Tribometry for Fluorine-Free Sliding Materials



Wear map of a high-performance polymer composite for sliding against steel



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Motivation

Regulatory restrictions on PFAS require the urgent development of fluorine-free polymer composites for sliding applications. The selection of suitable material candidates requires reliable tribological data on wear and sliding friction coefficient. However, classic laboratory tests are characterized by long test durations and high variance, which necessitates a large number of tests. The creation of material maps, which represent friction and wear data across numerous load parameters such as pressure and sliding speed, is therefore economically inefficient.

Objectives

The aim was to increase the efficiency of measuring tribological parameters in order to obtain reliable data and material maps for the evaluation of fluorine-free composite material candidates in a cost-effective manner.

Approach

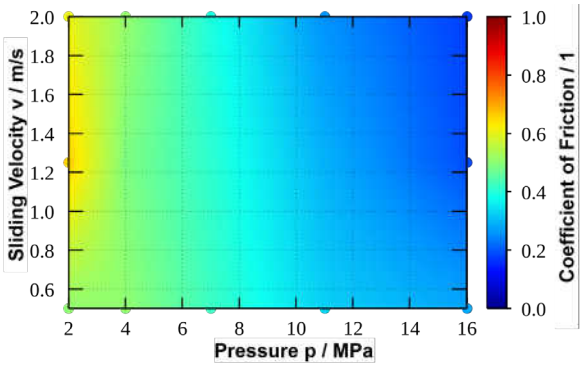
IVW uses tribometers with mounts for multiple test specimen pairs to conduct systematic tests in segments with variable pressure and speed settings in parallel. In addition, the test data collected in IVW's tribological database are analyzed to develop a formula for predicting the test specimen temperature and thermal expansion during segment changes. This prediction enables the optimization of the execution sequence of the individual test segments.

Results

The investigations showed that long test durations are primarily caused by thermal expansion, which masks the wear-related reduction in height of the test specimens. Optimized segment planning minimized the thermal expansion that occurs at the beginning of each segment change, reducing the average test duration for creating material maps (see figures) by 20%, even for unknown materials. Integration into IVW's tribological laboratory information system also enabled existing data on a material to be incorporated into the prediction, thereby increasing test throughput to even 50%. Together with industry partners, IVW investigated numerous fluorine-free composite materials and identified promising substitute materials for fluorine-containing sliding materials using the optimized test procedure.



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Friction map of a high-performance material revealing low friction coefficients at high loads and velocities

This project originated from IVW's internal research initiatives and ongoing scientific development.

ReGluWood

Partner ibwf INSTITUT FÜR BIOTECHNOLOGIE UND WIRKSTOFF-FORSCHUNG

In-Situ Lignin Modification to Recycle and Glue Waste Wood



ReGluWood's closed loop cycle

Motivation

Wood is a sustainable structural material and a natural carbon sink, making it a crucial entity in the realization of climate neutrality. Achieving a generally sustainable and circular economy of materials depends on both the transition from fossil to renewable resources and on the ability to recycle or upcycle available materials into circular use. Thus, it is necessary to achieve recyclability and circularity in wood materials. As well, interestingly, the wood macromolecular structure offers the possibility to recycle/upcycle wood into varying materials. Until now, these methods rely on non-sustainable chemicals and in most cases terminate the life cycle of wood. There is need for a more sustainable method that will ensure multiple life cycles with less environmental pollution.

Objectives

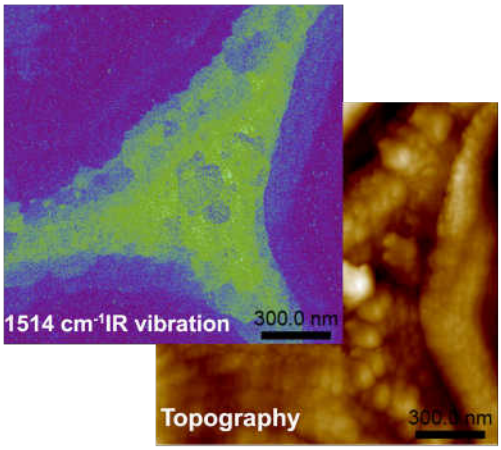
ReGluWood investigates the use of a modular biotechnological process to recycle wood waste into structural high-performance materials without the need for external chemical binders.

Approach

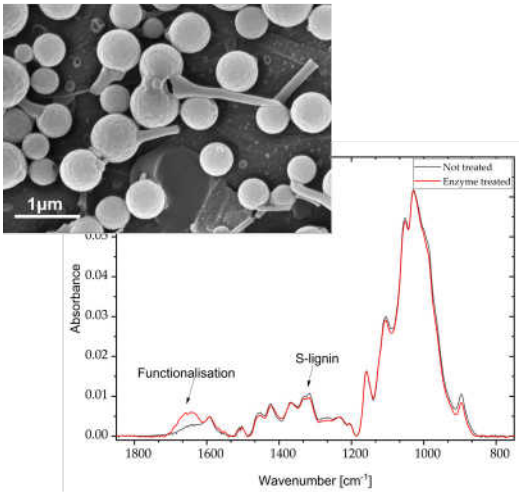
Building on the background knowledge of wood, sustainably deposited micro-sized pseudo lignin particles on the surface of wood are in situ converted into bio-based binders using enzymes.

Results

Thanks to our state-of-the-art AFM-nanoIR technology, the detection and characterization of the deposited particles and their functionalization are easily accomplished to facilitate further research and development.



AFM IR indentification of in situ developed particles



IR analysis of functionalization



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This project was funded by the Volkswagen Foundation, funding reference 9C910.

VolkswagenStiftung

Project Coordinator PCCL Polymer Competence Center Leoben

REPAIRTECTURE

Fast-Repairable Covalent Polymer Networks without Creep for a Circular Economy



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Motivation

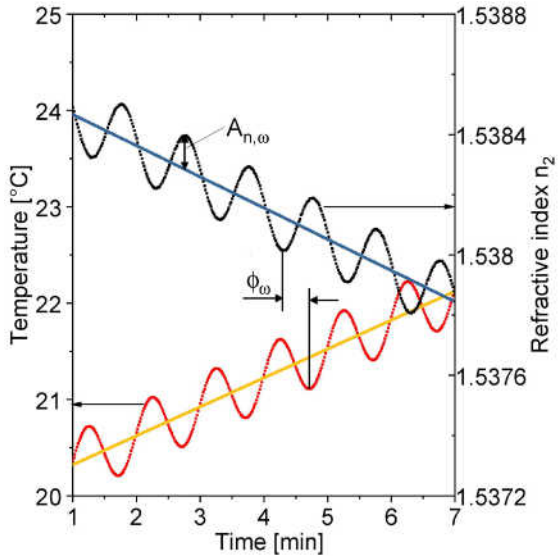
The goal of the project is to develop the next generation of thermosets. External stimuli, such as temperature or UV light, are used to switch the polymer from a solid to a flowable state and vice versa. These so-called dynamic covalent polymer networks, a class of materials that includes vitrimers, (see Klingler annual report) are distinguished by their ability to be repaired, reshaped, or even recycled despite being cross-linked polymer networks.

Objectives

As part of the Repairtecture project, we use materials provided by our project partners. The material state can be switched between a solid thermoset and a flowable phase through newly developed acid- and base-catalyzed bond exchange reactions, which can be activated or deactivated at the molecular level by temperature or UV light. These materials thus combine high creep resistance with remarkable macroscopic flow, depending on the respectively activated state.



Temperature-Modulated Optical Refractometer with UV extension (Dissertation M. Gilberg, in preparation)



Dynamic refractive index response of a model polymer system to temperature modulation at f=1.7 mHz

Approach

Thermo-mechanical and thermo-optical methods, such as rheology or temperature-modulated optical refractometry (TMOR), are used to characterize the material properties, both in their final states (solid or flowable), as well as during the activation or deactivation process.

Results

So far, the focus of the investigations has been on the properties after the material state has been switched via UV light. In the future, the studies will be extended to in-situ UV-TMOR measurements.

for more info, please visit

This project (project no.: 904927) was funded by the Austrian Government and the State Governments of Styria and Upper Austria within the framework of the COMET program of the Federal Ministry for Innovation, Mobility and Infrastructure and the Federal Ministry for Economy, Energy and Tourism.

Research Data Management

Research Data at IVW: Better Structured, More Visible, Continuing to Grow

Motivation

In 2025, IVW worked on making its research data easier to find, understand, and reuse. The goal was to make datasets, software, and other materials accessible not just to IVW researchers but also to the wider scientific community.

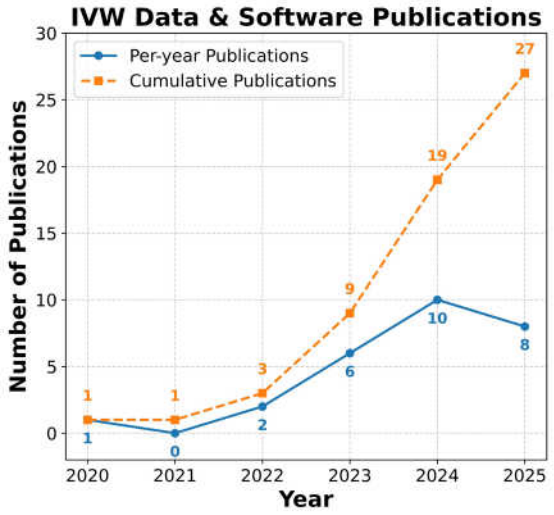
Approach

IVW's Zenodo community grew to 22 entries, with five more datasets added on GitHub and Mendeley Data, for a total of 27. The collection now includes data, software, posters, and presentations on topics like thermal and mechanical material properties, digital image processing, material models, epoxy resins, and X-ray tomography.

The institute also released the second edition of its RDM handbook, published a software management guide, and created a GitLab manual for researchers. Training sessions in Python, statistics, and Git helped researchers manage their data more effectively. A monitoring system tracks which Zenodo entries are accessed most often, helping IVW understand which topics are in demand and plan future publications.

Results

These efforts made more research outputs available and helped researchers manage their data and software better. Early insights from usage tracking show which topics are most sought after and help guide IVW's work. Overall, the institute is now better positioned to share its research on polymer composite materials and make it useful to the scientific community.



Data publications by IVW members, by years

Objectives

The main goals were to:

- **Share more research outputs in different formats**
- **Help researchers organize and share their data and software**
- **Improve data skills through training in Python, statistics, and version control**
- **Find out which topics are most useful to the scientific community**
- **Make IVW a reliable source for data on polymer composite materials**



IVW-Community on zenodo.org

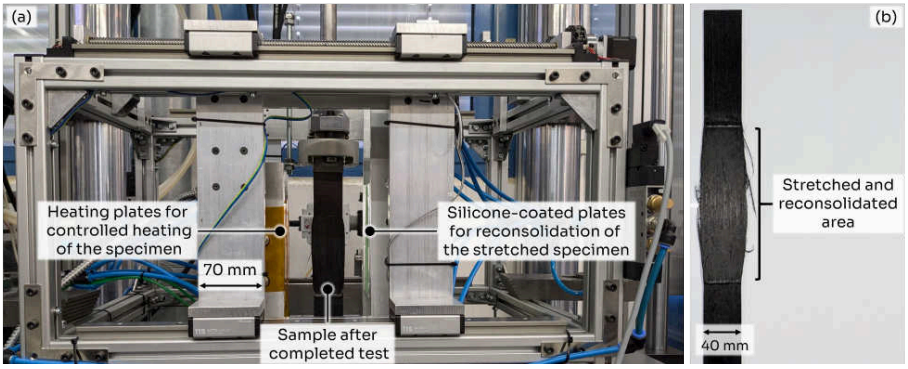


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This project originated from IVW's internal research initiatives and ongoing scientific development.

SFOB

Process Analysis of the Pseudo-Plastic Deformation in UD Staple Fiber Organo Sheets



(a) Test module for temperature-controlled tensile tests, installed in a high-speed tensile testing machine, and (b) reconsolidated specimen after the temperature-controlled tensile test



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Motivation

The use of recycled carbon fibers (rCF) contributes significantly to resource conservation and opens up potential for sustainable composite materials. For new applications of rCF staple fibers, it is necessary to understand their pseudo-plastic deformation behavior during thermoforming.

Objectives

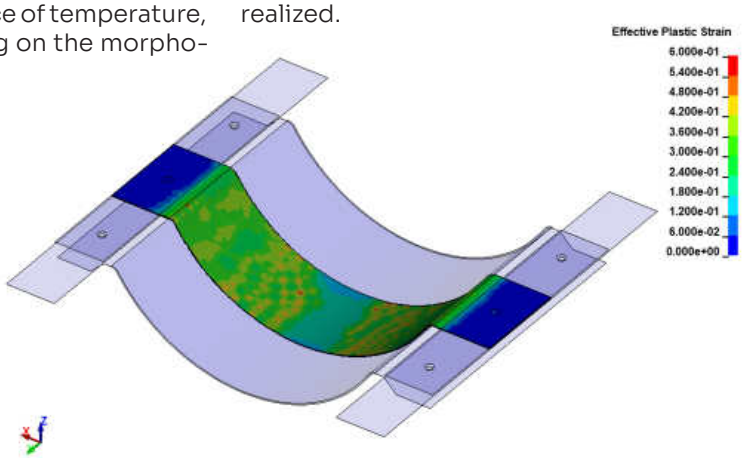
The aim of the project was to develop a process for manufacturing organo sheets from rCF staple fiber yarns. In order to gain an understanding of the processability of these organo sheets, their pseudo-plastic deformation behavior was investigated in high-speed tensile and thermoforming tests and the influence of process parameters on material behavior was determined.

Approach

The raw materials used were rCF/PA6 staple fiber yarns, which were characterized in terms of material composition, linear weight and thermal properties. At IVW, they were processed into tapes using a modified calendaring process, whereby the influence of temperature, process speed and stretching on the morphology and mechanical properties were investigated. This was followed by tape laying of the preform and consolidation in an autoclave to form organo sheets. The heating of the organo sheets above their melting temperature enables relative movement of the fibers, resulting in pseudo-plastic deformation behavior. To characterize this behavior, a tensile test set-up was developed that allows homogeneous heating of the test specimen and subsequent deformation at high strain rates. In these tests, the test speed, heating plate temperature and deformation rate were systematically varied. Based on the results, a simulation model was developed that transfers the tensile behavior to the thermoforming process and was validated by tests on omega profiles.

Results

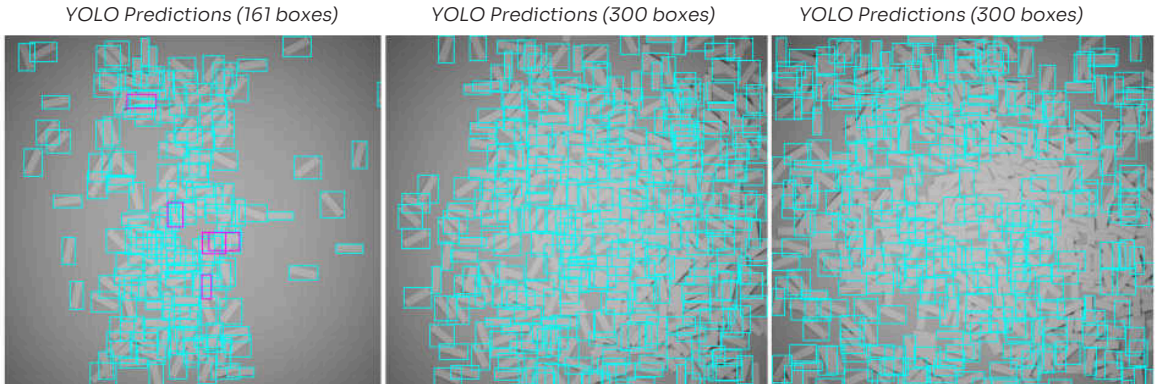
The dependencies of temperature and forming speed determined in the temperature-controlled tensile tests were confirmed in the thermoforming tests. Based on these findings, a quite homogeneous deformation could be realized.



Validated simulation model of the axial elongation of the omega profile at a material temperature of 255 °C

This project was funded by the German Research Foundation (DFG) – funding reference 471480678.

Synthetic Training Data for SMC Process Control



Influence of object density and quantity on detection quality

Motivation

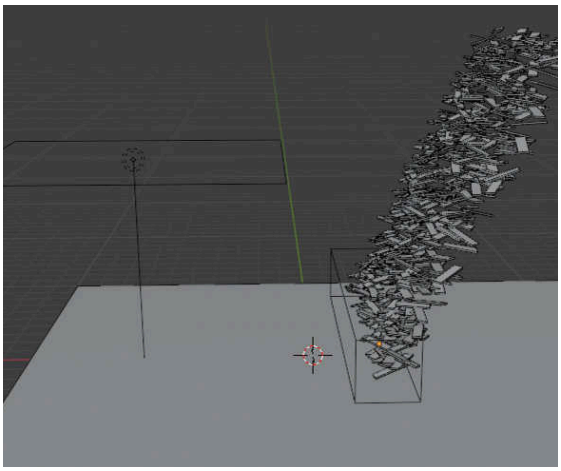
Within the in 2025 newly established competence field "Data-Driven Methods," a pipeline for generating synthetic training data for SMC manufacturing was developed to enable the development of robust optical inline process controls. Specifically for SMC, manufacturing defects such as locally low fiber content or deviations in fiber orientation are currently detected using polarization cameras. Conventional machine vision approaches rely on expert-defined features and rule-based methods and are limited in their adaptability to new part geometries, defect types, or processing variants.

Approach

The pipeline employs parameterized, rendering-based data synthesis using digital geometry models of SMC components. Fiber orientations, resin surfaces, and typical manufacturing anomalies are simulated, while expert knowledge guides the parametrization of lighting, camera angles, material properties, and defect characteristics to ensure physical realism. Based on these synthetic datasets, convolutional neural networks (CNNs) are trained to recognize individual fiber strands from RGB and polarization images via instance segmentation.

Objectives

The goal is to reduce dependence on extensive real-world datasets while ensuring adaptability to new geometries, defect types, and processing variants, thereby establishing a data-driven, scalable foundation for precise inline surface inspection in SMC manufacturing.



Simulation of the SMC production process using Blender software

Results

Using the synthetic data, CNNs were trained to recognize individual fiber strands from RGB and polarization images via instance segmentation. The models achieved very good detection performance at low to medium object densities and enabled the computation of local fiber volume content, fiber orientation distribution, as well as the analysis of the influence of lighting and background color on the segmentation results.



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This project originated from IVW's internal research initiatives and ongoing scientific development.

SUSAAN

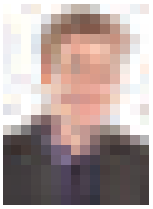
Partners

SUStainable Antimicrobial and Antiviral Nanocoating



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Bernd Wetzel

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Motivation

The emergence of infectious diseases and their detrimental impact on the economy and society requires effective protection in various environments, a need that can be met by antimicrobial and antiviral products. Core-shell (CS) particles supplied with an antimicrobial/antiviral (AM/AV) functional core have been developed for use in products within the medical, textile, automotive, and home sectors. CS particles are produced using sustainable processes. The cores contain actives that target functionality and controlled release, making them highly effective. However, to produce safer, more environmentally friendly AM/AV coatings that are highly durable, bio-based actives, such as cytotoxic and volatile essential oils, must be stabilized. Thus, robust core–shell nanocapsules are required that retain activity, reduce toxicity and enable redispersibility and scalability for industrial processing.

Objectives

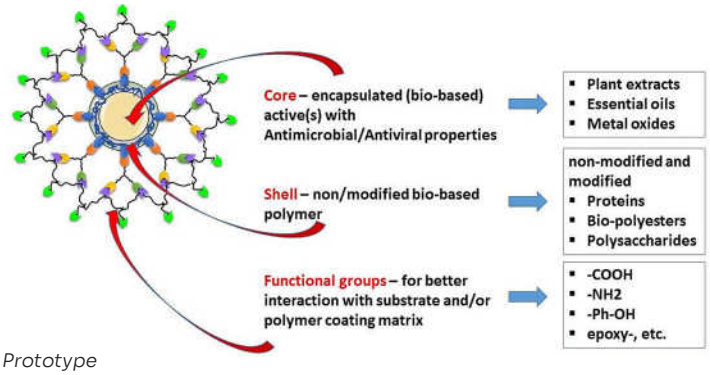
The key objective is to design and scale up the production process of bio-based nanocapsules (NCs) that can encapsulate various essential oils, such as oregano, thyme, eucalyptus and tea tree oils. Another target is to improve the distribution and polydispersity of the particles, as well as their stability, by using protein or synthetic, bio-compatible shells. Redis-persibility after concentration must also be ensured. Sufficient quantities of the scaled-up materials must be produced, and dispersions for coatings must be prepared.

Approach

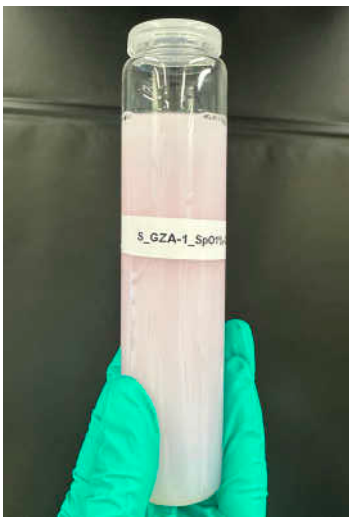
Various capsule families were developed based on proteins and modified copolymers for crosslinking. Nanoscale precipitation with controlled multi-channel dosing, optimized reactor geometry and temperature lead to minimized foaming and increased scalability of production up to ca. 5 kg per batch. The quality of nanocapsules was monitored using dynamic light scattering, zeta potential measurement, scanning electron microscopy and UV-Vis, while HPLC of the raw oils controlled the active content from batch-to-batch. Redispersion protocols are established to avoid capsule collapse.

Results

Modified and stable capsules with typical size of 100-200 nm, narrow particle size distribution, and low polydispersity were produced. Encapsulation efficiencies of more than 99% could be achieved and reproduced. The dispersions remained redispersible even after vacuum concentration. The nanocapsules showed strong antiviral efficacy (>99.99% vs. corona virus) and reduced cytotoxicity versus free oils, favorable for the integration into coatings.



Prototype



Prototype

SUSAAN
SUStainable Antimicrobial and Antiviral Nanocoating

European Commission

This project was funded by the European Union's Horizon Europe program under grant agreement No. 101057988 (SUSAAN).

UFO

Partners smartFactory KL SWMS CONSULTING

Environmentally Optimized FRP Production through Digitalization



IVW's Andreas Gebhard explaining Live-ATL-LCA to State Secretary Nicole Steingaß

Motivation

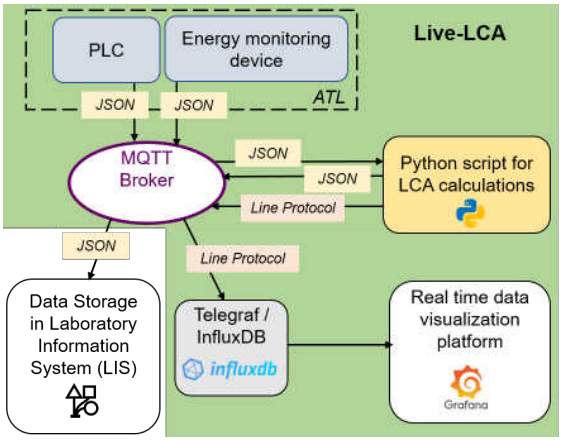
Fiber-reinforced plastic (FRP) production processes generate large amounts of heterogeneous process data, which, if continuously captured and analyzed, can significantly enhance process transparency, environmental assessment, and quality assurance. However, many production systems lack unified data communication and semantic integration across machines and measurement systems.

Objectives

To establish a unified digital infrastructure enabling real-time process monitoring, inline environmental assessment, and semantic data management across different FRP production processes — thereby laying the foundation for data-driven quality assurance and lifecycle analysis.

Approach

In 2025, continuous transmission of process data was implemented across multiple FRP production processes. This enabled, for the first time, an inline calculation of the CO_2 footprint during tape laying, providing immediate access to process-related environmental metrics (Live-LCA). The technical foundation is a project-specific WLAN combined with the MQTT protocol, which integrates heterogeneous measurement and control systems such as power meters, gas flow sensors, and machine controllers, specifically for the F2 Compositor, one of IVW's Automated Tapelayers (ATL). In parallel, control systems for the SMC line and winding unit were modernized, and process-related data acquisition was integrated into the Industrial Internet of Things (IIoT). The laboratory information system PKDE was established as a central data management component, structuring and persistently storing semantic metadata for the process chains of tape laying, thermoforming, winding, and SMC production.



The ATL transmits data to the IIoT, which includes a Python-based virtual CO_2 sensor

Results

The new IIoT-based infrastructure enables cross-process data integration, inline CO_2 assessment, and semantically annotated data management. Initial collaboration discussions were initiated with DLR and Fraunhofer ICT, and the follow-up project "From Process Parameter to Quality-Assured Component" was launched in October 2025 to advance the systematic linking of process parameters, data, and quality metrics across all program areas.



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UFO-FKV

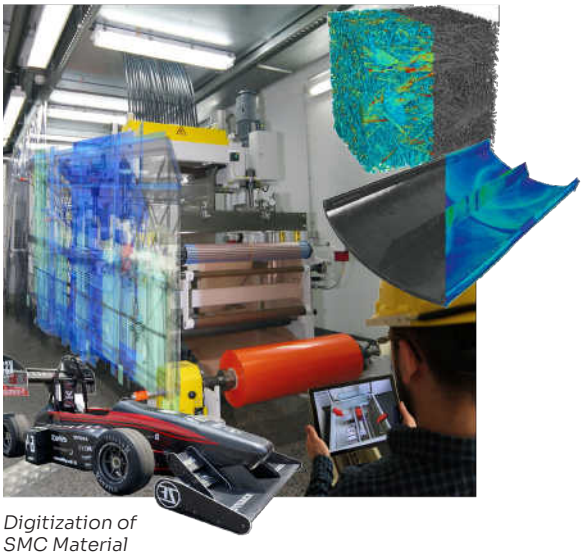
This project was funded by the Ministry of Science and Health of Rhineland-Palatinate.

RheinlandPfalz
MINISTERIUM FÜR WISSENSCHAFT UND GESUNDHEIT

Validation of Compression Molding Simulations

Fraunhofer High Performance Center Simulation and Software Based Innovation

HIGH PERFORMANCE CENTER
SIMULATION- AND SOFTWARE-BASED INNOVATION



Digitization of SMC Material Production



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Motivation

The validation of a process simulation model for the compression molding of Sheet Molding Compounds (SMC) is generally carried out by comparing press force, fiber orientation, and flow-front progression between experiment and simulation. A key factor influencing the flow behavior of SMC is the initial fiber orientation distribution within the specimen. If a synthetically generated fiber orientation distribution is assumed in the simulation, a direct comparison with individual specimens is not possible, since no real specimen with exactly this orientation exists. This situation typically occurs when commercial materials are used for experimental molding trials, for which the internal fiber orientation is unknown.

Objectives

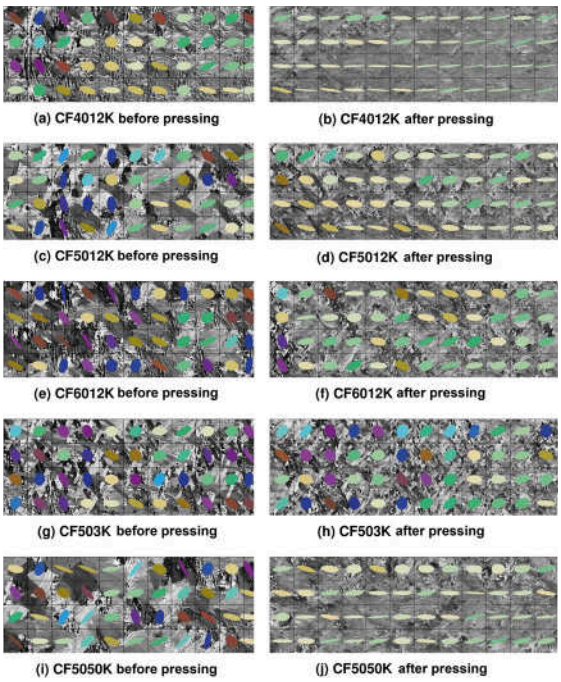
The goal of the project is to enable the validation of compression molding simulations through a direct comparison of fiber distributions generated in both simulation and experiment, based on individual specimens and corresponding virtual fiber representations. The project aims to verify simulation methods for compression molding by directly comparing fiber distributions — in terms of both position and orientation — between simulation and experimental results. The key advancement over the current state of the art lies in the use of simulation input data derived from the digitization of real fiber orientations in C-SMC semi-finished materials.

Approach

C-SMC semi-finished materials are produced on an SMC Line600 production line, where a polarization camera captures the fiber angles of the deposited rovings. Using image processing, these angles are converted into a digital representation of the fiber orientation distribution across the entire roll of material. From these digitized semi-finished products, cutouts are taken for compression molding tests, with the corresponding fiber orientation data serving as input for process simulations. The molding simulations are conducted at ITWM and the resulting fiber orientations are compared with those of the experimentally molded plates using computed tomography.

Results

Initial results show that even surface fiber orientation tensors reveal clear differences in orientation behavior among different C-SMC materials during long flow paths. Depending on the material formulation, the behavior ranges from almost complete fiber alignment in the flow direction to the preservation of the original material anisotropy. These observations highlight the strong influence of material composition on the evolution of fiber orientation during compression molding.



Comparison of images before (left) and after (right) compression molding for five C-SMC materials with overlaid local fiber orientation tensors

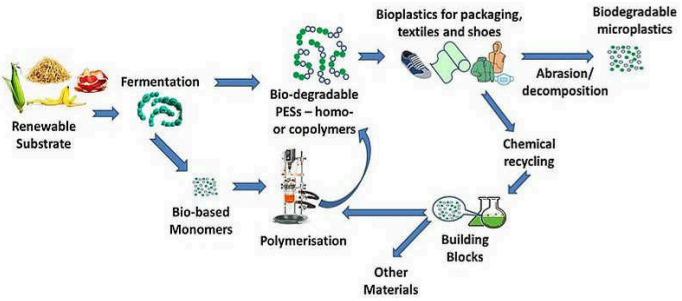
Fraunhofer ITWM

This project was funded by the Fraunhofer Institute for Industrial Mathematics (ITWM) within the framework of the High Performance Center for Simulation- and Software-Based Innovation.

Waste2BioComp

Converting Organic Waste into Sustainable Bio-Based Components

for more info, please visit



The cycle of bio-based and biodegradable polyesters (PES) begins with renewable raw materials and continues through fermentation and polymerisation to bioplastic products. These products can then be decomposed and recycled before returning to the cycle

Motivation

Microplastics persist in the environment and have been detected in oceans, freshwater, and even human and animal tissues. Packaging, textiles, and footwear are major contributors, e.g. through packaging waste, laundering, and abrasion. To mitigate these impacts, new biogenic, biodegradable polyesters (PES), including polyhydroxyalkanoates (PHAs), are being developed. Supply chains increasingly rely on low-risk biogenic resources, such as biomass waste, and polymers are being optimized for multiple recycling cycles. Sustainability assessments, including life cycle analysis (LCA) and toxicity evaluations, accompany development.

Objectives

The project aimed to develop biogenic, biodegradable, and recyclable PES for packaging, textile coatings, and shoe foams, ensuring high performance and environmental compatibility. PES were designed to resist premature degradation and microbial growth during use. To achieve this, PES were chemically modified and combined with proteins to form nanocapsules containing biogenic antimicrobial and antifungal agents. When incorporated into PES films or foams, these capsules enhance durability and hygiene. Further objectives included demonstrating industrial applicability (e.g., bio-based packaging films, nonwoven coatings for sportswear, and polyurethane foams for shoe soles) and establishing circular economy strategies. Recycling targeted hydrolysis into monomers/oligomers for PES resynthesis or chemolysis into PES-diols as building blocks for new polymers.

Approach

IVW collaborated within the Waste2BioComp consortium, combining expertise in polymer chemistry, materials engineering, and biotechnology. Newly developed PES and proteins were chemically modified to generate nanocapsules with biogenic active agents, which were integrated into packaging, coatings, and foams to improve stability and functionality. In parallel, process optimization addressed resin formulation, processing, and simulation-based performance prediction. Circular economy principles were central: PES at end of life could be hydrolyzed into monomers/oligomers or chemolyzed to PES-diols for reuse in polymer products. This integration of material innovation, functionalization, and recycling supports sustainable solutions for packaging, textile, and footwear industries.

Results

In May 2025, Waste2BioComp concluded successfully, unveiling a new generation of sustainable materials: bio-based packaging films, nonwoven coatings for sportswear, foams for shoe soles, and nanocapsules with antioxidant activity.



Innovation of bio-based materials production, three different manufacturing value chains



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This project was funded by the European Union (funding ref.: 101058654).

Waste2Wood

Partner cltech HIGHTECH HOLZBAU

Modified and Compacted High-Performance Wood from Residues of Native Woods

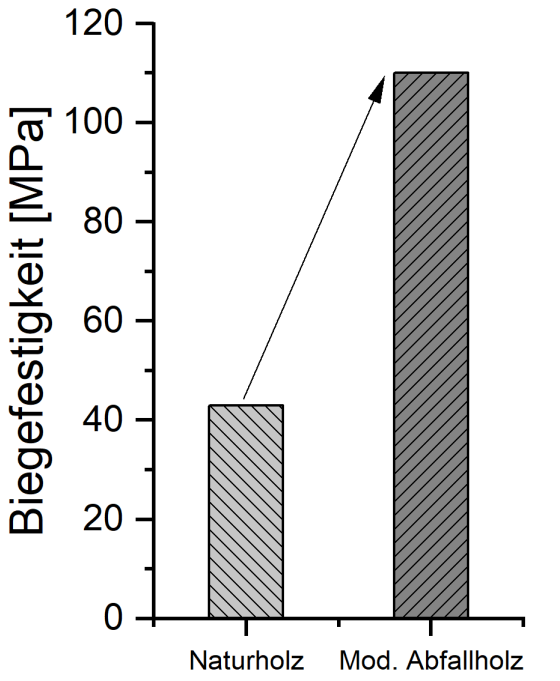


Emmanuel Akpan

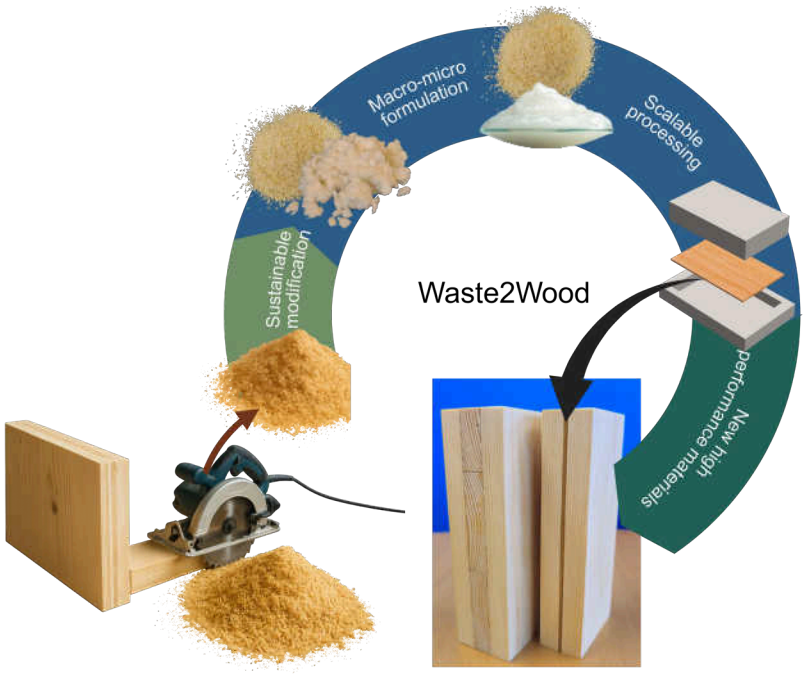
emmanuel.akpan@leibniz-iww.de

Motivation

The building and construction sector is the largest contributor to the global energy use and CO_2 emissions, accounting for over 36% of global energy use and 39% of energy- and process-related CO_2 emissions mostly arising from production energy of materials such as concrete, cement, steel and aluminum. An estimated 80% of emissions can be saved by improving material efficiency and replacing energy intensive and synthetic materials with renewable materials. Engineered wood such as cross-laminated timber (CLT) has the capacity to replace materials such as steel, concrete and carbon fiber reinforced composites in several applications. The global warming potential of laminated wood is 300% lower than that of concrete and replacing a cubic meter of steel bars with CLT can save more than 95% of energy. However, cross-laminated timber are usually designed to have very large volume in order to compensate for the property deficiency and dimensional stability leading to increase in transportation cost and CO_2 emission arising from transportation and logistics. Moreover, the production process of CLT's produce a large amount of wood waste and about 10 – 15% of timber in new constructions usually ends up as waste.



Waste2Wood mechanical properties surpases



Waste2Wood circularity process

Objectives

Waste2Wood aims to develop a high-performance, multi-material system with at least a 40% reduction in volume and improved mechanical properties to replace conventional CLT using the wood waste from the CLT production process.

Approach

This is achieved by replacing some layers of cross-laminated timber with a newly developed high performance isotropic wood (left), made from the production waste of cross-laminated timber production. In the process, a certain amount of lignin is removed from waste wood particles using an environmentally friendly process, and then the particles are compacted to obtain highly improved properties. This near-net-zero waste process ensures the circularity of the cross-laminated timber product.

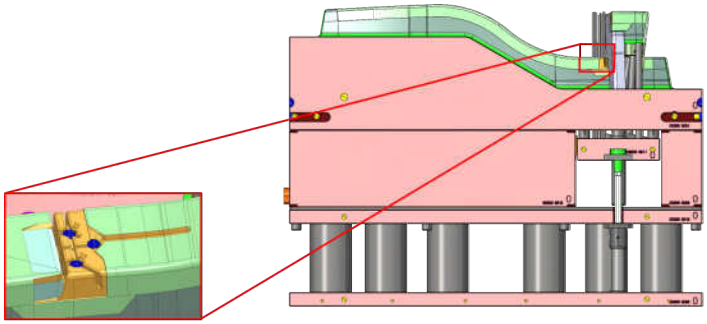
Results

Depending on the treatment process, the new isotropic material has at least twice the flexural strength of natural wood.

This project was funded by the Federal Ministry of Research, Technology and Space (BMFTR), funding ref.: 03WIR4506A.

ZEUS

Zero Emission Aircraft with Sustainable Fuselage Concept and Technology



CAD model of tool with injection molding cavity

Motivation

Thermoplastic fiber-reinforced polymer composites (TP-FRPC) are increasingly used in aerospace thanks to weldability and recyclability. In ZEUS, IVW addresses the resulting challenges, especially for structural aircraft components.

Objectives

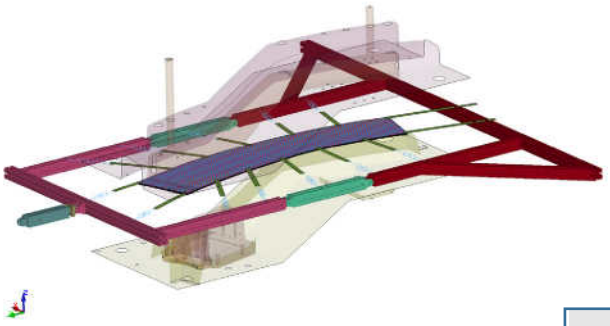
ZEUS aims to develop a thermoplastic composite "door environment" for passenger aircraft. Alongside a structurally optimized design, the project develops robust processing technologies for manufacturing high-performance parts, supported by digital strategies for quality prediction and assurance. Using TP-FRP and resource-efficient processes also helps reduce the ecological footprint.

Approach

IVW designs a lightweight, integrated door environment via topology optimization and extensive FEM validation, tailoring stiffening elements such as ribs. In manufacturing, a complete process chain is established including tape laying, thermoforming, co-consolidation, and overmolding. Process simulation supports tool design and thermal compensation, enabling improved pressure distribution and quality prediction (especially warpage). A dedicated work package develops the CCM process for profile production, including local reinforcements and thickness variations by leveraging thermoplastic joining options. Across process chains, comprehensive data acquisition from reference processes feeds digital models for quality prediction and control.

Results

A novel door-environment design was developed based on topology optimization and manufacturing constraints. A complex forming model for the door frame was created, experimentally validated, and used to optimize the design and define process parameters via filling simulation. These inputs informed the manufacturing tool design, built by Christian Karl Siebenwurst GmbH & Co. KG. For CCM, software was developed to visualize process data and cycle times (target vs. actual). In addition, an automated reinforcement method was implemented to apply and consolidate prefabricated patches onto profiles during continuous production, supported by a dedicated controller and simulation-based process optimization.



Thermoforming simulation model for the doorframe in LS-Dyna

Partners

Airbus Aerostructures GmbH
Airbus Operations GmbH
Albany Engineered Composites GmbH
Deutsches Zentrum für Luft- und Raumfahrt e.V.
Fraunhofer-Gesellschaft e.V.
XELIS GmbH



Martin Müller
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Jannis Hüppauff
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This project was funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 20W2106F).

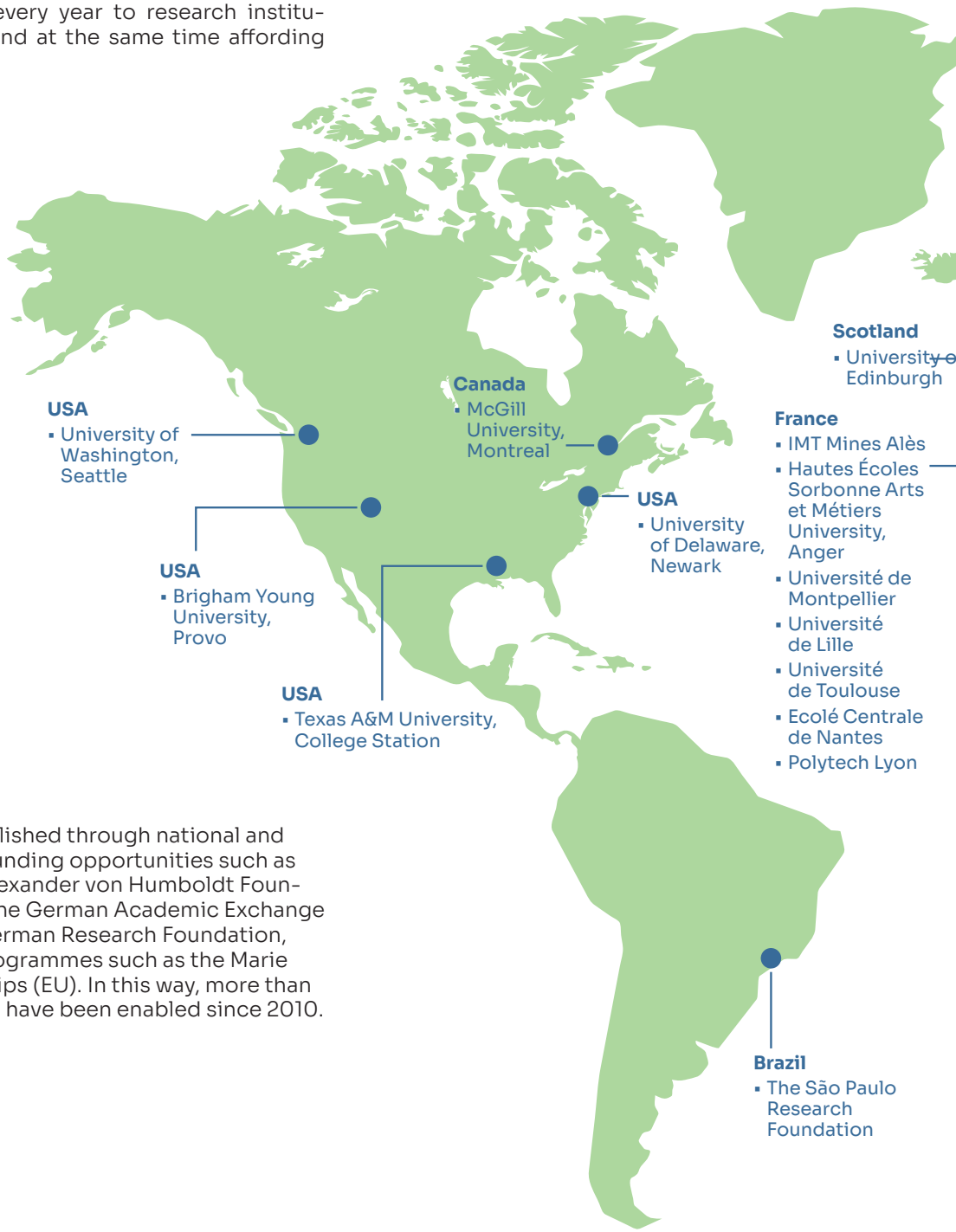
Current Cooperations

We are part of a global network of internationally leading composite research institutions. Through strong cooperation in international projects, exchange of world-class experts and our “on site” presence we have access to leading-edge technology and latest composite knowledge.

IVW expressly acknowledges the high importance of international exchange, both for the professional qualification of individuals and for the scientific quality of research at IVW.

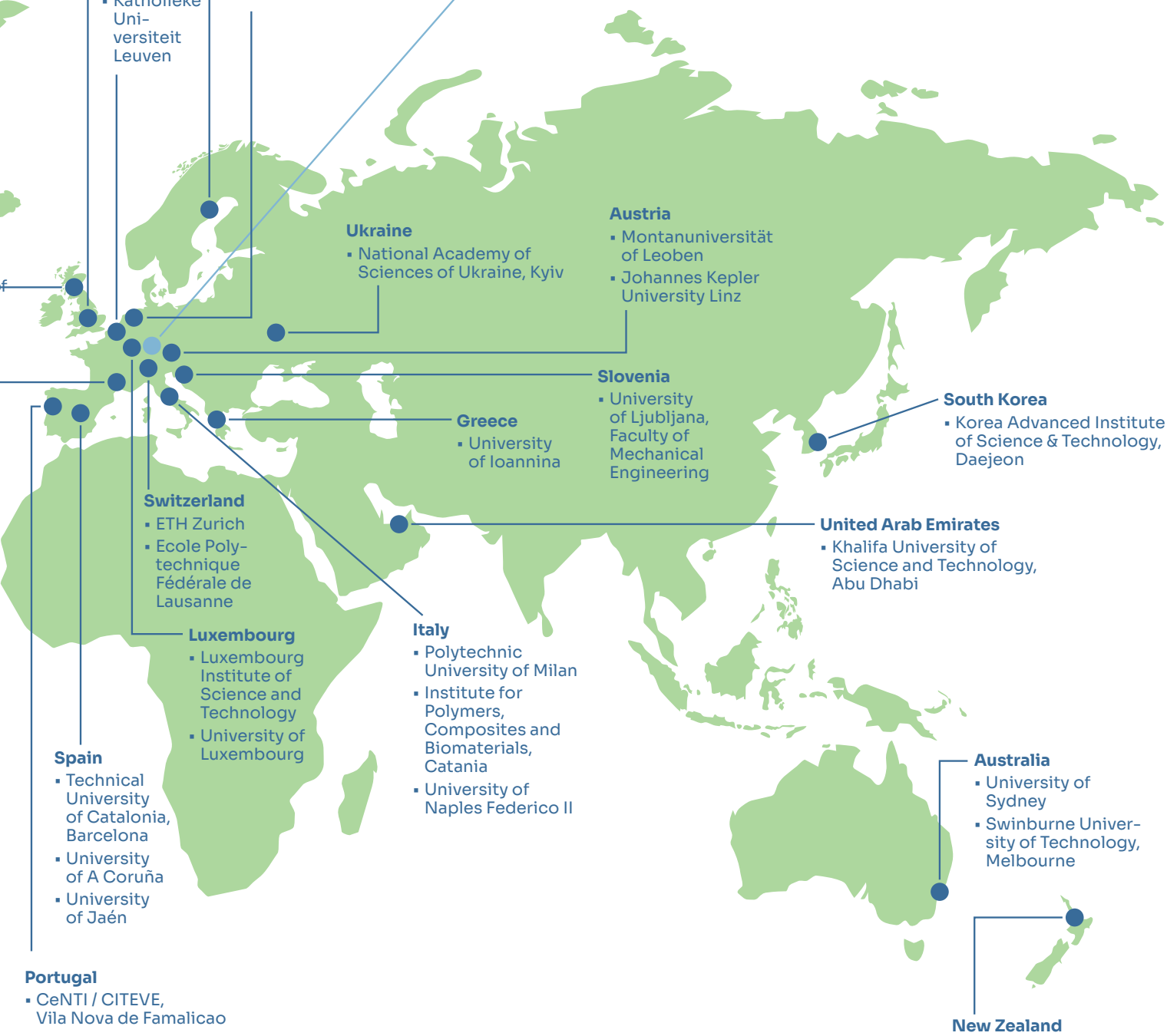
On this account, IVW is sending scientists and scholars every year to research institutions abroad and at the same time affording outstanding foreign guest scientists research stays at IVW. The exchange is promoted at the level of established researchers as well as the level of young scientists in order to enhance the development of the Institute and its staff in many ways:

- Qualification of young scientists
- Expansion of the international research network
- Joint projects with international partners
- Promotion of intercultural cooperation



This is accomplished through national and international funding opportunities such as those of the Alexander von Humboldt Foundation (AvH), the German Academic Exchange Service, the German Research Foundation, and foreign programmes such as the Marie Curie Fellowships (EU). In this way, more than 100 exchanges have been enabled since 2010.

Leibniz-Institut für Verbundwerkstoffe



England
- National Composites Centre, Bristol
- National Physical Labatory, Teddington
- University of Nottingham
- University of Sheffield
- University of Warwick, Coventry

Sweden
- Luleå University of Technology
- RISE Research Institutes of Sweden AB

Netherlands
- Delft University of Technology
- University of Twente, Enschede
- ThermoPlastic composites Research Center, Enschede

Belgium
- Katholieke Uni-versiteit Leuven

Ukraine
- National Academy of Sciences of Ukraine, Kyiv

Austria
- Montanuniversität of Leoben
- Johannes Kepler University Linz

Slovenia
- University of Ljubljana, Faculty of Mechanical Engineering

Greece
- University of Ioannina

South Korea
- Korea Advanced Institute of Science & Technology, Daejeon

Switzerland
- ETH Zurich
- Ecole Poly-technique Fédérale de Lausanne

United Arab Emirates
- Khalifa University of Science and Technology, Abu Dhabi

Luxembourg
- Luxembourg Institute of Science and Technology
- University of Luxembourg

Italy
- Polytechnic University of Milan
- Institute for Polymers, Composites and Biomaterials, Catania
- University of Naples Federico II

Spain
- Technical University of Catalonia, Barcelona
- University of A Coruña
- University of Jaén

Australia
- University of Sydney
- Swinburne Univer-sity of Technology, Melbourne

Portugal
- CeNTI / CITEVE, Vila Nova de Famalicao

New Zealand
- University of Auckland

Collaboration within r-LightBioCom

In October 2025, **Bernardo Libonatti** from Universitat Politècnica de Catalunya visited IVW as a guest scientist within the EU project r-LightBioCom, collaborating on bio-based additives, including lignin nanoparticles, for high-performance composites.



DAAD RISE Internship at IVW

In July 2025, **Kaela Nyland** from Western Washington University joined IVW for a research internship supported in part by the DAAD RISE program, working on residual stresses in fiber-metal laminates and stress analysis of a CFRP-based orthosis.



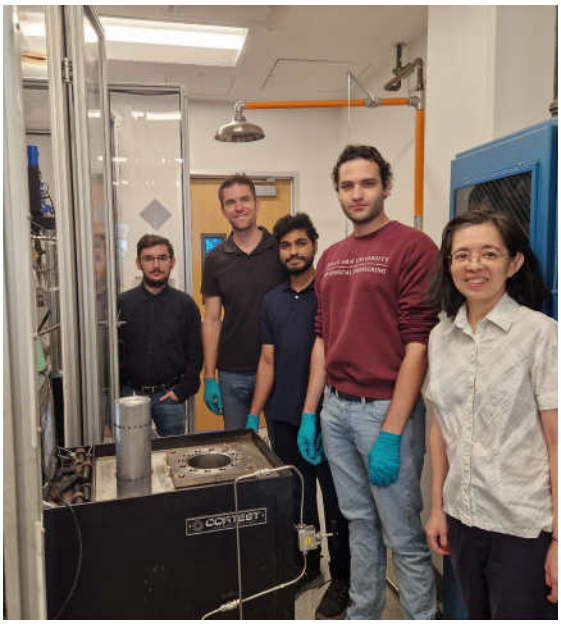
Guest Scientist from KAIST

In September 2025, **Wonki Kim** from KAIST joined IVW as a guest scientist, developing a simulation process chain for CFRP tank design to improve burst pressure prediction and analyze manufacturing effects on performance.



Research Exchange at Texas A&M

In October 2025, **Dr. Andreas Baumann** visited Texas A&M University for academic exchange with **Prof. Anastasia Muliana** on compression testing of unidirectional composites and high-pressure testing, funded by MWG



ConnectH2Australia – Strengthening International Collaboration



In November 2024, IVW, together with the Swinburne University of Technology in Melbourne, launched the ConnectH2Australia project, funded by the German Federal Ministry of Research, Technology and Space (BMFTR). The aim of this collaboration is to develop innovative, lightweight hydrogen storage solutions for sustainable aviation applications and unmanned systems.

A central focus of the project is the integration of hydrogen pressure vessels into UAVs and aircraft structures, enabling the operation of hydrogen-powered small and medium-range aircraft as well as long-range drones. At Swinburne's Air Hub, researchers are developing hydrogen-powered drones for applications such as medical transport, where battery-powered alternatives reach their limits. IVW contributes its expertise in pressure vessel design and composite component development to create efficient hydrogen tanks tailored to these demanding applications. Together, we are driving the energy transition in aviation – in Australia, Germany, and beyond.



Last year, **Dr. Nicole Motsch-Eichmann**, **Jannis Hüppauff**, **Matthias Bendler**, **Ulrich Blass**, **Nora Feiden**, and **Nithya Sindhe** traveled to Melbourne to work with researchers at Swinburne University toward the project's objectives.

This year, the successful collaboration was continued and further strengthened. Our Australian partners from Swinburne University, **Patryk Burka**, **Michael Jurdana**, **George Miris** and **Alex Cardew-Hall**, visited IVW in Germany, where we jointly visited industry partners across the country to identify synergies and explore new opportunities for cooperation. This in-person exchange deepened mutual understanding and reinforced the foundation for joint research and development in the field of sustainable hydrogen technologies.

Beyond the technical discussions, there was also time to experience German culture and further strengthen the personal connections between the teams – a valuable contribution to long-term international collaboration.

Scan to learn more

Composites United

The CU West duster aims to make a decisive contribution to strengthening regional competencies in the field of high-performance fiber composite technology. Together with IVW, future technologies are being developed in the following working groups:

- Thermo-plastics - from material to automated production
- Smart Structures - multifunctional composites
- Composite Fatigue
- Bio Composites
- Orthopedic Technology

In the monthly “Jour Fixe”: CU members briefly introduce themselves and then discuss a central topic from their technology field with the participants under expert guidance, while the „Composites meet User Industries“ series takes place quarterly. Guests are welcome.

CU West is one of the seven regional clusters in Composites United e.V., the world‘s largest network for fiber-based multi-material lightweight construction with 350 members. CU West has 60 members in western Germany - a number of highly innovative SMEs, renowned large companies and international research institutions.

Scan to learn more

+49 175 2141051 I heinz.kolz@composites-united.com
https://composites-united.com/cluster/cu-west/

Science & Innovation Alliance Kaiserslautern e.V.

Science and Innovation Alliance Kaiserslautern (SIAK) is a non-profit association based in Kaiserslautern. It brings together the region's scientific and technical expertise and innovative business skills in order to initiate and catalyze successful projects, collaborations and business relationships. We have set ourselves the goal of being the most effective innovation network in Germany, Europe and the world on topics relating to digital transformation and in the fields of mathematics, IT, natural sciences and technology (STEM). We want to maintain our leading position in the region and further expand it nationally and internationally. To achieve our goals, we are focusing our activities in the following three areas: Effective knowledge and technology transfer, competitive location marketing and the recruitment and retention of skilled workers.

Scan to learn more

For further information on current projects and contacts at SIAK, please visit www.siak-kl.com.

Knowledge & Technology Transfer

Our goal is the transfer of knowledge and technology to business, science and society — and we are pursuing various transfer paths to achieve this.

Spin-offs

- We proactively support spin-offs
- We promote Exist projects - from application to implementation

Contract Research

- We find the right solution for industrial R&D challenges
- We are active in all important networks to connect you with the right partner

Science Communication

- We are active at trade fairs and in networks
- We impart knowledge: To school students, citizens, science, industry and politics

Standardization

- In the interest of users, we advocate the right standards
- IVW experts are active in national and international working groups for standardization

Transfer through Heads

- Technology is in the mind: We organize the right technical seminars for you
- We educate: Our graduates are bearers of advanced technology

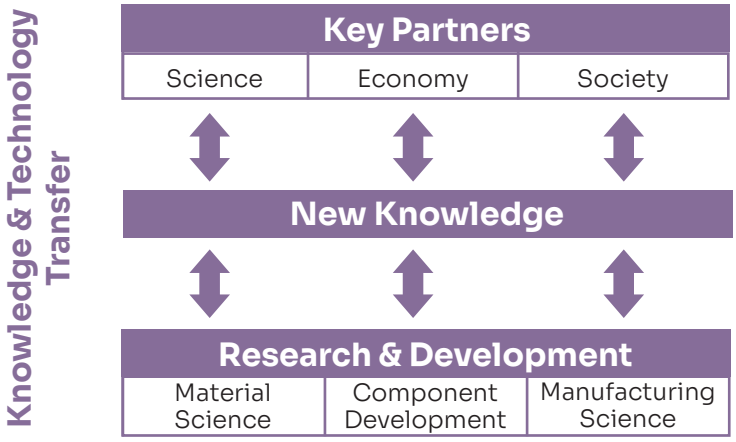
Infrastructure Services

- You are looking for support, e.g. in materials testing or structural testing - we can help you
- You want to break new ground in production technology - we have the equipment for you

Property Rights

- We foster the culture of innovation
- We promote inventions - from the idea to the industrial property right

Contact us!





Regina Köhne, Matthias Bendler, Dr. Birgit Bittmann-Hennes, Dr. Max Kaiser

Staff

Valuable knowledge, experience and research results were once again gained in 2025 through outstanding and innovative work. These were developed by an average of 114 committed and creative employees (FTE). 21 student and research assistants provided active support.

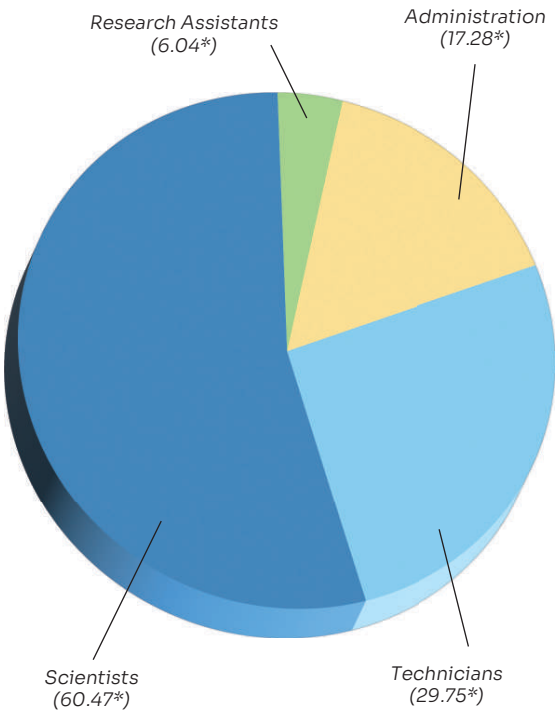
In total, 159 people from 16 different nations were employed in various positions at our company this year.

In addition, ambitious scientific guests, doctoral students, interns and students were able to make a valuable contribution to our research and development work as part of their degree, diploma, bachelor's and master's theses.

The average proportion of female employees over the year was around 28%, around 22% in the scientific field.

The proportion of foreign scientists was around 21%.

We would like to congratulate **Maximilian Eckrich**, **Torsten Heydt**, **Jan Janzen**, and **Harutyan Yagdjian**, who successfully completed their doctorates this year.



*Number of full-time equivalents


Maximilian Eckrich


Torsten Heydt


Jan Janzen


Harutyan Yagdjian

Equality Opportunities at IVW



Anna Dlugaj, Valentine Domengie Öztas, Francis González Ramírez and Dr. Barbara Güttler

In 2025, IVW continued to strengthen its commitment to gender equality and equal opportunity through a combination of strategic initiatives and practical support measures. Core activities included regular coordination with management, the extended management team, and the works council, as well as involvement in recruitment processes and support for employees on questions related to equality, diversity, and work-life balance. IVW also continued its mentoring efforts, maintained relevant internal information services, and expanded exchange with external networks and working groups, including within the Leibniz Association.

A key focus in 2025 was the promotion of young talent and the visibility of women in science and engineering. IVW once again participated in STEM outreach activities and, through its 2nd Female Recruiting Day, underscored its commitment to encouraging women to pursue scientific and technical career paths. These efforts were complemented by talks and discussion formats on equality-related topics, including the impostor phenomenon and the needs of international staff.

Another important step was the further development of a pilot childcare concept near the university campus. In collaboration with partner institutions, IVW advanced a proposal for a flexible, multilingual daycare service intended to better support families in research environments. This initiative reflects IVW's broader understanding of equal opportunity, encompassing not only representation, but also the structural conditions needed for fair participation and supportive working environments.



Female Recruiting Day

Excerpt from our Intellectual Property Rights

- **DE102013102486B3**
  Verfahren zur kontinuierlichen Messung des hydro-dynamischen Kompaktierungsverhaltens einer Verstärkungsstruktur
  Becker, David; Rieber, Gunnar; Franz, Holger

- **DE202019102255.8**
  Zylinderauszugskörper zur Prüfung des Adhäsionsvermögens zwischen Kunststoff/Metall-Kunststoff-Hybriden
  Becker, Yves

- **DE102011056637B4**
  Verfahren zur Fertigung eines Kunststoffbauteils
  Brzeski, Markus

- **DE102018113797.4**
  Herstellverfahren und Herstellungsvorrich tung zum Herstellen eines Speichensterns aus einem Endlosfaser-Kunststoff-Verbund sowie Speichenstern und Speichenrad
  Bücker, Marcel

- **DE202020101561.3**
  Vorrichtung zur Konditionierung von Werkstoffen
  Donhauser, Tobias

- **DE102021114985.1**
  Verfahren und Vorrichtung zur Deorbitie rung eines künstlichen Satelliten aus der Erdumlaufbahn
  Esha

- **DE102021109854.8**
  Verfahren zur Auslegung und Betriebsvor hersage von trockenlaufenden und mangelgeschmierten Maschinenelementen mit Gleitfunktion
  Fickert, Marc; Gebhard, Andreas

- **DE102018101758.8**
  Vorrichtung zur tribologischen Vorqualifizierung von Filamenten
  Gebhard, Andreas; Brunner, Stefan

- **DE102018110692.0**
  Verfahren und Vorrichtung zur zeitaufgelösten Analyse von Transferfilmen
  Gebhard, Andreas; Jim, Bai-Cheng

- **DE102015106802B3**
  Biegeaktuator mit Formgedächtniselement
  Hübler, Moritz; Fritz, Lisa; Nissle, Sebastian; Gurka, Martin

- **DE202018001559.8**
  Gitter aus Formgedächtnislegierung mit einem Kupferanker
  Hübler, Moritz; Gurka, Martin; Nissle, Sebastian

- **DE102012102841B3**
  Verfahren zur Präparation eines Roving
  Lichtner, Jens; Mack, Jens; Steeg, Markus

- **DE102005018477B4**
  Garn mit mineralischen Fasern
  Molnár, Peter

- **DE102006005104B3**
  Verfahren zur Überwachung eines Bauteils aus einem Kunststoffmaterial
  Molnár, Peter; Ogale, Amol; Mitschang, Peter

- **DE102015107281.5**
  Faserverbundwerkstoff-Hohlprofilstruktur mit verlorenem Hohlkern
  Motsch, Nicole; Magin, Michael

- **DE112015003290A5**
  Faserverbundwerkstoff-Verbindungsabschnitt und Herstellverfahren
  Pfaff, Thomas; Magin, Michael; Schmitt, Uwe

- **DE102012109671B4**
  Vorrichtung und Verfahren zur Fertigung einer Vorform
  Rieber, Gunnar

- **DE102011009506B4**
  Vorrichtung zur Herstellung hohler Formbauteile aus einem Faserverbundwerkstoff
  Rieber, Gunnar; Hummel, David

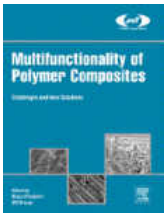
- **DE5020130001471.1**
  Deformationselement zur Absorption kinetischer Energie, aus derartigen Elementen hergestellte Einheit sowie Verfahren zur Herstellung eines derartigen Elements
  Schmeer, Sebastian; Schmitt, Uwe; Pfaff, Thomas; Scheliga, David

- **EP 4146460**
  Verwendung eines Faserverbundwerkstoff-Verbindungsabschnitts zur Verbindung einer rohrförmigen Faserverbundwerkstoffstruktur mit einer Anschlusseinrichtung
  Schmitt, Uwe; Pfaff, Thomas; Magin, Michael

- **DE102008009540B3**
  Vorrichtung zum Umformen eines Werkstückes aus einem thermoplastischen Werkstoff
  Velthuis, Rudi

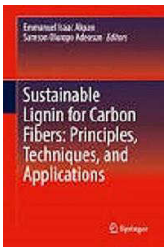
- **DE102005018478B4**
  Vorrichtung zum Induktionsschweißen von Kunststoffteilen
  Velthuis, Rudi; Collet, Christoph

Books



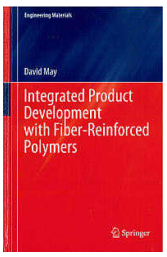
Multifunctionally of Polymer Composites: Challenges and Applications (Second Edition)
Ulf Breuer, Bernd Wetzel, Martin Gurka

Elsevier, 2nd revised and expanded edition, 2025
ISBN: 978-0-443-28872-2



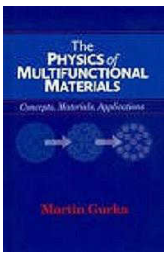
Sustainable Lignin for Carbon Fibers: Principles, Techniques, and Applications
Emmanuel Akpan, Samson Oluropo Adeosun (Eds.)

Springer, 2019
ISBN: 978-3-030-18792-7



Integrated Product Development with Fiber-Reinforced Polymers
David May

Springer Vieweg, 2021
ISBN: 978-3-030-73407-7



The Physics of Multifunctional Materials: Concepts, Materials, Applications
Martin Gurka

DEStech Publications, 2019
ISBN: 978-1-60595-260-4



Composite Technology Prepregs and Monolithic Part Fabrication Technologies
Hauke Lengsfeld, Javier Lacalle, Thomas Neumeyer, Volker Altstädt

Hanser Verlag, 2. Edition, 06/2021
ISBN: 978-1-56990-825-9



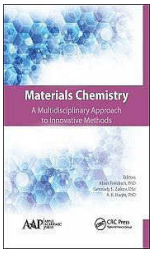
Commercial Aircraft Composite Technology
Ulf Paul Breuer

Springer, 2016
ISBN 978-3-319-31917-9



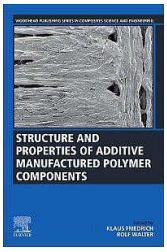
Integrierte Produktentwicklung mit Faser-Kunststoff-Verbunden
David May

Springer Vieweg, 2020
ISBN: 978-3-662-60285-0



Materials Chemistry: A Multidisciplinary Approach to Innovative Methods
Klaus Friedrich, Gennady E. Zaikov, A. K. Haghi (Editors)

Apple Academic Press, 2015
ISBN: 978-1-77188-251-4



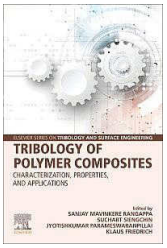
Structure and Properties of Additive Manufactured Polymer Components
Klaus Friedrich, Rolf Walter

Woodhead Publishing, 2020
ISBN: 978-0-128-19683-0



Handbuch Verbundwerkstoffe: Werkstoffe, Verarbeitung, Anwendung
Manfred Neitzel, Peter Mitschang, Ulf Breuer (Hrsg.)

Hanser Verlag, 2., aktualisierte und erweiterte Auflage, 2014
ISBN: 978-3-446-43696-1



Tribology of Polymer Composites: Characterization, Properties and Applications
Sanjay Mavinkere Rangappa, Suchart Siengchin, Jyotishkumar Parameswaranpillai, Klaus Friedrich (Editors)

Elsevier, 2020
ISBN: 978-0-128-19767-7

Teaching

In 2025, the institute was able to offer 48 semester hours of lectures and laboratories at the University of Kaiserslautern-Landau and the University of Applied Sciences Kaiserslautern with its 4 professors as well as 8 internal and external lecturers. In addition, students gained insights into modern research operations and current, promising research topics by working on student theses. 6 project and student research projects, 4 bachelor theses, 6 master and diploma theses as well as 4 dissertations were completed last year. Colloquia, technology transfer, and internships supplemented IVW's offer in teaching and research. In addition, the institute's employees also contributed to non-university lectures and training, e.g. the biannual fundamental seminar "Thermoplastic Reinforced Composites", organized by CUeV.

RPTU – Rheinland-Pfälzische Technische Universität

Winter Term	SWh
Introduction to Composite Materials Neumeyer / Breuer / Hausmann / Wetzel	3
Design and Analysis of Composite Materials Hausmann	2
Commercial Aircraft Composite Technology Breuer	2
Joining Technologies for Composites Geiß / Neumeyer	2
Designing with Plastics Endemann	2
Laboratory "Technology of Materials" Blinn / Geiß / Seewig / Wetzel	4
Integrated Product Development with Composites May	4
Biomimetics in Materials Science Wetzel	4
Laboratory "CAE with Composite Materials" Duhovic	3
Physics of Polymers *Gurka*	2

Summer Term	SWh
Processing of Composite Materials Neumeyer	2
Design of Composite Structures Schmeer	2
Fatigue and Life Cycles Magin	2
Light Weight Design Hausmann	4
Laboratory "Machine Design" Beck / Eigner / Geiß / Neumeyer / Müller / Sauer / Stephan	4
Physics of Multifunctional Materials Gurka	2

Hochschule Kaiserslautern – University of Applied Sciences

Winter Term	SWh
Tribology Gebhard	2
General Chemistry Gryshchuk	4

Summer Term	SWh
Materials from renewable resources and material cycles Gryshchuk	2

IVW Colloquium 2025: From Fibre to Future

On September 29 and 30, 2025, IVW hosted its colloquium **From Fibre to Future** in Kaiserslautern. Over two days, the event brought together experts from academia and industry to discuss the latest developments in fiber-reinforced polymer composites along the entire value chain, from material development and characterization to processing, simulation, applications, and sustainability.



Alongside presentations by IVW researchers, keynote speakers from **Airbus**, **Toray Advanced Composites**, and **SWMS Systemtechnik** provided insights into current challenges and future prospects, including large-scale adoption of composites, quality assurance in manufacturing, and mobility solutions. A guided lab tour and an evening reception created additional opportunities for professional exchange and networking.





A particular highlight of the colloquium was the official handover of the funding approval for the joint research project **Predict-TPC**. During the event, **Ministerial Director Katharina Heil** presented **€1.1 million in funding** from the Ministry of Science and Health of Rhineland-Palatinate to IVW and the **Fraunhofer Institute for Industrial Mathematics (ITWM)**.



In Predict-TPC, the two institutes combine expertise in mechanical material characterization, digital twins, and advanced simulation to develop an application-oriented material model for fiber-reinforced thermoplastics based on digital microstructure analysis. The project is intended to advance the industrial use of sustainable lightweight materials, particularly in the automotive and aerospace sectors.



New World Record at the Mainz Science Market: High-Performance Adhesive Lifts the Heaviest Weight



At the 2025 Mainz Science Market, IVW set a new world record for the heaviest weight lifted using adhesive bonding. **The record was achieved with a newly developed adhesive technology based on the high-performance polymer PEEK** (polyether ether ketone, supplied by Victrex).



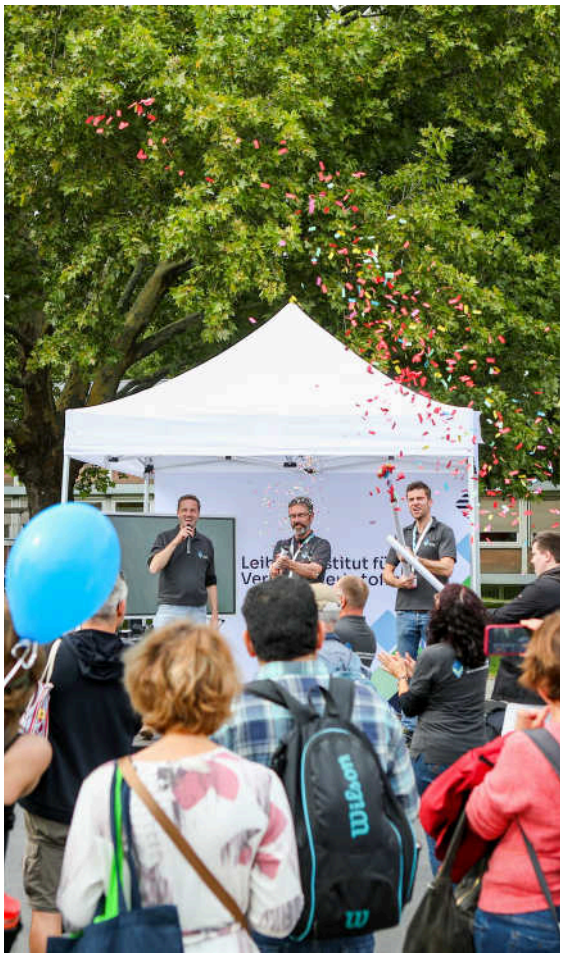
For the record attempt, massive steel cylinders were joined using the adhesive effect of the PEEK-based material. Following the official opening by **Clemens Hoch**, Minister for Science and Health of Rhineland-Palatinate, the bonded cylinders were used to lift a concrete weight of **more than 20 metric tons**. The load was suspended by a crane for one full hour, exceeding the previous record of 17.5 metric tons set in 2019. **The bonded surface measured just 40 square centimeters**, roughly the size of a credit card. The performance was documented live before an expert audience, media representatives, and numerous visitors and was verified by independent witnesses.



The attempt also showed the challenges involved in such a demonstration. After 30 minutes, the first bond failed with a loud crack. Thanks to the IVW team's careful preparation, a second set of bonded specimens was ready, and the attempt could be restarted successfully, this time achieving the full one-hour holding time. The record attempt was carried out under the leadership of **Dr. Andreas Baumann** and under the direction of **Prof. Joachim Hausmann**. Its success was made possible by the close collaboration, technical expertise, and commitment of the entire team involved.

The record highlights the potential of modern high-performance polymers and the growing importance of adhesive technologies in industrial applications. Compared with conventional joining methods such as screws or bolts, adhesive bonding offers mechanical advantages and opens up new possibilities, particularly when joining different materials in lightweight construction.

IVW's participation in the Science Market and the realization of the world record attempt were made possible through the support of the Ministry for Science and Health of Rhineland-Palatinate. Presented at the joint booth of the Leibniz institutes in Rhineland-Palatinate, the activity also highlighted the importance of science communication by making research visible and accessible to a broad audience.





Student Internship at IVW



On **January 15–16**, Noah and Junot from **Gymnasium am Rittersberg** gained hands-on insights into composite materials and lab work at IVW. During their two-day internship, they explored material strength, reproducibility in the lab, and the differences between paper and glass-fiber-reinforced composites. As souvenirs, they took home self-made flying discs and rulers.

IVW at Night of Science

On **May 9**, IVW took part in the **Night of Science** in Kaiserslautern and invited visitors of all ages to discover innovative materials through hands-on exhibits and interactive demonstrations. A crowd favorite was the station where visitors pressed their own disc from natural fiber mats. Additional exhibits highlighted composite processing, fiber orientation, lightweight design, hydrogen applications, and medical technology.



IVW at Rhineland-Palatinate Day



From **May 23–25**, IVW presented its research at **Rhineland-Palatinate Day** in Neustadt an der Weinstraße as part of the joint tent of the **Rhineland-Palatinate Ministry of Science and Health**. Visitors explored materials research in an interactive setting and learned more about IVW's work in composites and future technologies. The stand also welcomed prominent political guests, including Minister-President **Alexander Schweitzer** and Science Minister **Clemens Hoch**.

"Mephisto Meets Machine" at Heinrich Heine Gymnasium

On **June 25**, **Dr. Andreas Gebhard** and **Dr. Max Kaiser** used an **IVW-developed chatbot** to explore Faust with 12th-grade students at **Heinrich Heine Gymnasium**. The workshop combined literary analysis with discussions of AI, prompt design, information control, and media literacy. By comparing GPT- and RAG-based systems, students gained a practical understanding of both the potential and the limitations of generative AI.



IVW at the RPTU Summer School “Engineers of the Future”



On **August 29**, students from **Heinrich Heine Gymnasium** took part in IVW’s workshop **“Flying Emission-Free with Natural Fibers”** as part of **RPTU**‘s **“Engineers of the Future” Summer School**. Guided by **Prof. Ulf Breuer**, **Prof. Thomas Neumeyer**, **Valentine Domengie**, and **Dr. Florian Gortner**, they gained insights into fiber-reinforced composites and their applications, from medical technology to aerospace.

IVW at MI(N)Tmachwelt at Gartenschau

From **September 11-13**, IVW offered workshops on composite materials and welcomed visitors of all ages to its booth at **MI(N)Tmachwelt** at Gartenschau in Kaiserslautern. Through hands-on activities and direct exchange, participants learned more about structures, natural fibers, and sustainable materials. The event highlighted how research can be made accessible, interactive, and engaging for broad audiences.



BMFTR Werkstoffferien at IVW



From **October 20-24**, young participants joined a week of hands-on materials science at IVW as part of the **BMFTR Werkstoffferien**. The program included safety training, lab tours, sustainable materials, mechanical testing, microscopy, and composite manufacturing. By preparing samples, analyzing materials, and producing their own components, the group gained practical insights into research, engineering, and modern materials technology.

CU Trainee Day at IVW

On **November 11**, students in the **CU Trainee Program** gained practical insights into joining technologies for thermoplastic composites at IVW. The program combined multiphysical simulation, induction welding, and lab demonstrations with a tour of the winding and pressing hall. The event offered young talents a close look at current research and hands-on engineering practice in lightweight materials.



Injection Molding Meets Digitalization



In cooperation with **ENGEL Deutschland GmbH**, IVW expanded hands-on teaching and research in plastics engineering with a new all-electric **ENGEL e-mac 100 injection molding machine**. The system combines energy-efficient, precise processing with advanced software and digital connectivity, giving students and researchers direct access to industry-relevant technologies in laboratory courses and research projects.

IVW at JEC World 2025 in Paris

From **March 4–6**, IVW presented current developments in **mobility**, **medical engineering**, **production**, and **energy** at **JEC World 2025** in Paris. The trade fair also provided opportunities to exchange ideas with project partners, alumni, and the international composites community, while discussions at and beyond the booth strengthened existing networks and opened up new perspectives for future collaboration.



IVW at the 29th SAMPE Symposium in Aachen



From **April 2–3**, IVW researchers took part in the **29th SAMPE Germany Symposium in Aachen**, one of the key networking events for composite materials. The institute was represented through scientific exchange, current research contributions, and participation in the **SAMPE Innovation Award**, which highlighted the work of early-career researchers connected to IVW.

IVW at PPS-40 in Auckland

From **April 22–25**, Dr. **Miro Duhovic** represented IVW at **PPS-40** in Auckland, an international conference on polymer processing attended by researchers from 34 countries. A keynote on the **Leibniz collaborative project ML4SIM** highlighted how artificial intelligence and digital material characterization can improve process simulation in composite manufacturing.



IVW Alumni Day 2025



On **June 27**, IVW welcomed alumni back to Kaiserslautern for a day dedicated to exchange, professional perspectives, and personal reunion. The program included institute updates, the presentation of the **IVW Alumni Award 2025** to **Rodrigo Luengo Scotto**, industry talks, an excursion to the **historic lime mine** in Wolfstein, and a concluding barbecue that encouraged informal networking.

State Secretary Visits IVW

On **July 22**, State Secretary **Nicole Steingaß** visited IVW for an in-depth exchange on **medical technology research** funded and supported in Rhineland-Palatinate. A central topic was the **GESFOR** project, which is developing an implant for treating pectus excavatum, alongside further insights into projects such as **HySpine**, **FIXTER**, and **3Dprint2fiber**.



IVW at ICCM24 in Baltimore



From **August 4–8**, IVW researchers contributed to **ICCM24** in Baltimore through presentations and session chairing. Contributions by **Prof. Ulf Breuer**, **Prof. Thomas Neumeyer**, **Dr. Nicole Motsch-Eichmann**, and **Dr. Andreas Baumann** covered **hydrogen pressure tanks** for small aircraft, **fiber metal laminates**, **squeeze-flow testing** of carbon-fiber SMC, and **digital twins** for automated manufacturing processes.

IVW at DLRK 2025 in Augsburg

From **September 23–25**, IVW was represented at the **German Aerospace Congress** in Augsburg with scientific presentations and session chairing. The contributions addressed **prepreg** draping behavior, digitally supported development of **thermoplastic aircraft structures**, and approaches for integrating **hydrogen pressure tanks** into small aircraft.



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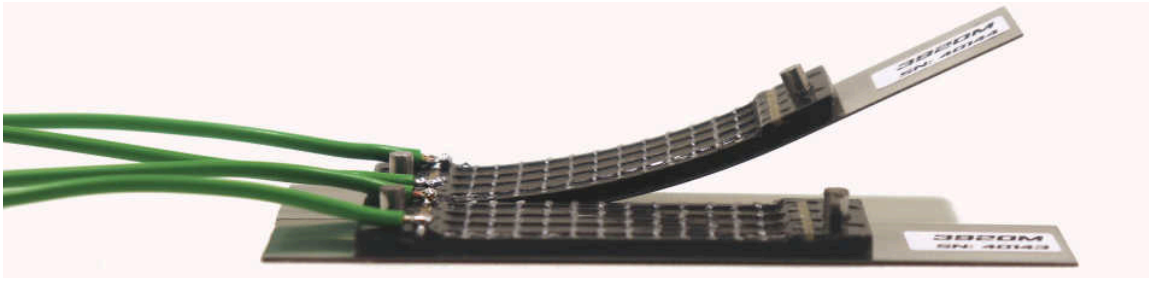
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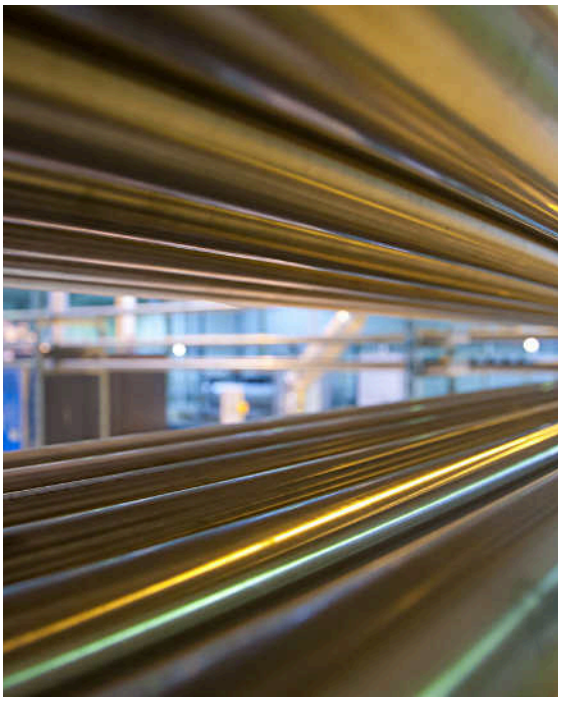
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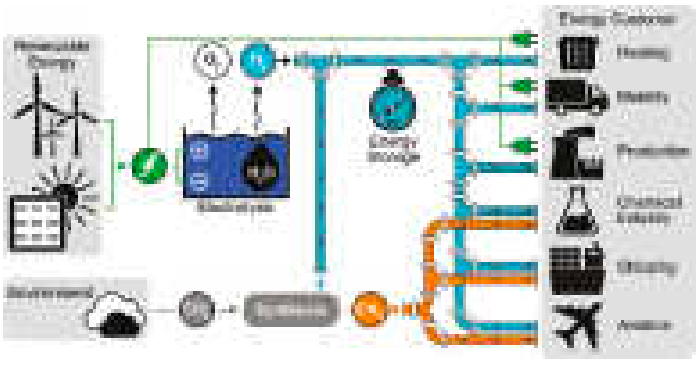


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The Gründungsbüro (start-up office), established in 2008, supports members of the Leibniz-Institut für Verbundwerkstoffe als well as the RPTU University Kaiserslautern-Landau and the Hochschule Kaiserslautern, University of Applied Sciences in founding their own companies. Its task is to promote entrepreneurial spirit and leadership skills in academic and scientific circles in order to create more spin-offs, particularly in the technology sector.

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A. Baumann, S. Mrzljak, F. Walther, and J. Hausmann, "Modified curing cycles and accompanying polymer and adhesion changes in fiber metal laminates," presented at the 24th International Conference on Composite Materials - ICCM24, Baltimore, USA, 2025

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M. Duhovic, D. May, T. Schmidt, S. Cassola, D. Korolev, M. Hintermueller, M. Nuske, D.K. Natarajan, D. Becker, K. Steiner, R. Reichenbaecher, G. Auernhammer, and C. Scheffler, "Leibniz Collaborative Excellence Project ML4SIM," presented at the 40th International Conference of the Polymer Processing Society – PPS40, University of Auckland, New Zealand, 22.04.2025

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B. Guettler, "Halogenated polymers for high-performance applications," presented at the ETOS-Halocycles Summer School 2025, Boppard, Germany, 11.06.2025

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N. Motsch-Eichmann, "Structural integrity of load carrying H2 pressure tanks for small aircraft," presented at the 24th International Conference on Composite Materials - ICCM24, Baltimore, USA, 04.08.2025

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T. Schmidt, S. Cassola, M. Duhovic, and D. May, "Comparison of different dual scale methods for numerical permeability prediction," presented at the FPCM-16 The 16th Conference on Flow Processes in Composite Materials, Khalifa University, Abu Dhabi, VAE, 14.01.2025

N. Sindhe Narayana Rao, N. Motsch-Eichmann, T. Pfaff, U. Blass, U. Schmitt, and J. Hausmann, "A double-wall CFPR liquid hydrogen distribution system as a structural component in aircraft applications- CF-Hydro," presented at the Deutscher Luft- und Raumfahrtkongress - DLRK 2025, Augsburg, Germany, 23.09.2025

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Delft University of Technology, Facility of Aerospace Engineering, Delft, Netherlands

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Doctorates

March 25, 2025
Jan Philipp Janzen, M.Sc.
"Prozesskette zur Herstellung epoxidbasierter Feststoffharzprepregs und deren Verarbeitung zu Faser-Kunststoff-Verbunden"

Chairperson:
Prof. Dr.-Ing. Tilmann Beck, RPTU

Report:

Prof. Dr.-Ing. Thomas Neumeyer, IVW
Prof. Dr.-Ing. habil. David May, Universität Bremen, Faserinstitut Bremen FIBRE
Prof. Dr.-Ing. habil. Bodo Fiedler, Technische Universität Hamburg, Institut für Kunststoffe und Verbundwerkstoffe

April 24, 2025
Torsten Heydt, M.Sc.
„Beitrag zur experimentellen Ermittlung des Dämpfungsverhaltens von Faser-Kunststoff-Verbunden“

Chairperson:
Prof. Dr.-Ing. Ulf Breuer

Report:
Prof. Dr.-Ing. Joachim Hausmann
Prof. Dr.-Ing. Paul Geiß, RPTU Kaiserslautern

June 26, 2025
Harutyun Yagjian, M.Sc.
"The thermal N-layer model as a basis for further development and extension of IRT data post- processing methods using model simulation and machine learning methods"

Chairperson:
Prof. Dr.-Ing. Ulf Breuer, IVW

Report:
PD Dr. rer. nat. habil. Martin Gurka, IVW
Prof. Dr. Dr. h.c. Peter Maaß, Universität Bremen

August 28, 2025
Dipl.-Ing. Maximillian Eckrich
"Auslegung mittels Nassfaserlegen hergestellter Strukturen aus Faser-Kunststoff-Verbund auf Basis einer Topologieoptimierung"

Chairperson:
Prof. Dr.-Ing. Thomas Neumeyer, IVW

Report:
Prof. Dr.-Ing. habil. David May, Universität Bremen, Faserinstitut Bremen FIBRE
Prof. Dr.-Ing. Joachim Hausmann, IVW
Prof. Dr.-Ing. Axel Spickenheuer, Leibniz-Institut für Polymerforschung Dresden IPF

Internal Colloquia

February 11, 2025

Alexander Nuhn
Application dimensioning of the hybrid injection molding process on free edges under tension

April 9, 2025

Andreas Krämer
Reactive thermoplastic prepregs: New processing possibilities for an acrylic resin system

Fabian Röder
Presenting the Capabilities of UFO-FKV: The New In-House Platform for Aggregating, Visualizing, Storing, and Transforming Process Data

May 14, 2025

Stefan Schmidt
Fiber Reinforced Compound Foil Bipolar Plates for Compact Fuel Cells

Martin Detzel
Unlocking Deep-Drawing Capability: A Process Route Based on rCF staple Fiber Yarns

July 23, 2025

Megha Rani
Process and Plant Development of Geometrically Flexible Hydrogen Pressure Tanks Using Carbon and Bio-based Epoxy Resin System (H2-Flex)

Anna Dlugaj
Development of Dual-Curable Epoxy Resin Systems for Wet Fiber Placement (TopComposite)

November 12, 2025

Jan Janzen
Updates on our Solid Resin Prepreg Research

International Cooperations

- Johannes Kepler University, Linz, Austria
- University of Leoben, Austria
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- Swinburne University of Technology, Melbourne, Australia
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- University of Delaware, Newark, USA
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- DGM Deutsche Gesellschaft für Materialkunde e.V.
- DGZfP Deutsche Gesellschaft für zerstörungsfreie Prüfung e.V.
- DIN - Deutsches Institut für Normung e.V.
- European Alliance for SMC/BMC
- European Structural Integrity Society (ESIS), Technical Committee 4 (TC4) Polymers, Polymer Composites and Adhesives
- FGW Forschungsgemeinschaft Werkzeuge und Werkstoffe e.V.
- Forschungsgesellschaft Kunststoffe e.V. (FGK) – Arbeitskreis Flammschutz
- fimatec fiber materials technology network
- GfT Gesellschaft für Tribologie e.V.
- Health + Innovation Hub
- IASB Industrieausschuss Strukturberechnungsunterlagen
- Kompetenznetz Adaptronik e.V.
- Polymer Processing Society
- RCI – RENEWABLE CARBON INITIATIVE
- SAMPE Europe Society for the Advancement of Material and Process Engineering,
- Science and Innovation Alliance Kaiserslautern e.V.
- Society of Plastics Engineers - SPE
- Unternehmensnetzwerk Erfolgsfaktor Familie
- VDI Verein Deutscher Ingenieure e.V.
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Expert Panels / Reviews

- Advanced Materials Engineering (AME)
- AiF – Arbeitsgemeinschaft industrieller Forschungsvereinigungen
- Alexander von Humboldt-Stiftung
- Arbeitskreise der AVK e.V.
  - » endlosfaserverstärkte Thermoplaste
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- CU West, Vorstand
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- DLR – Deutsches Zentrum für Luft- & Raumfahrt
- DLRK – Deutscher Luft- & Raumfahrtkongress
- DFG Begutachtung für Normalverfahren & koordinierte Programme
- European Society for Composite Materials
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2025