Leibniz
Gemeinschaft

Leibniz-Institut für
Verbundwerkstoffe

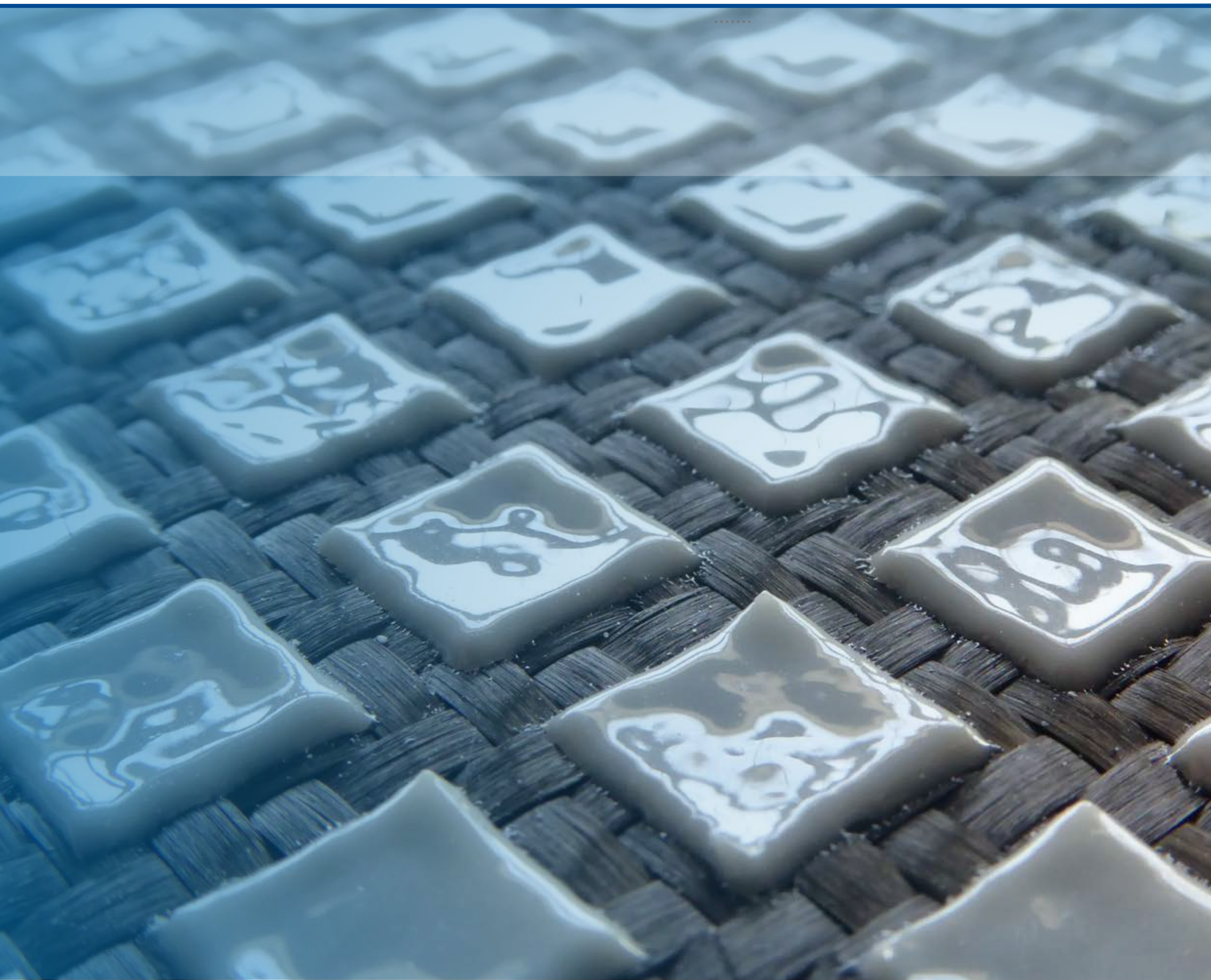


Photo Jan Janzen: Epoxy based Solid-Resin-Prepreg developed in the MarineCare-Project

Annual Report 2022

Imprint
Publisher: Leibniz-Institut für Verbundwerkstoffe GmbH (IVW)
Editors: Ariane McCauley, Silvia Hochstätter
Layout: Silvia Hochstätter
Photos: IVW, unless otherwise noted
Adress: Erwin-Schrödinger-Straße 58
67663 Kaiserslautern Germany
Phone: +49 631 2017-0
www.ivw.uni-kl.de

Leibniz-Institut für Verbundwerkstoffe
at a Glance

2022

Overall budget [m€]	16.8
Project funding [m€]	7.1
Investments [m€]	4.1
Projects	129
Publications in peer-reviewed journals	29
Lectures, laboratories	
Summer term [h]	18
Winter term [h]	28
Doctorates	6
Habilitation	1
Staff	
*Permanent staff**	64
*Scientific staff**	49
Guest scientists	6
Student assistants	37

* 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%).

CONTENT

ANNEX

Dear Readers,

The past year 2022 unfortunately began for us with a sad event. On January 24, our founding father and long-time Managing Director, Prof. Dr.-Ing. Manfred Neitzel, passed away. With his positive attitude and creative energy, but above all with his special talent for motivating the people entrusted to his care, he shaped our organization from the very beginning and laid the foundation for our success. We think back to him with great appreciation and gratitude.

In the spring of 2022, unfortunately, Russia's terrible war of aggression on Ukraine also began, the terrible effects of which we also feel in the research landscape. We were all the more pleased to be able to host Prof. Nataliia Hudzenko and Dr. Maryna Novitska, two outstanding Ukrainian visiting scientists who ideally complement our team.

A very important pillar of our business is technology transfer. We were also successful with spin-offs in 2022: The IVW spin-off Evolime GmbH, which develops and markets innovative spoke wheels made of composite materials, was awarded the "Founder of the Year" prize by the Science and Innovation Alliance. The new spin-off project "isitec composites" convinced the expert jury of the German Federal Ministry of Economics and Climate Action (BMWK) with its business idea of composite tubes for the transport of gaseous hydrogen, thus clearing the way for funding of around € 900,000 over a period of 2 years.

Another pillar of technology transfer and an expression of the creativity of our employees are our patents, a selection of which can be found in this report on page 80. In 2022, we were particularly pleased to receive the "Space Sustainability Award" from the European Space Agency (ESA) for the concept of the "next generation self-cremating satellite" developed by our scientific employee Esha. There were 221 applications for this award.

Our students also developed new ideas: Our "Congenial Composite Carrier" competition was about innovative means of transportation made of fiber composites. Rubber and wind-powered vehicles, radio-controlled electric cars with carbon fiber chassis and sandwich constructions with 3D-printed components with winch drive achieved speeds of over 80 km/h (page 78).

The use of fiber composites for efficient hydrogen technology is the subject of important research projects. For example, we are working on particularly lightweight and functionally integrated storage systems that will be indispensable for tomorrow's means of transportation. Examples of this can be found in the project descriptions in this report (CF Hydro, page 23, TPC-H2-Storage, page 53). We are also upgrading our building to use environmentally friendly energy sources and particularly efficient energy use. We are pleased to have received a grant from the state of Rhineland-Palatinate that will enable us to install photovoltaics and modernize our lighting systems and server infrastructure, among other things.

A highlight of the year was the commissioning of our new large press, which also enables us to investigate and optimize the production of larger fiber composite structures. It is possible to process continuous fiber-reinforced thermoplastics, which we will also expand in 2023 by combining it with injection molding. This completes our capabilities installed in the "Thermoplastic Composites Technology Center (TTC)" for the design, manufacture and characterization of thermoplastic fiber composites.

Visit us and be inspired by this report on the potential of composites!

Yours sincerely

Pascal Sadaune, Ulf Breuer

From Fundamental Research to Application

The Leibniz-Institut für Verbundwerkstoffe (IVW) is a non-profit research institution of the state of Rhineland-Palatinate and University of Kaiserslautern-Landau (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.

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%).

| Health | Mobility | Energy | Climate | Environment | Production Technology |

| Automotive | Aerospace | Mechanical Engineering | Medical Technology | Sports |

IVW Develops Composites for a Wide Variety of Applications

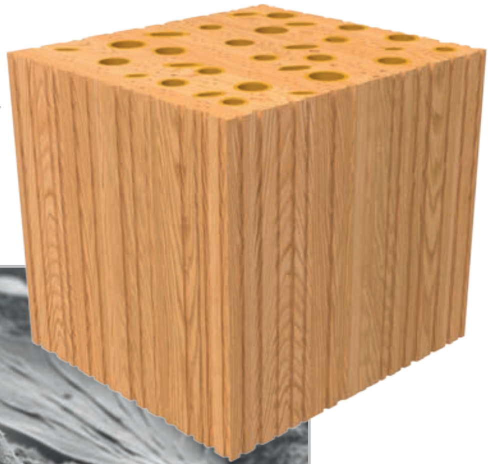
from A to Z

- *Component Control*
- *Component Testing*
- *Design*
- *Development of Semi-Finished Materials*
- *Failure Behavior*
- *Fatigue Analysis*
- *Filament Winding & Simulation*
- *Film Extrusion*
- *Forming Technology & Simulation*
- *Functionalized Matrix Systems*
- *Hybrid Materials & Structures*
- *Hybrid Processes*
- *Hydrogen Storage & Technologies*
- *Impact / Crash Behavior & Simulation*
- *Joining Technology / Welding & Simulation*
- *Material Analytics*
- *Methods of Material & Process Characterization*
- *Multi-Axial Material Testing*
- *Multifunctional Composites & Simulation*
- *Nanocomposites*
- *Non-Destructive Material / Component Testing & Simulation*
- *Press Molding Technology & Simulation*
- *Resin Injection Technology & Simulation*
- *Stress Analysis*
- *Tape and Fiber Placement & Simulation*
- *Textile Preform Technology*
- *Tribology*

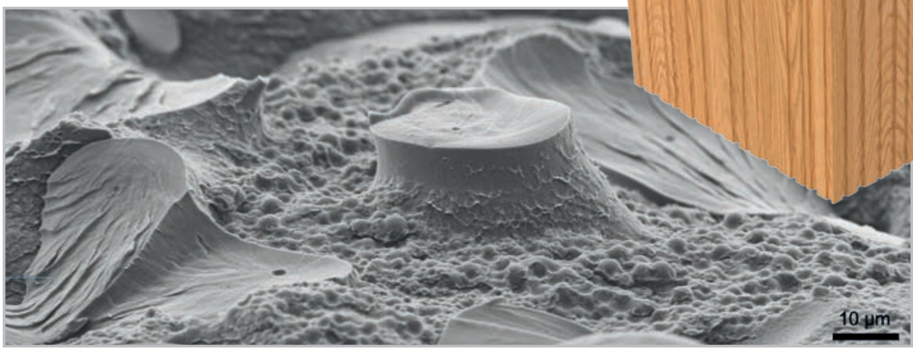
Fields of Competence Overview

Tailored Thermosets & Biomaterials

The competence field Tailored Thermosets & Biomaterials has an interdisciplinary focus on energy, mobility and eco-efficiency. Core element is the development of reactive multifuncional composites in the context of environmentally benign manufacturing processes and tailor-made properties. The focus is on the development of an innovative modular building block system as a bottom-up technology platform, with new materials, preferably from sustainable raw materials, as well as functional fillers and reinforcing materials. Substances with interaction between matrix and particles as well as the use of functional principles from nature are of particular interest. Competencies in physical, chemical and especially fracture mechanics methods are constantly evolving. Focal points are the elucidation of structures and properties on a micro/nano scale as well as the failure behavior (fatigue crack propagation, environmental stress cracking formation). New measurement methods, such as Temperature-Modulated Optical Refractometry (TMOR), are used. Thus, our aim is to develop innovative materials from the fundamental understanding of morphologies, mechanisms and correlating models.



Treated wood



Multifunctional polymer matrix

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?*

Carbon fibers

Typical materials

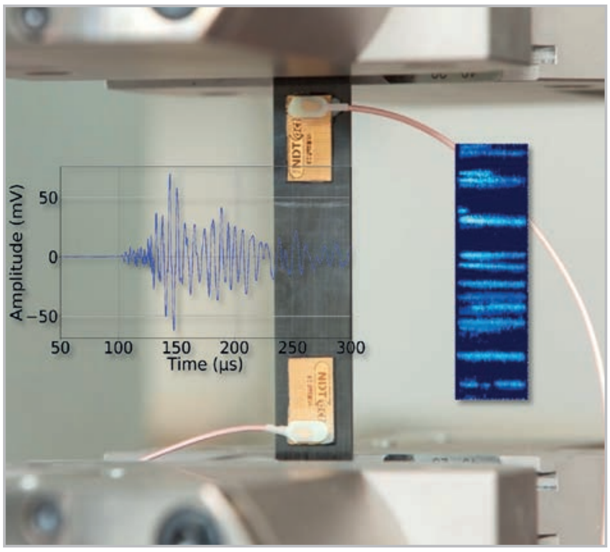
Reactive systems, biobased materials, micro-/nanofillers, wood, fibers

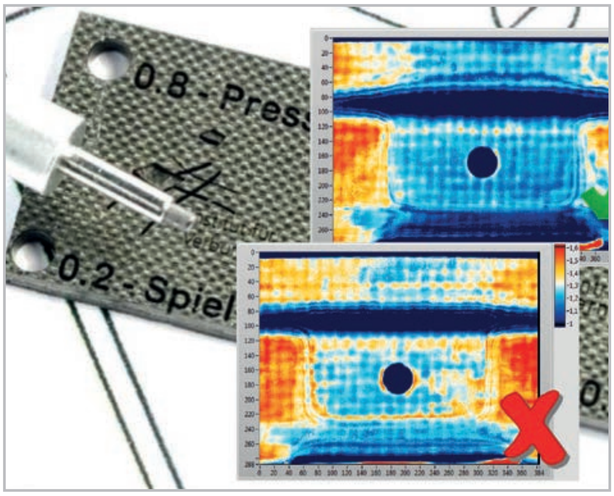
Special expertise:

- *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*

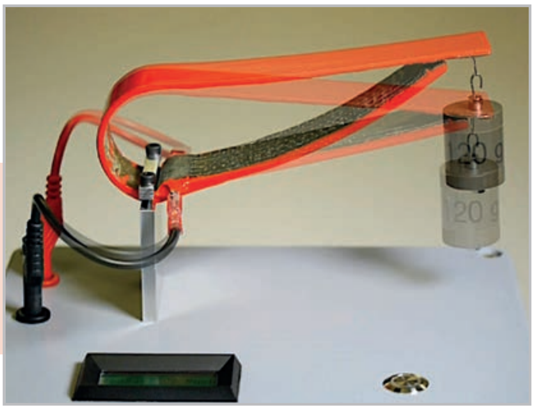
Dr.-Ing. Bernd Wetzel | ✆ +49 631 2017 -119 | bernd.wetzel@ivw.uni-kl.de

Tailored & Smart Composites





From multifunctional material to system – composite materials allow a variety of functional properties 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 master 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 comprehensively characterize both the material properties and the special functions.



Typical materials
Composites
Piezo ceramics
Shape memory alloys

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*

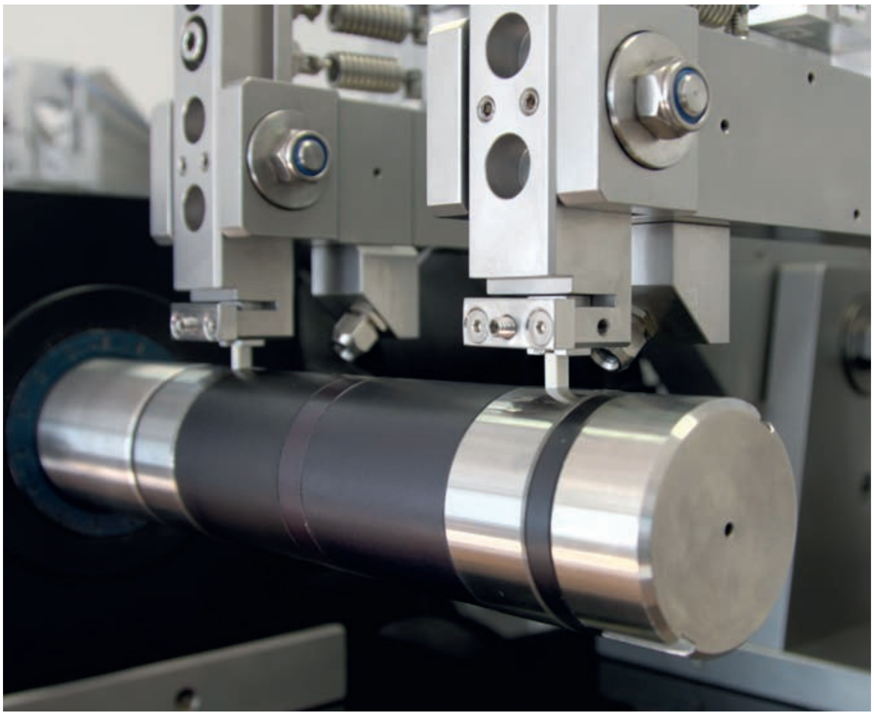
Special expertise:

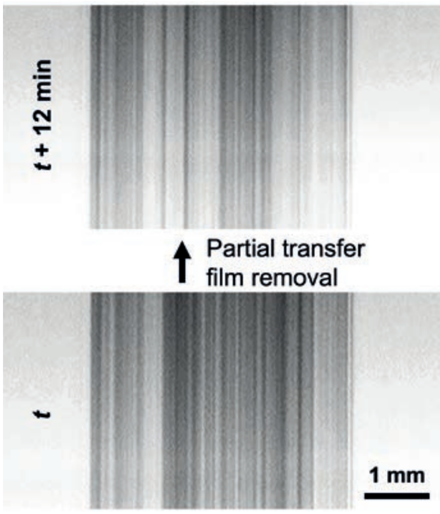
- *"One Stop Shop": design - simulation - realization - testing*
- *Combination of composite know-how with smart materials expertise*
- *Hybrid composites based on various material combinations*

Dr. rer. nat. Martin Gurka | ✆ +49 631 2017 -369 | martin.gurka@ivw.uni-kl.de

Tribology

In the competence field Tribology we develop composite materials, testing technologies and methods adapted to specific applications. Basis is the analysis of the respective technical application and the structuring of the specific task together with our customers. We develop solutions by applying our know-how from fundamental scientific research, the understanding of both friction and wear mechanisms, and the relationships between material structures and properties, thereby deriving new and improved material formulations. We characterize and evaluate composite materials using in-house designed and constructed model and component test rigs equipped with precision sensors, following standard or application adapted testing methods. These high performance composites are typically applied as e.g. slide bearings with high thermal stability, low friction coefficient, and extended service life. They are able to operate under dry, boundary and hydrodynamic lubrication conditions. Tribology's close networking with related competence fields enables IVW to offer research and development of tribologic composites along the entire value-added chain. This includes manufacturing processes, testing technology and methodology, and material analytics from a single source.





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

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?*

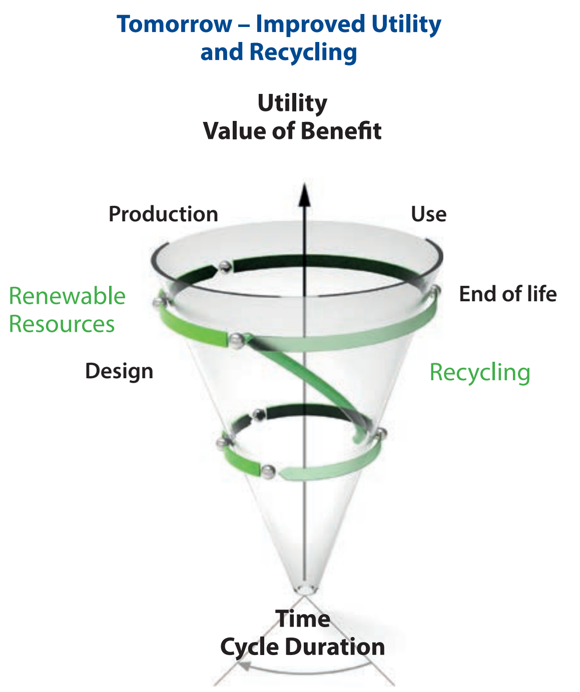
Special expertise:

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

Dipl.-Chem. Andreas Gebhard | ✆ +49 631 2017 -342 | andreas.gebhard@ivw.uni-kl.de

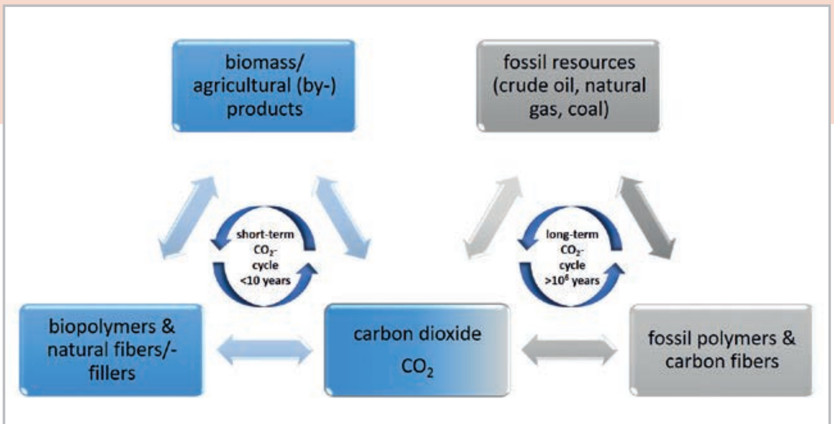
Material Cycles

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.



Schematic representation of improved utilization and recycling to prolong the duration and value of materials' applications

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



Schematic representation of the short- and long-term carbon cycle

Special expertise:

- *Modern testing facilities with coupling options for material properties such as:*
  - *Thermal degradation in controlled environments*
  - *Melting and crystallization behavior as well as curing behavior of polymers*
  - *Thermal expansion and shrinkage*
  - *High resolution structural analysis incl. determination of fiber orientation and void content*
  - *Damage analysis and investigation of impuritie*
  - *Surface energy analysis and wetting behavior*

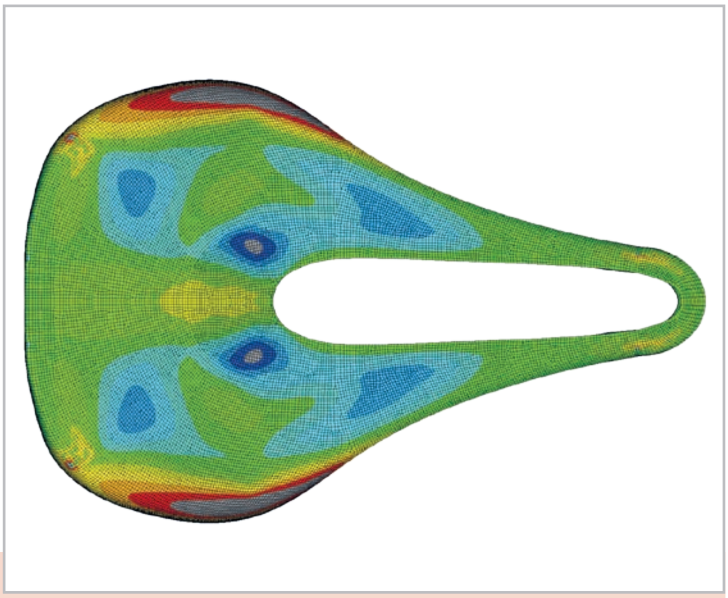
TYPICAL QUESTIONS:

- *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 fibers influence the behavior of composite materials?*

Dr. Barbara Güttler | ✆ +49 631 2017 -462 | barbara.guettler@ivw.uni-kl.de

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 well 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, Isight) 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.



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

Special expertise:

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

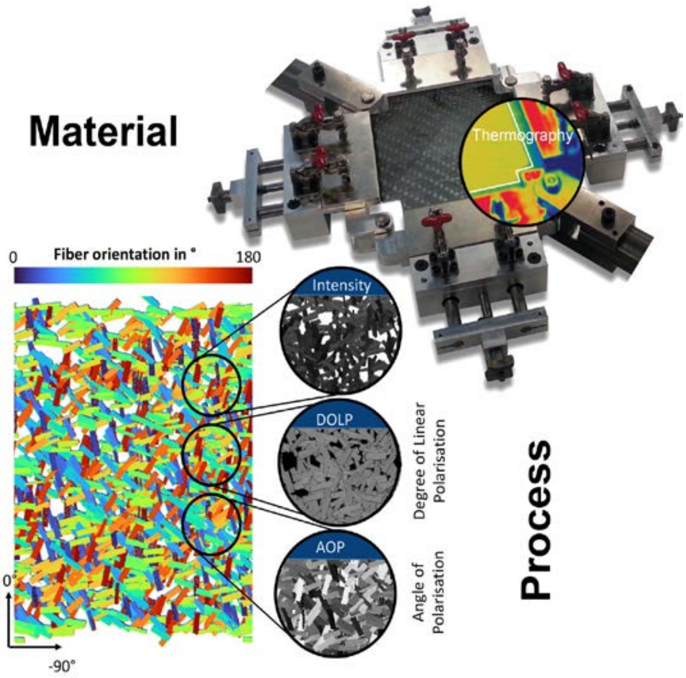
TYPICAL QUESTIONS:

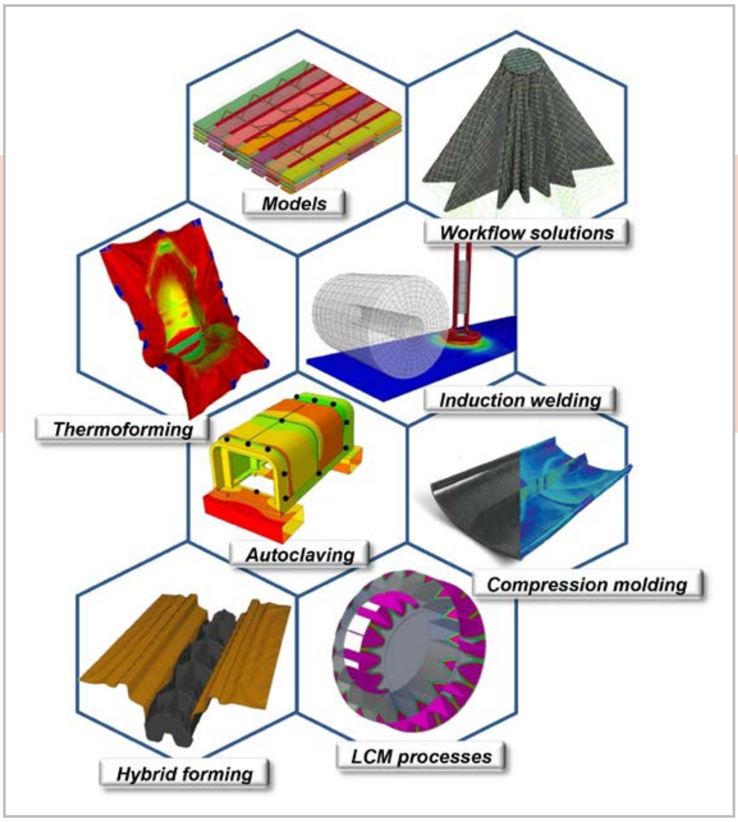
- *Can structural components with good mechanical properties be produced by using recycled fibers?*
- *Is a high level of lightweight design quality achievable even for complex component geometries by cleverly combining continuous fiber-reinforced and short fiber-reinforced areas?*
- *How can lightweight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

Dr.-Ing. Nicole Motsch-Eichmann | ✆ +49 631 2017 -423 | nicole.motsch@ivw.uni-kl.de

Process Simulation

Today, process simulation plays a crucial role in composites manufacturing science. It helps us understand, refine, and optimize the processes we use to make complex composite parts. At IVW, process simulation is focused on four key topics: processing of thermoplastic sheet materials, liquid composite molding, processing of bulk molding and structural molding compounds and the welding of thermoplastic composites by electromagnetic induction. Process simulation begins with material characterization, a procedure of defining and measuring the material's behavior, usually deformation or flow as well as thermal behavior, experienced under the specific conditions during manufacturing. In most cases, temperature, strain-rate, pressure and time are the key parameters. The experiments provide the source of input and form of verification required for computer based simulations which can then be carried out in place of physical experiments using mathematical and engineering software tools, essentially allowing what engineering software providers have termed "virtual manufacturing".





Typical materials

CFRP, GFRP
Continuous and discontinuous
fiber reinforced systems

TYPICAL QUESTIONS:

- *Can material characterization and manufacturing processes be digitalized in order to streamline the connection to numerical simulations?*
- *Which simulation methods can be used to simulate the ply-level induction heating behavior of CF UD-laminates?*
- *How can Model Order Reduction and Machine Learning be used to enhance process simulation?*

Special expertise:

- *Characterization and finite elements based multi-physics simulation of highly complex composites manufacturing processes*

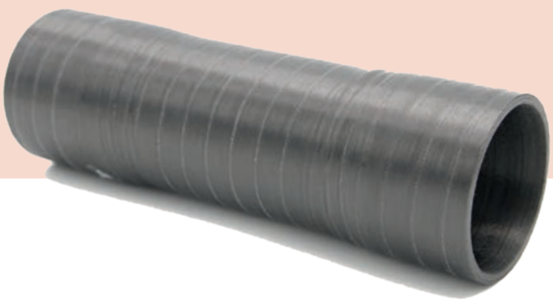
Dr. Miro Duhovic | ✆ +49 631 2017 -363 | miro.duhovic@ivw.uni-kl.de

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*
- *Modern 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*
  - *3D-ultra-high-speed pictures up to 1 million Hz frames per second*
  - *3D-ultra-high-resolution pictures up to 40 MPix*

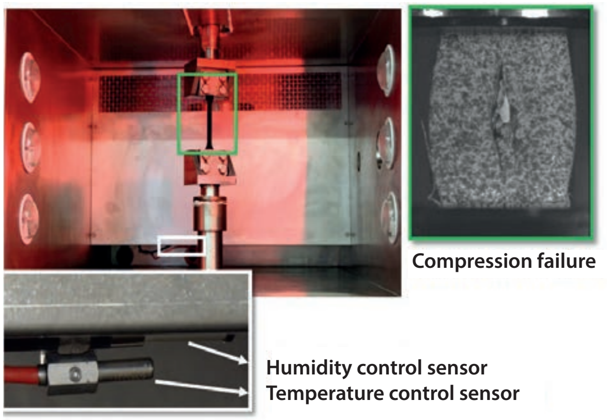
TYPICAL QUESTIONS:

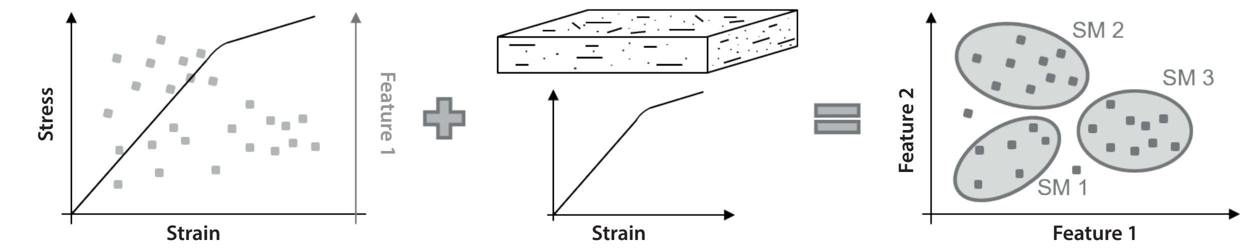
- *Will you support us in creating FE-parameter sets for FE-simulations or with validating simulation results?*
- *Are you able to test materials and structures also under the influence of temperature and varying test velocities?*
- *How can structures made of FRP absorb energy effectively and show a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

Dr.-Ing. Sebastian Schmeer | ✆ +49 631 2017 -322 | sebastian.schmeer@ivw.uni-kl.de

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.





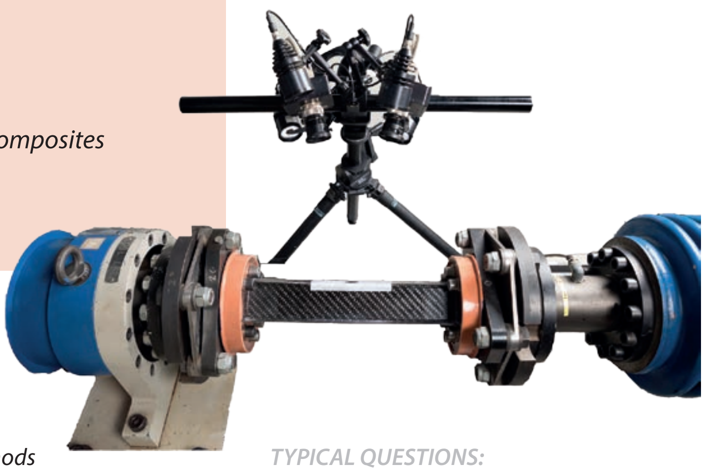
Typical materials

GFRP

CFRP

Continuously and discontinuously reinforced polymer composites

Thermoplastic and thermoset matrix systems



Special expertise:

- *Fatigue life 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*

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?*

Prof. Dr.-Ing. Joachim Hausmann | ✆ +49 (0)631 2017 -301 | joachim.hausmann@ivw.uni-kl.de

Press- & Joining Technologies

This field of competence focuses on the development of new materials and processing technologies for so-called organo sheets, discontinuously and continuously reinforced based on staple fiber yarns (CF, rCF, GF, NF), with standard or modified thermoplastics. Novel and innovative forming technologies as well as concepts for more energy efficient processes for component manufacturing are being further developed. A key area in compression molding of SMC, LFT and GMT is the use of renewable or recycled raw materials and process development for composites using conventional or bio-based polymers. Another focus involves combining processes in connection with pressing processes and customized highly efficient joining technologies to develop special processes for the welding of thermoplastic FRPC and metal-FRPC hybrid materials.

Typical materials

Fiber reinforcement GF, CF, rCF, NF, AF in form of textiles or cut fibers
Combinations of continuously and discontinuously reinforced systems
PP, PA, PPS, PEI, PEEK, PU, EP, UP, biopolymers, vitrimers, etc.

Special expertise:

- *Combination of continuous fiber / discontinuous fiber reinforcement*
- *Development of special profile shapes, open and closed, in CCM technology*
- *Biocomposites*
- *Industrial scale equipment:*
  - *- SMC production line*
  - *- Continuous compression molding press*
  - *- Several parallel controlled presses with up to 2,500 t press force, a table size of 2 m x 3 m, IR field and integrated injection molding unit for compression molding, thermoforming and new hybrid processes*
  - *- Plastification unit and convection oven*
  - *- Welding robot*
  - *- Different test rigs for induction welding*
- *In-line and off-line process solutions*
- *Digital mapping of process chains*

TYPICAL QUESTIONS:

- *Is it possible to predict the properties of composites made from renewable raw materials?*
- *How can composites contribute to electro mobility?*
- *Can vitrimers replace thermoplastics?*

Prof. Dr.-Ing. Peter Mitschang | ✆ +49 631 2017 -103 | peter.mitschang@ivw.uni-kl.de

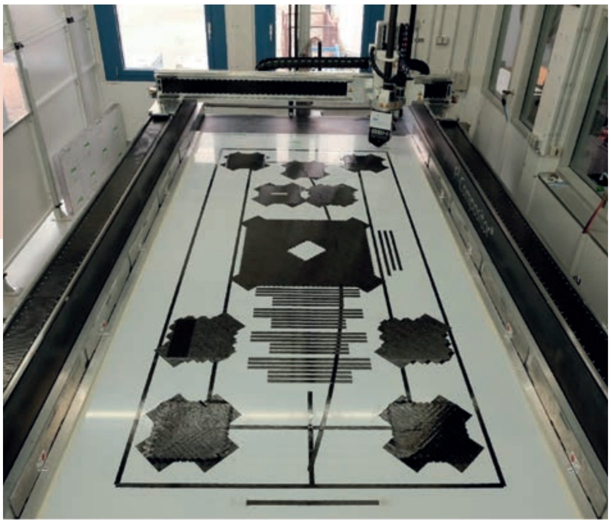
Roving & Tape Processing

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 as well as hybrid injection molding 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) and injection molding technology with continuous filaments in load direction.

Tie-bar-less injection molding machine with automation cell

Typical materials

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



Ultra-fast multiaxial tape laying machine

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?*
- *In which areas can hybrid injection molding be used particularly economically?*

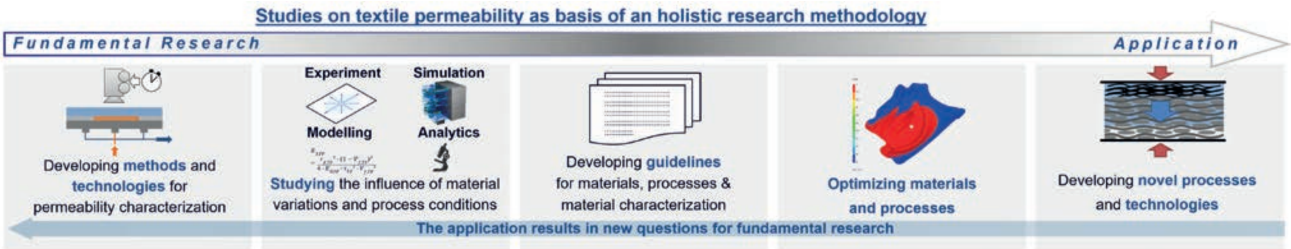
Special expertise:

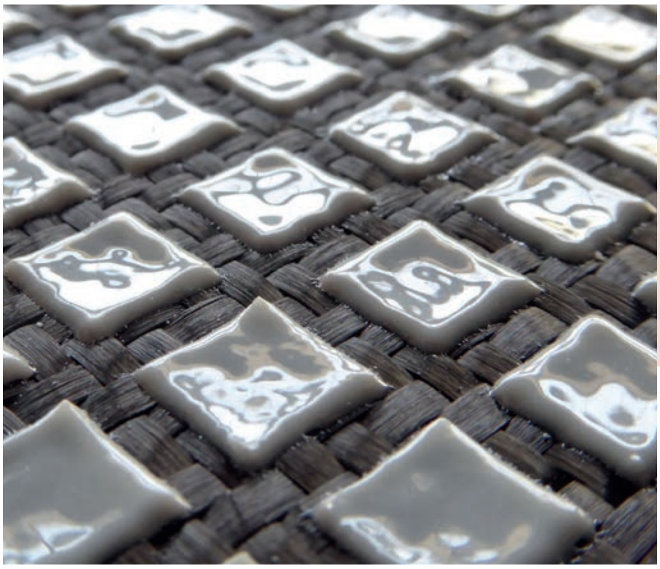
- *Industrial scale equipment:*
  - *- Ultra high speed tape laying gantry system (3.5m x 1.5m layup area, up to 4 m/s layup speed)*
  - *- Industrial robot with tape laying head (Innovation Award) and external rotation axis (robot winding)*
  - *- 7-axis winding machine for conventional wet winding, thermoplastic winding and towpreg winding*
  - *- Ring winding head with 48 rovings for increased throughput (JEC Innovation Award)*
  - *- Siphon impregnation technology*
  - *- Tie-bar-less injection molding machine with automation cell*
- *Development of procedures specifically for large quantities*
- *Special tape-laying developments (TP tapes, TS tapes, binder tapes, towpregs)*
- *Autoclave with inert gas environment (up to30bar)*
- *3D-printers also with endless fiber reinforcement*

Dr.-Ing. Jens Schlimbach | ✆ +49 631 2017 -312 | jens.schlimbach@ivw.uni-kl.de

Impregnation & Preform Technologies

The focus of this field of competence is on Preform-LCM process chains. In these process chains, near-net shape preforms are first produced from rovings or textiles. The preforms are then impregnated in a liquid composite molding (LCM) process, using a low-viscosity (usually thermoset) matrix polymer by overpressure and / or vacuum. The scientific basis of the field of competence is basic research on the effects of structural material variations and varying process conditions on the processing behavior of materials during preforming (e.g. draping behavior) and impregnation (e.g. permeability). Experimental studies on self-developed measuring systems are synergetically combined with acquired process data and in-house developed simulation methods, in order to achieve a deeper understanding of processes and materials. On this basis, new and further development of Preform-LCM technologies - including materials, tools and equipment - is carried out.





Close-up of a novel prepreg type based on solid resin

Typical materials

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

TYPICAL QUESTIONS:

- *What textile deformations occur during high-pressure injection (> 100 bar)?*
- *How can powder resins be used to increase process robustness?*
- *How can resin flow through fiber structures be realistically represented in simulation models?*

Special expertise:

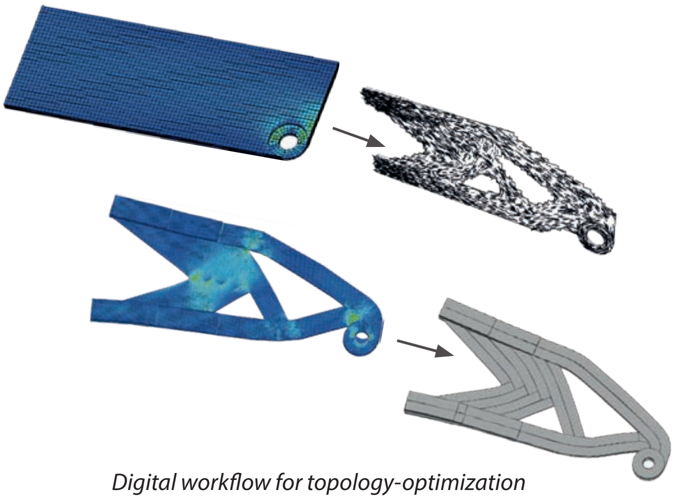
- *Patented permeability measurement systems*
- *GeoDict® – Software for material simulation*
- *Sewing machines and sewing automats*
- *RTM injection systems for thermosets and reactive thermoplastics (e.g. ε-Caprolactam)*
- *Technology carrier tool with extensive sensor equiment*
- *Delevoment of production concepts*

PD Dr.-Ing. habil. David May | ✆ +49 631 2017 -400 | david.may@ivw.uni-kl.de

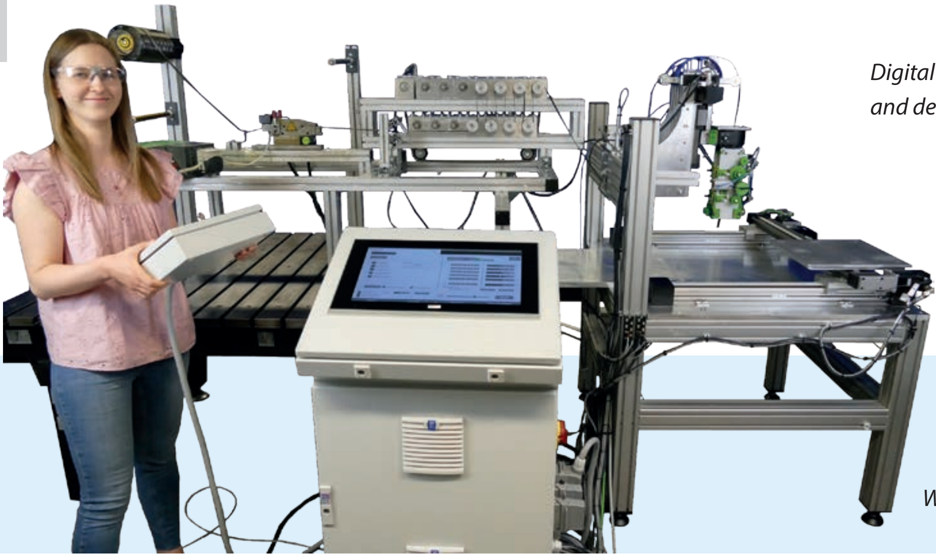
TopComposite – Topology-Optimized and Ressource-Efficient Composites

David May

The aim of this group is to realize a novel additive manufacturing process for thermoset-based fiber-reinforced polymers, namely the wet fiber placement. This process allows the continuous conveying and deposition of in situ impregnated fiber bundles. In addition to the process engineering challenges, the interdisciplinary group is also addressing the question of how the lightweight potential of the new process can be fully exploited through an efficient design strategy. The goal is a continuous workflow from the design problem all the way to the machine-readable deposition plan, whereby the specific restrictions of the process (e.g. the defined bundle cross-section) are to be directly integrated into a topology optimization. In parallel, resin systems will be modified to meet the requirements of the process as well as the final mobility and transportation applications. The group is funded by the German Federal Ministry of Education and Research (BMBF) for a period of five years after David May prevailed in the "NanoMatFutur" competition for young scientists. An academic-industrial advisory board supports the group.



Digital workflow for topology-optimization and deposition path generation



Wet fiber placement system

Advisory board of the junior research group

SPONSORED BY THE
Federal Ministry of Education and Research

The junior research group "TopComposite – Topology-Optimized and Ressource-Efficient Composites for Mobility and Transport" is funded by the Federal Ministry of Education and Research (BMBF) on the basis of a decision by the German Bundestag (funding reference 03XP0259).

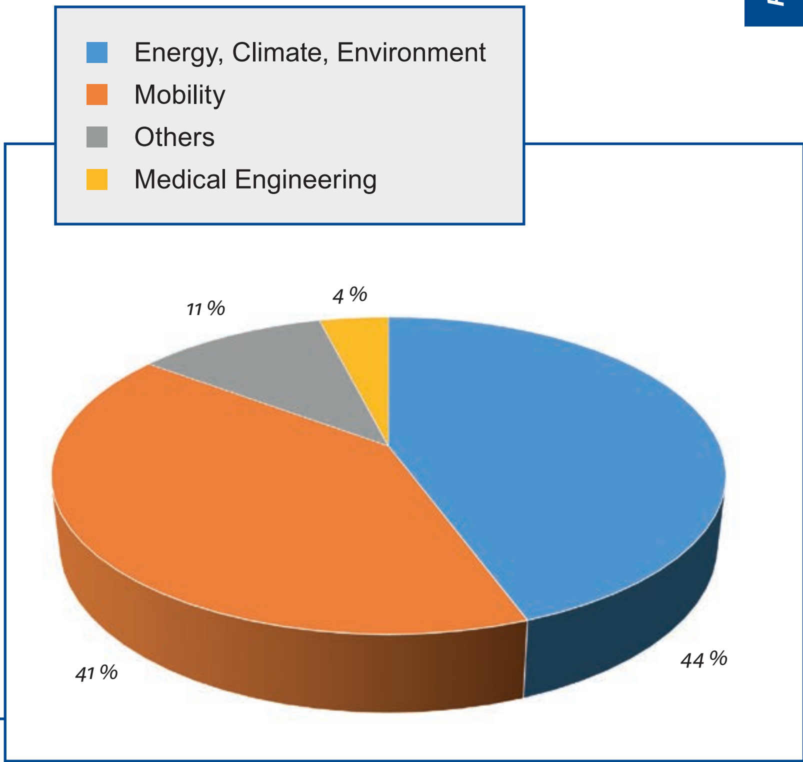
Projects

In 2022, a total of 129 projects were processed.
53 projects were funded by public funding agencies such as

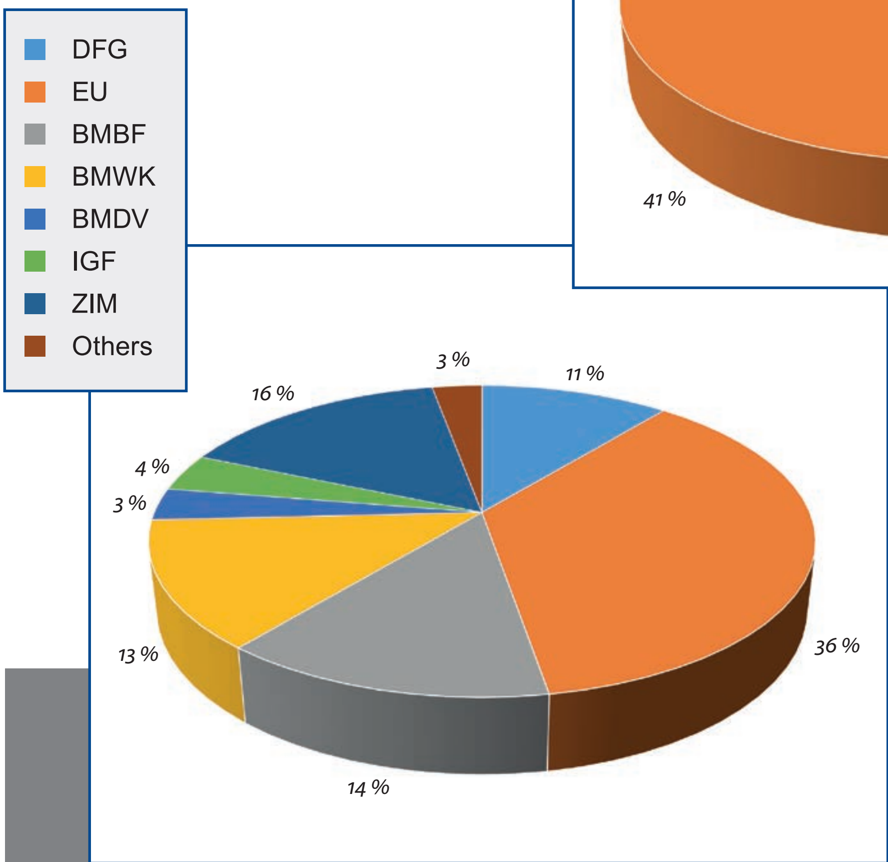
- *the German Research Foundation (DFG)*
- *the European Union (EU)*
- *the Federal Ministry of Education and Research (BMBF)*
- *the Federal Ministry for Economic Affairs and Climate Action (BMWK)*
- *the Federal Ministry of Digital Affairs and Transport (BMDV)*
- *the Industrial Cooperative Research (IGF)*
- *the Central Innovation Programme for SME´s (ZIM)*

and others.

76 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.



Industrial revenue 2022 by sector



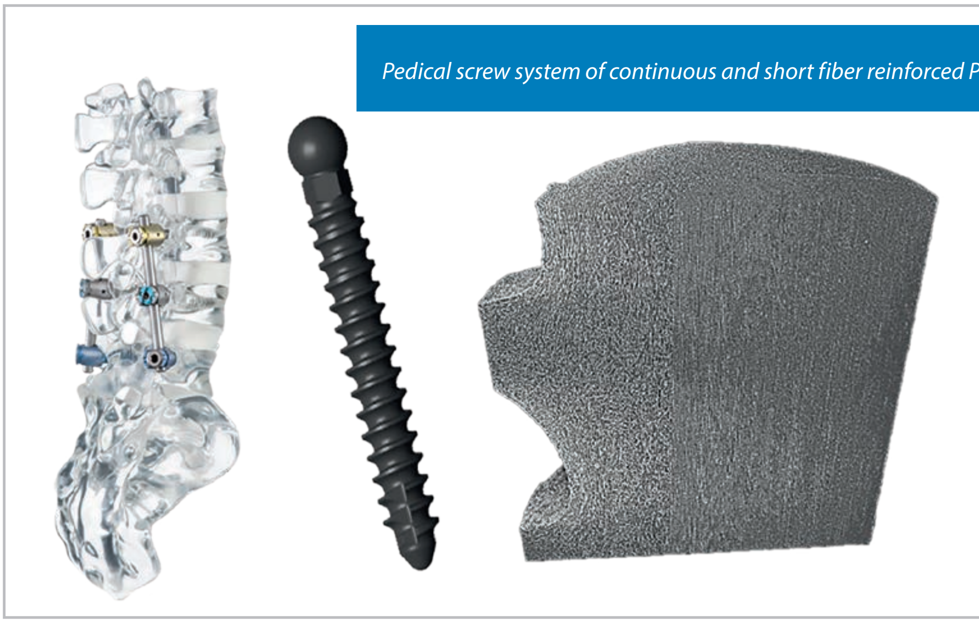
Revenues 2022 from public funded projects by funding authority

nicole.motsch@ivw.uni-kl.de janna.krummenacker@ivw.uni-kl.de

Activities in the Medical Sector

Janna
Krummenacker

Nicole
Motsch-Eichmann



Pedical screw system of continuous and short fiber reinforced PEEK systems

The demand for solutions made of fiber-reinforced plastics in the medical sector is constantly increasing. In recent years, IVW has developed promising products in this area, both in the field of implant technology and in the field of therapeutic devices. For example, within the framework of an EU-funded project, a pedicle screw system made of fiber-reinforced plastic was developed to increase patient comfort and improve post-operative follow-up care („HySpine"). The development of an aneurysm clip takes advantage of the radiolucency of fiber-reinforced plastic, so that the position of the implant can be checked using imaging techniques („InnoClip"). In the "FIXTER" project, a low-cost, easy-to-use closure system was developed for fixing the two halves of the sternum after a median sternotomy. In the orthopedic technology sector, a method was developed to produce individualized ankle orthoses using 3D printing processes and then subsequently reinforcing with thermoplastic fiber tapes („3Dprint2Fiber").

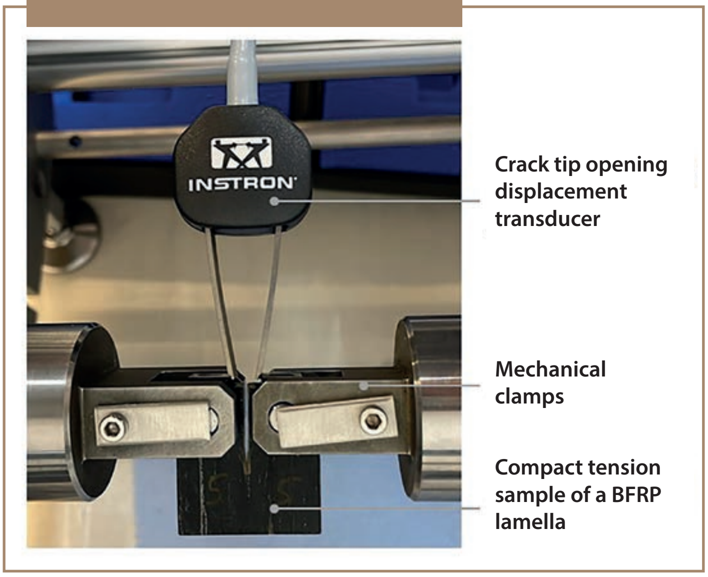
IVW networks with partners from the region to further expand its competencies in the healthcare sector. For example, there is a close cooperation with the Chair of Innovative Implant Development at Saarland University to develop novel implants using the properties of fiber-reinforced plastics. Within the network "Science and Innovation Alliance Kaiserslautern", a promising exchange with the chair "Motion and Exercise Science" of the TU Kaiserslautern has been established. IVW has also expanded its activities in Composites United e.V. by founding a working group on the use of composite materials in orthopedic technology and organizing an innovation day on this topic.

Visit of State Secretary Petra Dick-Walther
at the fair "9th medtech Rhineland-Palatinate"

BFKcraft – Durability of Composites in a Chemically Aggressive Environment

Basalt fiber reinforced composites (BFRP) represent an economical and ecological alternative to the established glass fiber reinforced composites. Due to lower energy consumption during production, high chemical resistance, and complete recyclability, basalt fibers enable the development of sustainable and cost-effective high-performance polymer composites. In the BFKcraft project, this class of materials is used as a component in building renovation. For example, BFRP-based lamellae can be attached to ceilings to increase their load-bearing capacity. Current research activities are focused on investigating the resistance and durability of BFRP lamellae to caustic media (pH>13), which are necessary in interaction with concrete structures. Based on a systematic development and modification of the resin system, the adaptation of the sizing of the basalt fibers to the resin system, and the necessary modification of the processing technique, fracture mechanics fatigue crack propagation tests in media have now been successfully used to characterize and better understand the resistance of such materials to alkaline media.

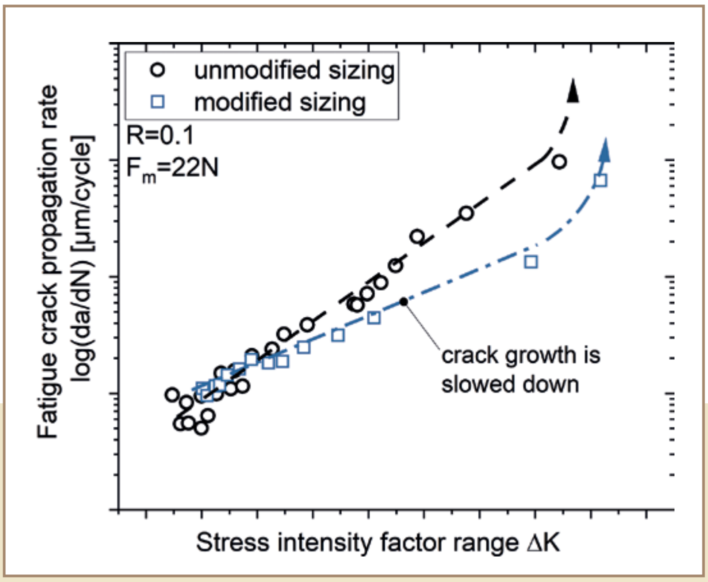
Fatigue crack propagation of a basalt fiber reinforced polymer lamella; a crack tip opening displacement (CTOD) transducer is used to assess the crack propagation



Andreas Klingler

Emmanuel Akpan

emmanuel.akpan@ivw.uni-kl.de andreas.klingler@ivw.uni-kl.de



Influence of the sizing on the fatigue crack propagation of a basalt fiber reinforced polymer lamella

Partners:

CG TEC GmbH

DBF – Deutsche Basalt Faser GmbH

H&W Hoffmann & Weber Unternehmensberatung

S&P Clever Reinforcement GmbH

Fachgebiet Massivbau und Baukonstruktion, Prof. Pahn, Technische Universität Kaiserslautern

The project "BFKcraft – Development of a Basalt Fiber Reinforced Composite Structure as Concrete Paving for Static Building Renovation" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 03ET1653D).

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Partner

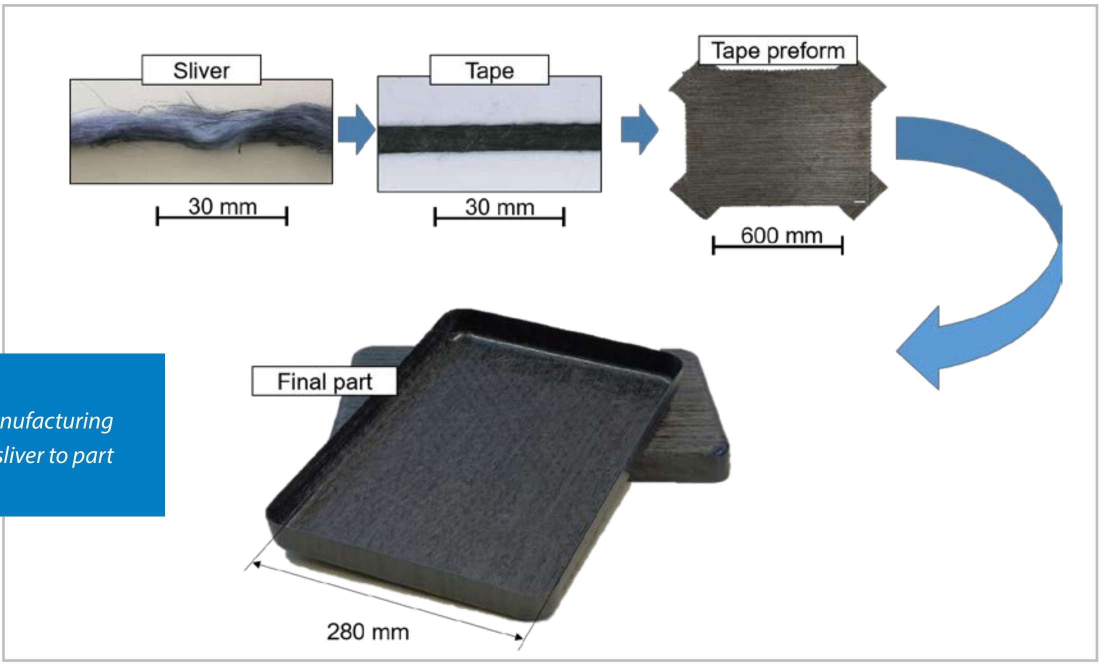
jens.schlimbach@ivw.uni-kl.de

CarboSteer – Effective Recycling of Carbon Fibers

Jens Schlimbach

In the cooperative research project "CarboSteer – Effective Recycling of Carbon Fibers", a process chain was developed together with the special machine manufacturer Automation Steeg & Hoffmeyer GmbH. The aim was to bring recycled carbon fibers, highly orientated through stretching, into the production of high performance CFRP parts. The starting material is a CF/PA6 sliver with a defined fiber weight content of recycled staple fibers and polymer fibers. The process chain comprises the three major steps: tape production, manufacturing of a tape preform and thermoforming. All involved processes are characterized by full automation capability and isothermal temperature control of the tools, resulting in short cycle times and low manufacturing costs. Both the stretching of the sliver during tape production and the variable-direction placement of the tapes by automated tape-laying process ensure that long fibers are load-path oriented in the final part. In this manner, high mechanical properties are achieved in combination with optimized material application.

In contrast to continuous fibers, staple fibers offer quasi-plastic deformation behavior, which allows to displace the neutral fiber, resulting in reduction of residual stresses in complex layup paths such as curvatures during manufacturing the tape preforms. The production of demonstrator components by means of thermoforming demonstrated the feasibility of the process chain on component level.



Demonstrator manufacturing from sliver to part

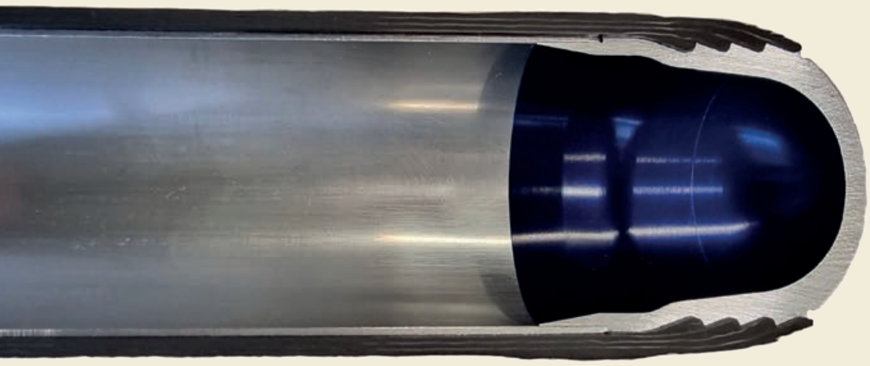
The aim of the research project was the effective recycling of carbon fibers in the tape-laying/thermoforming process chain. Therefore, an end effector was developed for the automated deposition of recycled staple fiber tapes.

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

ZIM Zentrales Innovationsprogramm Mittelstand

The project "CarboSteer – Development of a Laying Head for Staple Fiber Semi-Finished Products with Thermoplastic Matrix; Development of rCF Staple Fiber Tapes for Further Processing in the Tape Laying Process" was funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference ZF4052334).

CF-Hydro – FRP-Based Hydrogen Transportation and Storage



Cross section of demonstrator of the IVW load introduction for integration of the dome in the hydrogen pressure vessel

Nithya Sindhe

Ulrich Blass

nithya.sindhe@ivw.uni-kl.de

ulrich.blass@ivw.uni-kl.de

The aim of the CF-Hydro research project is to develop lightweight construction methods and processes for manufacturing FRP piping for hydrogen distribution in aircrafts, including investigation whether the construction methods and processes are also suitable for manufacturing a cylindrical/tubular hydrogen storage system. In each case, a system for the trans-critical (cryo compressed) and for the liquid distribution / storage of hydrogen will be targeted. In order to be able to keep the hydrogen at the necessary temperature of well below –200°C in both types of storage, the tank and the pipeline consist of a double-wall construction made of FRP. The inner pressure cylinder is used to store the hydrogen and absorbs the internal pressure. The outer shell of the double-wall system provides the thermal insulation and the connection to the surrounding systems. The pressure cylinder and outer shell are mechanically decoupled. As a result, the tank/pipeline can be designed as structurally load-bearing components and thus substitute existing components for stiffening in the future. The basis of the work in the CF-Hydro project is the patented design of a novel lightweight hydrogen pressure tank developed at IVW. In this design the load is transferred layer by layer from the axial fiber layers of the cylindrical area of the pressure vessel into the dome. In this way, the metallic dome areas are integrated in a load optimized manner. In addition to the development of the design of the tank and the piping, the development of the manufacturing process is also planned. A decisive feature of the envisioned process is the possibility to produce cylindrical CFRP components with an almost freely selectable diameter for an optimum use of the available space in the aircraft. The fiber orientations are in the axial and tangential directions, which means that one production line can be used for both the tank and the pipeline.

The project "Development of an Integrated FRP-Based Hydrogen Storage and Distribution System for Aerospace Applications – CF-Hydro" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 20E2103).

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

andreas.baumann@ivw.uni-kl.de

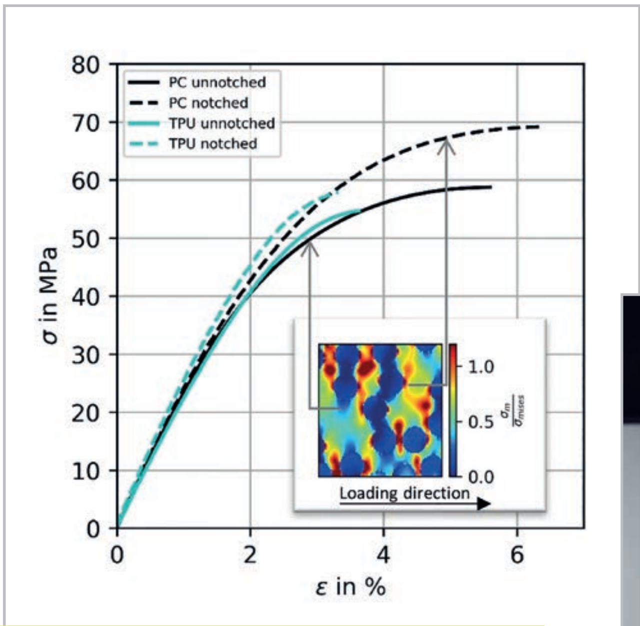
Correlation of Matrix Properties to the Fatigue Behavior of Fiber Reinforced Polymers

Andreas Baumann

Continuous fiber reinforced materials are a class of materials with exceptionally good fatigue properties, due to the durability of the fibers under cyclic loading. However, the polymer and the fiber-matrix interface are basic prerequisites to utilize these properties in a composite. Especially the matrix plays an important role regarding the initiation of damage. The initiation can be, for example, a small crack or an increased fiber misalignment under compressive loading. Although these damage mechanisms are typically at the micro-scale, it is well established that this initial damage grows and threatens laminate integrity at the macro-scale.

Despite this knowledge and the realization that the matrix polymer is important to the fatigue resistance of the laminate, engineers and material developers can only rely on guesswork to find the right properties for the matrix polymer. To establish a correlation between the matrix properties and the laminate's fatigue behavior, this project uses high-energy radiation to modify the matrix polymer. This type of modification allows to change the properties of the matrix without major geometrical changes, size changes and other factors, as it is the last step of sample preparation. A two-stage approach is used. The first stage is used to identify the right polymer and dosage; the second stage then investigates the most promising doses and polymers both as neat matrix material and as laminate in order to find the correlation with the laminates fatigue properties. The gradual change in polymer properties helps to identify how sensitive the laminate is to certain polymer properties under fatigue loading.

The project's goal is a basic and systematic understanding of dependencies between the mechanical matrix properties and the fatigue behavior of fiber-reinforced composites on a micromechanical level.



Triaxial stress state between the fibers and its effect on the polymer's stress-strain response (PC Polycarbonate, TPU thermoplastic Polyurethane)

Approximated stress state in-between fibers by the use of a notched round specimen of neat polymer

Deutsche Forschungsgemeinschaft

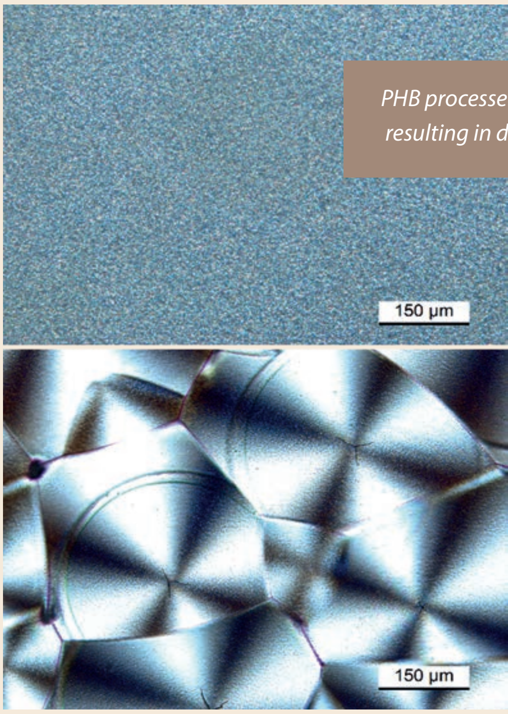
The project "Correlation of Matrix Properties to the Fatigue Behavior of Fiber Reinforced Polymers" is funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 468045930.

Crystallization in Biocomposites

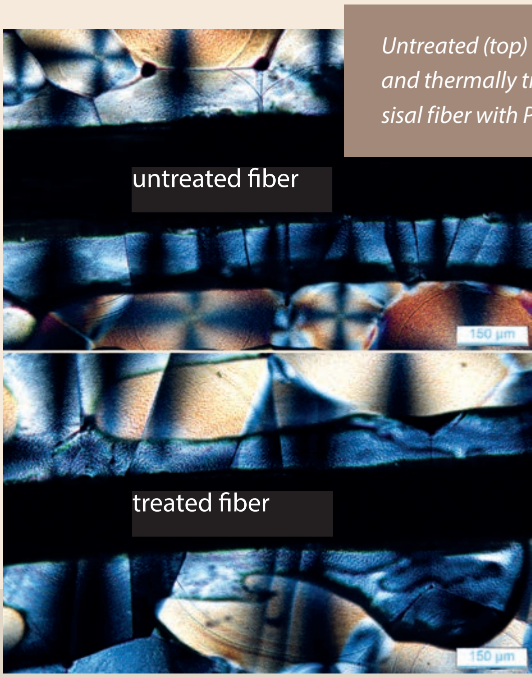
Thermoplastic polymers can be classified as amorphous or semi-crystalline regarding their ability to orientate the polymeric chains and create spherulites. This ability depends on the chemistry of the monomers and their linkage with each other. Furthermore, nucleating agents can induce the growth of spherulites and, depending on their concentration, control their sizes. Since the physical properties are directly related to the amount and morphology of the crystals, it is key to understand and target the crystal structure. In composite materials, the fiber surface can also act as crystallization initiator and thus influence the performance in thermoplastic composite materials. Especially when working with new types of biopolymers, it is still necessary to study how fiber surfaces as well as fiber/matrix interphase can be modified to improve the overall performance of biocomposite materials. In current studies on thermoplastic biopolymers, the crystallization behavior of the neat polymer under different conditions was studied to investigate the influence on the spherulite size. In combination with natural fibers, the crystallization between the fiber surface and the polymer was investigated before and after thermal treatment of the natural fibers. The surface energies of the fibers as well as the surface tension of the molten polymer play an important role in the wetting behavior and subsequently in the creation of chemical bond within the fiber/matrix interphase. Other routes to modify this interphase are chemical treatments or physical treatments such as plasma coatings. In addition to the development of the design of the tank and piping, the development of the manufacturing process is also planned. A decisive feature of the envisioned process is the possibility to produce cylindrical CFRP components with an almost freely selectable diameter for an optimum use of the available space in the aircraft. The fiber orientations are in the axial and tangential directions, which means that one production line can be used for both the tank and the pipeline.

Barbara Güttler

barbara.guettler@ivw.uni-kl.de



PHB processed at different conditions resulting in different spherulite sizes



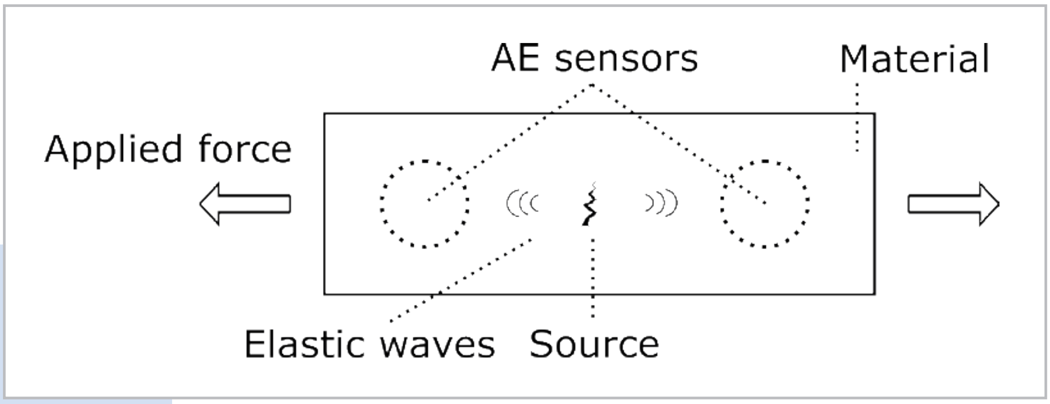
Untreated (top) and thermally treated (bottom) sisal fiber with PHB matrix

janna.krummenacker@ivw.uni-kl.de

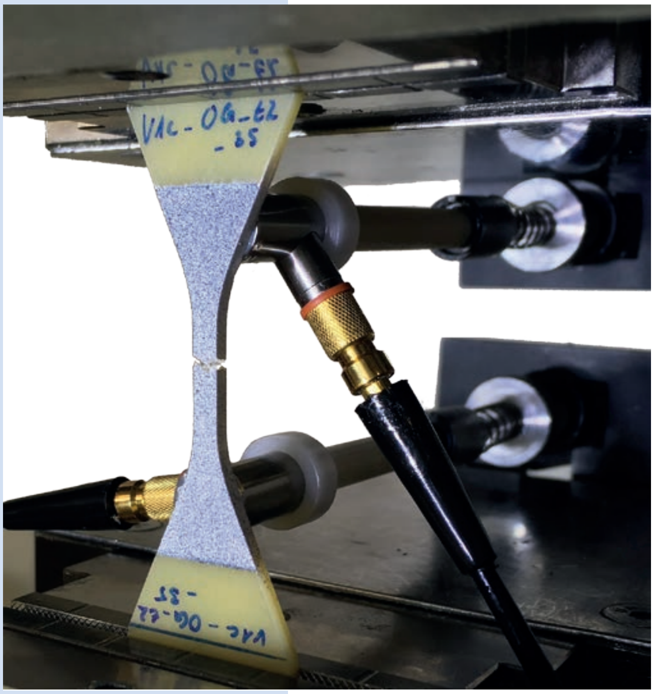
Damage of Short-Fiber Reinforced Thermoplastics under Fatigue Loading

Janna Krummenacker

The transportation industry is increasingly focusing on weight-optimized solutions in order to meet the requirements for a reduction in CO_2 emissions. The substitution of metallic components with composite materials can be an answer to this. In the automotive sector, the process cycle times of these vehicle components must be short in order to be available in sufficiently large quantities. For this reason, short-fiber-reinforced thermoplastics are increasingly being used here, which are characterized in particular by their cost-effective processing by injection molding. The present project investigates the fatigue behavior of short glass fiber-reinforced polyamide 66 in the range of very high numbers of load cycles and studies the question of whether an endurance limit exists. In this context, a new method is developed to detect the occurrence of micro-damage under different fatigue loading using acoustic emission analysis. In addition, the deformation and stress data collected under cyclic fatigue loading are analyzed using data mining to obtain information on the different fatigue life regimes low cycle, high cycle and very high cycle fatigue. In a third part of the work, a digital twin is generated to investigate the micromechanical mechanisms at the experimentally identified characteristic stress levels.



General procedure of acoustic emission analysis



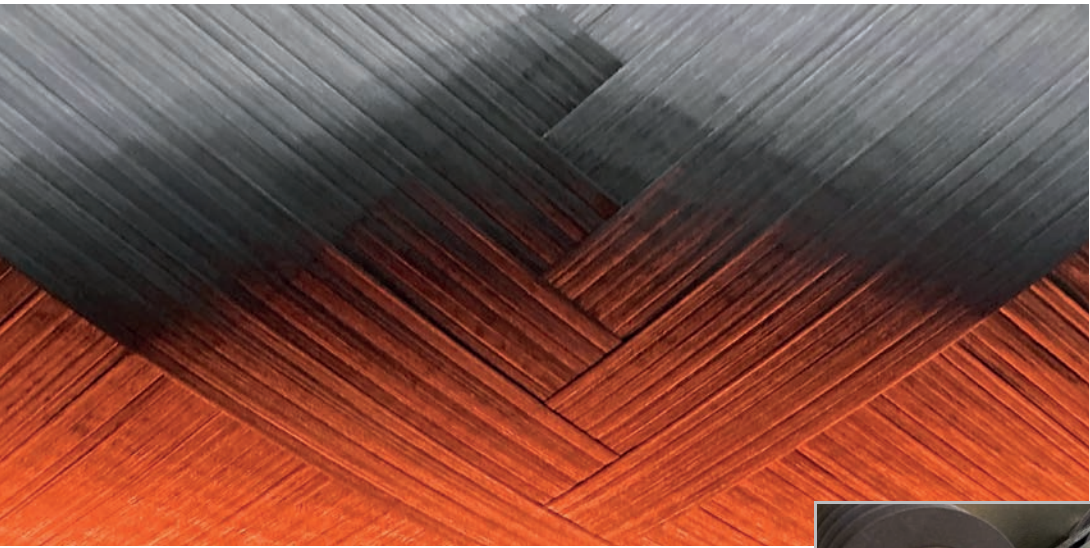
Test set-up for quasi-static tensile tests with sensors for acoustic emission testing

The aim of the project is to develop a methodology that allows the estimation of fatigue strength in the range of high numbers of load cycles based on as few and time-efficient tests as possible.

DFG
Deutsche Forschungsgemeinschaft

The project "Systematic Identification of Damage Mechanisms of Short Fibre Reinforced Thermoplastics under Fatigue Loading and Development of a Method for Time Efficient Determination of the High Cycle Fatigue Strength" is funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 398483802.

Development of Efficient H2 Pressure Vessels and their Industrialization



Benedikt Bergmann

benedikt.bergmann@ivw.uni-kl.de

Pressure Vessel-Towpreg-Laminte heated by infrared radiation

Mobility concepts with locally emission-free powertrain systems are one of the main drivers in the automotive industry. In mobile applications, the use of hydrogen as an energy carrier is seen as a promising alternative to the available battery-electric vehicles. The pressurized tank is a key element in this context, enabling a sufficient quantity of hydrogen to be made available in vehicles for long ranges. The necessary operating pressure of 700 bar and the lightweight construction requirements placed on mobile applications make the use of carbon fiber-reinforced plastics unavoidable. In the research project "MaTaInH2 - Material-efficient and cycle-time-optimized industrialization of H2 pressure vessels", a competitive alternative to the state of the art is to be realized by using Towpregs. As part of the project, a Type-IV hydrogen pressure tank will be developed from scratch, manufactured using a winding process and validated. By dividing the subsequent process chain into its sub-processes, these can be individually and independently optimized. IVW characterizes reference materials as well as the Towpreg newly developed by TUM. For this purpose, IVW created a material card that summarizes all relevant mechanical and process-sensitive characteristic values. In order to meet the requirements of a near-series winding process, the existing winding system at IVW was further developed for the use of Towpreg semi-finished products. The knowledge gained from the manufacture of prototype pressure tanks from Towpregs is being used to specify an optimized winding system on an industrial scale. The pressure tanks were successfully tested for their burst pressure in a first validation step. Currently, cyclic endurance tests according to the UN ECE R134 standard are being carried out. Finally, an overall analysis will be performed.

Modified winding head for Towpreg winding

Within the project "MaTaInH2", funded by BMDV, the project partners Mahle, TUM and IVW are pursuing the goal to industrialize high volume production at reduced product costs.

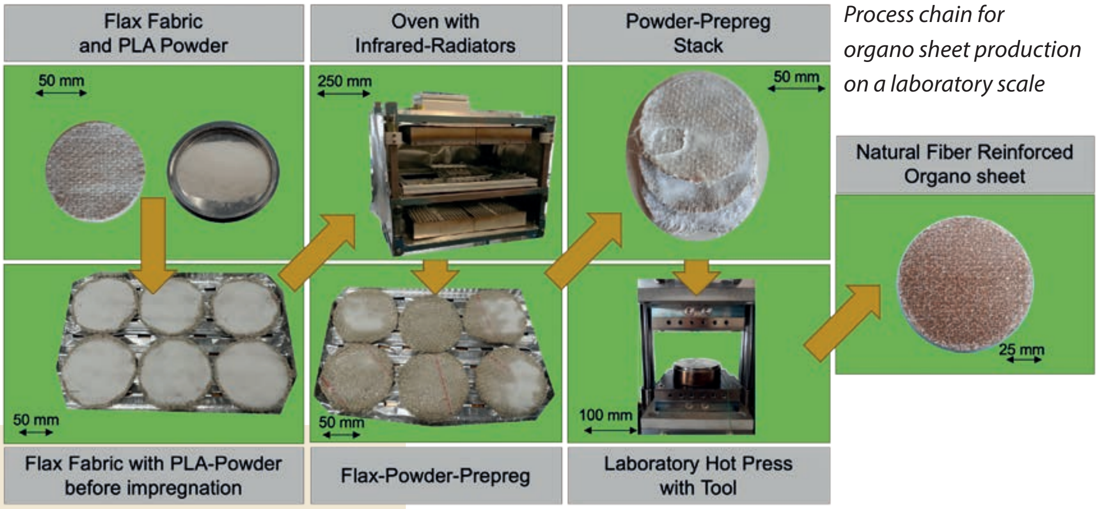
The project "MaTaInH2 – Material-Efficient and Cycle-Time Optimized Industrialization of H2 Pressure Tanks" is funded by the Federal Ministry of Transport and Digital Infrastructure (BMDV) on the basis of a decision by the German Bundestag as part of the program "National Innovation Program Hydrogen and Fuel Cell Technology Phase 2 (NIP II) (funding reference 03B10111C).

Supported by:
Federal Ministry of Transport and Digital Infrastructure
on the basis of a decision by the German Bundestag

maximilian.salmins@ivw.uni-kl.de

Durable and Resoure-Saving Bast Fiber Reinforced Composite Components

Maximilian
Salmins



Process chain for organo sheet production on a laboratory scale

DURO BAST

Partners:

DST Dräxlmaier Systemtechnik GmbH

Eta Ressourcenmanagement

Fraunhofer LBF

Gustav Gerster GmbH & Co. KG

Institut für Textiltechnik (ITA) der RWTH Aachen

Lehrstuhl für Werkstoffprüftechnik (WPT) der Technischen Universität Dortmund

nova-Institut GmbH

Rhenoflex GmbH

Silbaerg

Wagenfelder Spinnereien GmbH

https://durobast.de/

Natural fibers have a high potential for a more sustainable and resource-saving production of structural components. Selection of regionally available bast fiber (in particular hemp fibers are cultivated in Germany) in combination with bio-based polymers, e.g. polylactic acid (PLA), enable future-oriented production of natural-fiber-reinforced composites. Moisture absorption in natural fibers is a major challenge that must be overcome for higher market penetration. The project Durobast considers the entire process chain, starting from the selection of suitable natural fibers up to the manufacture of components. A particular focus lies on fiber treatment through cavity polymerization for reducing moisture absorption. The hollow natural fibers are impregnated with a low-viscosity monomer, which is then polymerized to form a thermoplastic polymer. The Leibniz-Institut für Verbundwerkstoffe investigates composite components made with semi-finished products, so-called organo sheets. They can be produced with textiles made of pure natural fibers combined with polymer films or powder or alternatively with hybrid fabrics or fabrics made with both natural and polymer fibers. The identification of suitable process temperatures is of decisive importance. Impregnation with the thermoplastic polymer is facilitated by increasing process temperature, however, exceeding specific temperatures damages the bast fibers, reducing their strength and toughness. Beyond the optimization of organo sheet production, the characterization of their draping behavior is a focal point of the project. FE-based simulation of thermoforming processes allows optimization of part production while minimizing trial and error experimentation.

The project Durobast pursues a holistic approach to manufacture natural fiber reinforced composites by combining pretreated natural fibers and bio-based polymers to enable future-oriented production.

Supported by:

Federal Ministry of Food and Agriculture

on the basis of a decision by the German Bundestag

The project "Durobast – Durable and Resource-Saving Composite Structural Components on the Basis of Novel Pretreated and Processed Bast Fibers" is funded by the Federal Ministry of Food and Agriculture on the basis of a decision by the German Bundestag (funding reference 2220NR090C).

EasyEntry2TPC – Thermoplastic Liquid Impregnation

Fiber-reinforced thermoplastics offer a number of advantages over fiber-reinforced thermosets. They can be re-melted, enabling thermoforming and welding processes as well as material recycling.

Processing by thermoforming is suitable for large-scale production, but is limited to shell-shaped components and requires large investments in equipment due to the required temperatures and pressures. These costs represent a significant barrier to entry for small and medium-sized companies. The aim of the project is therefore to significantly reduce this barrier by developing a liquid impregnation process with in-situ polymerizing thermoplastics. This technology is similar to thermoset liquid impregnation processes - which are already in widespread use - but poses additional challenges in process control, for example with regard to the moisture sensitivity of the monomers or the corrosion resistance of the equipment used. Over the past two years, the necessary plant technology and experience have been built up at the institute to support companies in the application of this technology. The main focus is on the processing of caprolactam to polyamide 6, but the plant has a modular design to enable the processing of different polymer systems and additives on a pilot plant scale. For this purpose, an adapted resin injection system and a sensor-equipped injection tool were developed, which are now available for research as well as for interested companies for technology transfer.

Stainless-steel injection tool with modular sensor inserts

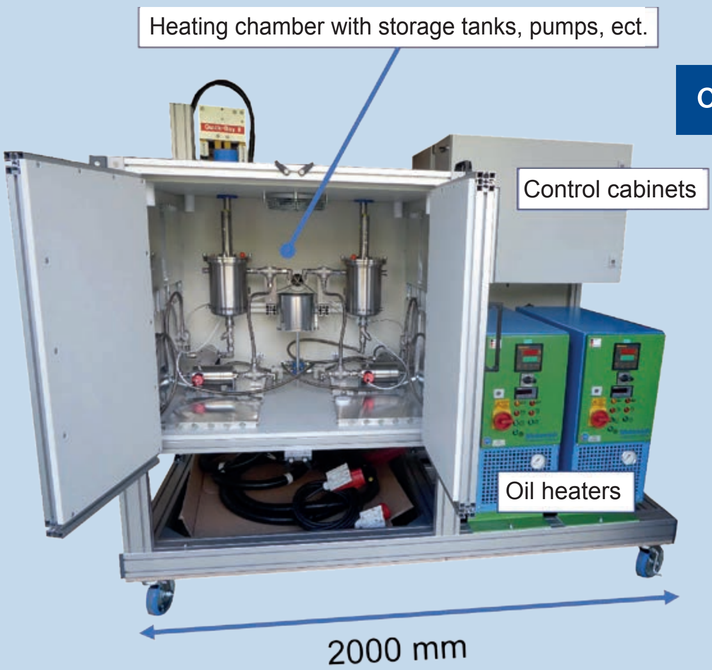
Alexander Faas

Andreas Klingler

alexander.faas@ivw.uni-kl.de

andreas.klingler@ivw.uni-kl.de

Overview injection machine



Das Projekt zu Investitionen in Wachstum und Beschäftigung

EasyEntry2TPC

wurde von der Europäischen Union aus dem Europäischen Fonds für regionale Entwicklung und dem Land Rheinland-Pfalz gefördert.

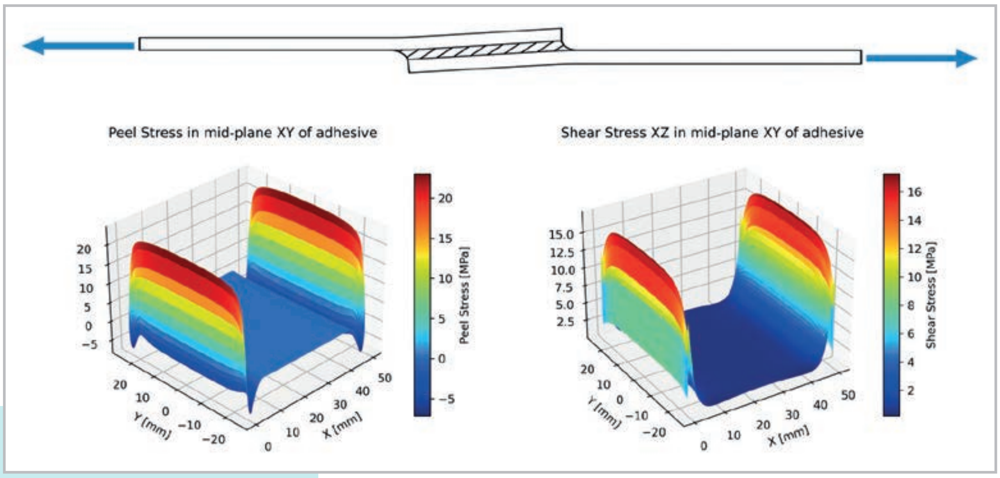
The project "EasyEntry2TPC – Thermoplastic Liquid Impregnation for Rapid Entry into the Production of Continuously Fiber-Reinforced Thermoplastic Composites Based on Established Thermoset Process Chains" is funded by the European Regional Development Fund (ERDF) and the Ministry of Economy, Transport, Agriculture and Viticulture (MWVLW) (grant number 84007039).

francis.gonzalez-ramirez@ivw.uni-kl.de

Partner

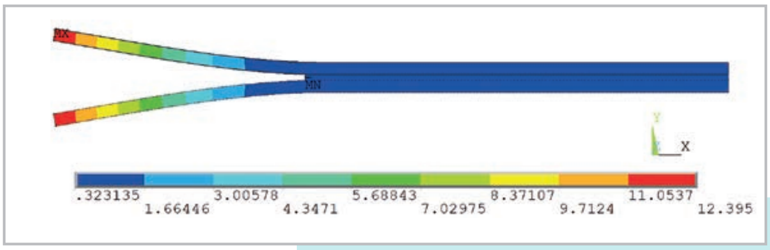
FAnTeStick – Numerical Prediction of the Fatigue Behaviour of Composite Bonded Joints

Francis
Gonzalez Ramirez



Top: Schematic representation of a single-lap shear sample
Bottom left: (Exemplary) peel stresses in the joining zone
Bottom right: (Exemplary) shear stresses in the joining zone

The use of composite adhesive joints has been increasing in the transportation industry as a suitable joining technique between structural components or as an appropriate repair method in the case of local damage. Bonded structures are submitted to a great variety of tensile (mode I) and shear (mode II) stresses. Therefore, it is crucial to experimentally characterize their mixed-mode I+II fracture behavior. During service, bonded joints are constantly subjected to fatigue loading, which can cause damage at a lower percentage of its static strength, eventually leading to failure. Thus, fatigue characterization and prediction is of great importance for fail-safe and damage tolerance designs. Fatigue experimental campaigns are quite challenging, as they are significantly time consuming and present high variability in the results. Fracture mechanics based approach is one of the most common methodology to deal with delamination growth and to predict the fatigue life and inspection periods of composite components. This approach analyses the fatigue crack propagation based on strain energy released rate, G. In the FAnTeStick project, the fracture and fatigue/fracture behavior of glass-fiber reinforced polymers bonded joints has been characterized. Additionally, the stacking sequence effect on the mechanism of failure under quasi-static and fatigue loading was analyzed and compared. The stacking sequence of composite joints, especially the ply orientation at the substrate/adhesive interface, plays an important role on their fracture behavior. However, few works are available in this subject, especially under fatigue loading conditions. The results of such experimental work have been used to validate a FEM numerical model.



Total deformation of a double cantilever beam specimen under pure mode I loading

ZIM Zentrales Innovationsprogramm Mittelstand

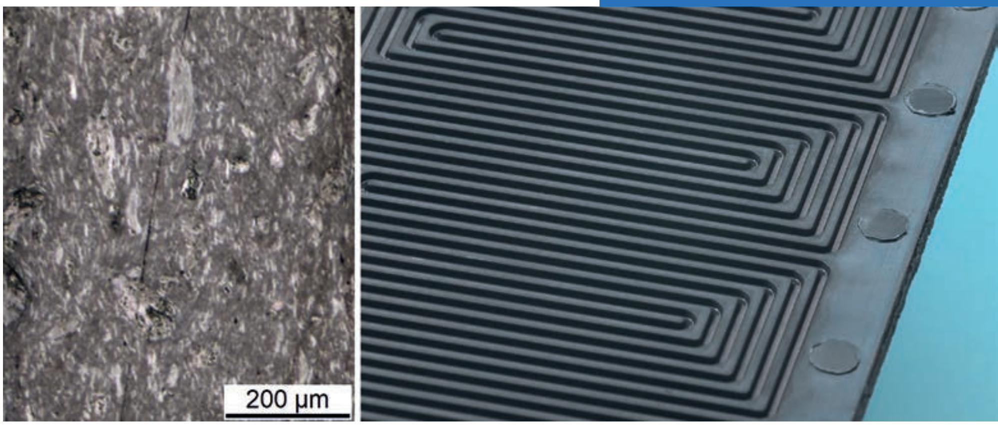
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

The project "FAnTeStick – Fatigue Analysis and Test Procedures for the Design of Bonded Joints" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference KK5003702EB0).

Partner ZBT

Fiber Reinforced Compound Foil Bipolar Plates for Compact Fuel Cells

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 expensively coated metals or polymers filled with graphite, so-called graphite polymer compounds. Advantages of the compound bipolar plates are the missing coating and, therefore, the lifetime. However, the injection molding process and the low mechanical properties of the compound foils yield in a high wall thickness which increases the volume and decreases the power density of the fuel cell. In this project the wall thickness is intended to be decreased by incorporating a foil extension process instead of injection molding and by reinforcing the foils with carbon fibers. Therefore, a reinforcing concept with few efficiently placed fibers, suited for the manufacturing process, and a comprehensive characterization of the fiber influence on mechanical, electrical and chemical properties of the compound foil are needed. Furthermore, a manufacturing process needs to be developed to impregnate the fibers with the highly viscous compound and to form the reinforced foils to biopolar plates.



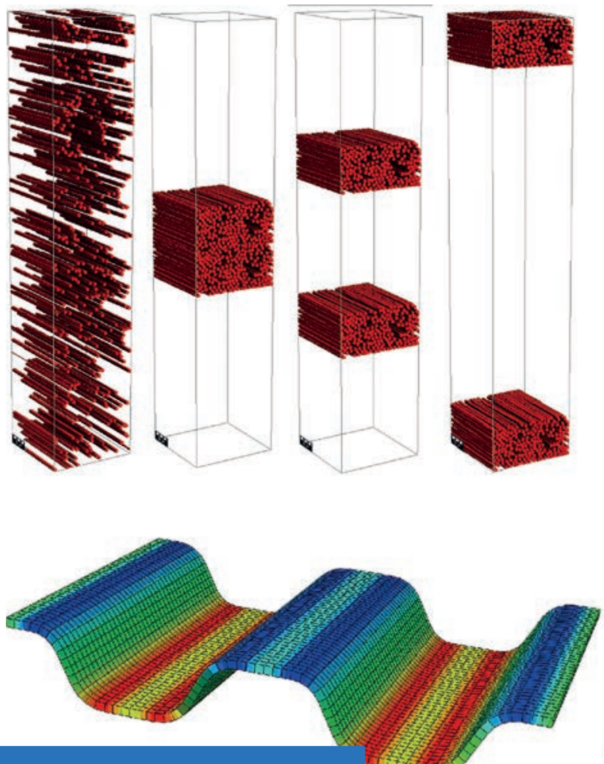
Left: Micrograph of a graphite polymer compound foil
Right: Injection molded compound biopolar plate

© ZBT Duisburg

Stefan Schmidt

Alexander Nuhn

stefan.schmidt@ivw.uni-kl.de
alexander.nuhn@ivw.uni-kl.de



Exemplary simulation setup for the development of the fiber reinforcing concept of bipolar plates
Top: Several possibilities of fiber placement
Bottom: Corrugated structure of the biopolar plate for stress analysis using the finite element method

AiF iGF

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

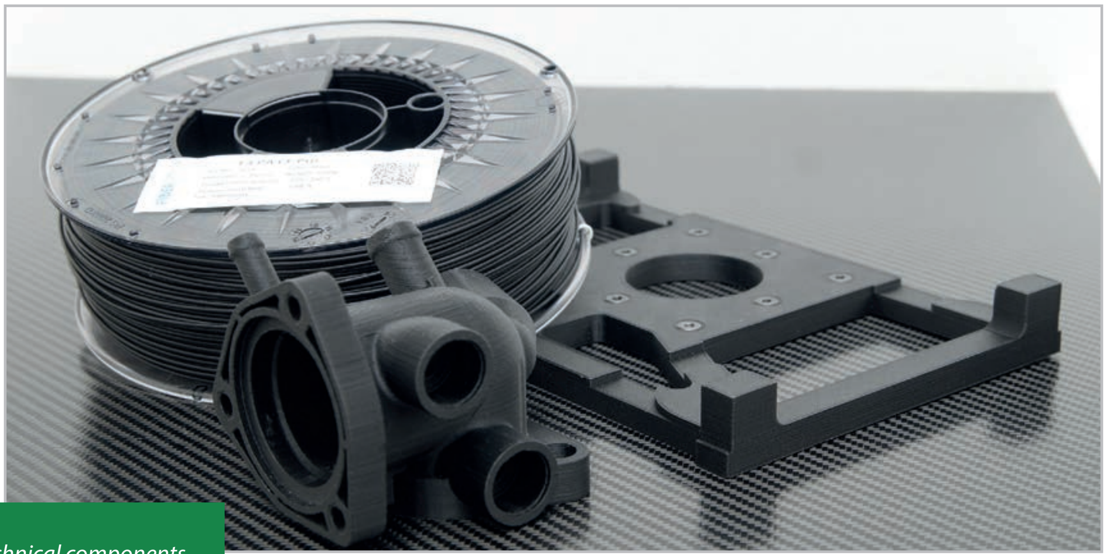
The project "Fiber Reinforced Compound Foil Bipolar Plates for Compact Fuel Cells" is funded within the framework of the German Federation of Industrial Research Associations (AiF) and Joint Industrial Research (IGF) by the Federal Ministry of Economics and Climate Action on the basis of a decision by the German Bundestag (funding reference 22342 N).

FIBERTHREE

Future of 3D Printing: Knowledge-Based Development of Multifunctional Filaments

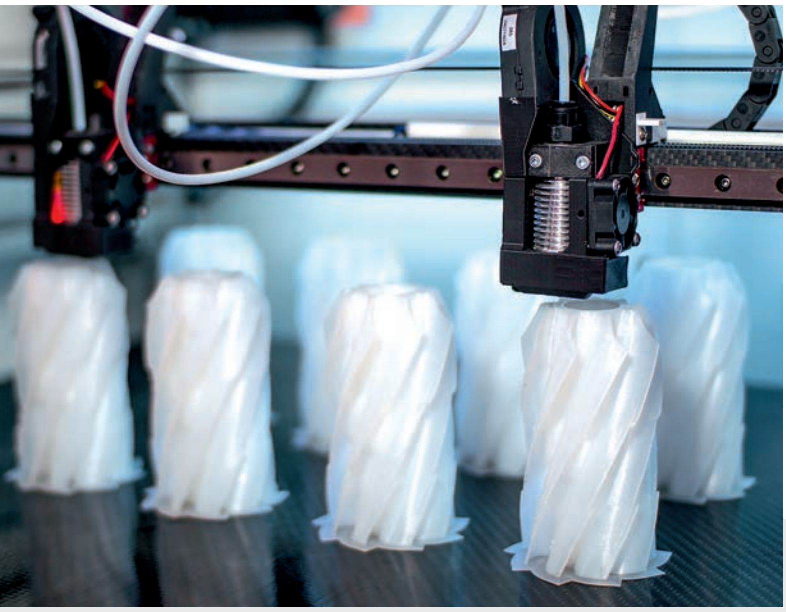
rolf.walter@ivw.uni-kl.de

Rolf Walter



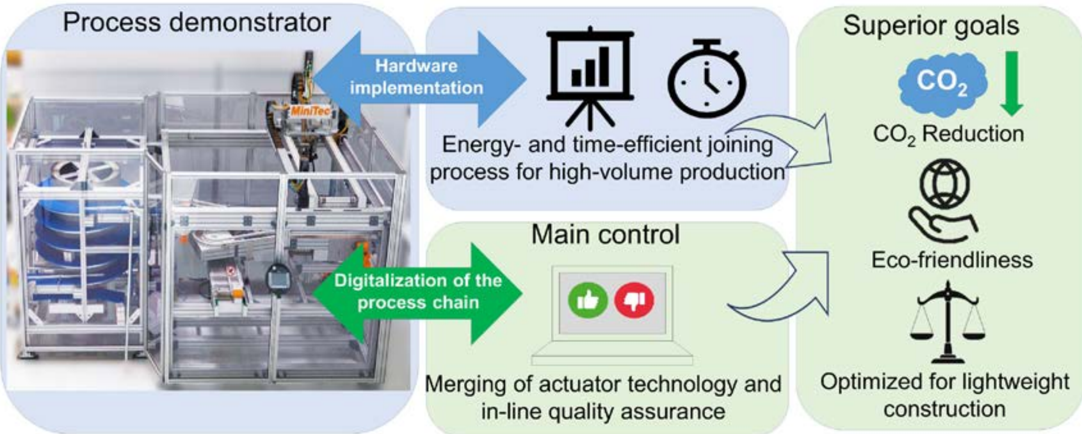
3D printing filament and technical components

3D printing uniquely allows component geometry to be customized to the application with batch size 1. The ability to tailor material-based multifunctional properties just as specifically needed is a new quality that opens up a wide range of applications. Due to the relatively low sales volumes of customer-specific material variants, this is an enormous opportunity for small and medium-sized material suppliers. Typically, the development of a printing filament is an iterative process that needs to take a strong dependence of the component properties on the printing process parameters as well as the filament properties into account. In addition to the actual target component property (e.g. strength), filament manufacturability and specific 3D printing challenges, e.g. component warpage or strong anisotropies, must also be considered. The iterative development of a new material composition means a large investment of time, even for developments that address only one target variable. The consideration of several target variables potentiates the interactions and often exceeds the feasible effort. The project focuses on the development of a knowledge-based digital material model for the efficient application-related realization of 3D printing filaments with multifunctional property profiles. The model links relationships between material, process and structure, both in semi-finished product and component manufacture, with the specific material parameters of micro- and nanoscale fillers to form a fundamental knowledge base for the "electrical and thermal conductivity" use case. What is currently state of the art for metal printed parts - series production with extended functionality - is also to be achieved for polymers by the project results. Mechanical properties, especially layer adhesion, are to be improved by 10-30% and electrical conductivity by 9-10 orders of magnitude compared to short fiber reinforced filaments produced at present.



3D printing of technical components

HyBe – Automated Hybrid Welding of Metal Fasteners to Composite Parts



Goals of the HyBe project

Stefan Weidmann

stefan.weidmann@ivw.uni-kl.de

Mixed metal and fiber reinforced polymer composite (FRPC) assemblies are a key issue for a wide range of applications, e.g. in industry, mobility, sports and leisure. In order to fully exploit the material properties of the individual assembly elements, efficient joining processes and optimized bonds are of major interest. Surface-mounted, geometry-optimized fastening elements represent easy-to-assemble lightweight connection points. These bond to thermoplastic FRPC parts by means of a functional coating and thus without fiber damage, as it is the case for example with drilling or clinching, allowing optimum force introduction. The fastening elements provide a standard screw connection to the metallic joining partner. These fasteners can be reliably joined by an especially developed joining process that is reproducible and takes full data gathering in the context of a digitalize process chain into account. The automated joining process is supplemented by a comprehensive parameter study to determine the optimum process parameters in terms of strength, corrosion resistance and fatigue strength.

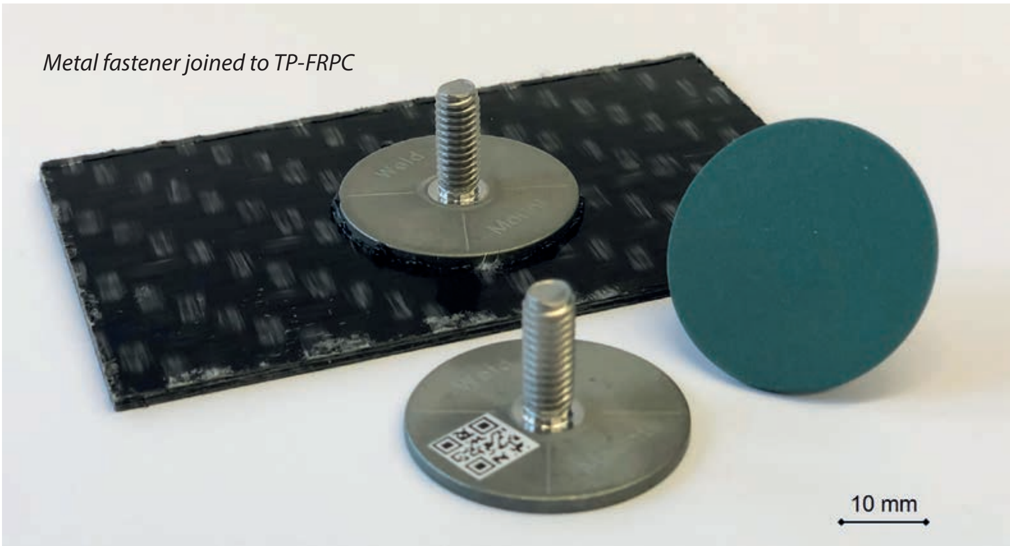
Partners:

Himmelwerk Hoch- und Mittelfrequenzanlagen GmbH

Kömmerling Chemische Fabrik GmbH

MiniTec GmbH & Co.KG

Metal fastener joined to TP-FRPC



The aim of the HyBe project is to develop an enabling technology for the automated, energy- and time-efficient joining of metallic fasteners to thermoplastic FRPC.

ZIM Zentrales Innovationsprogramm Mittelstand

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

The project "HyBe – Automated Hybrid Welding of Metal Fasteners to Fiber-Reinforced Polymer Composites" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference KK5003706FF1).

HyTraLeicht – Hybrid Structures for Automotive Lightweight Construction

Vinay Nagaraj

vinay.nagaraj@ivw.uni-kl.de

Developed tool for RTM process

Non-traditional / new manufacturing processes in the field of fiber reinforced polymers (FRP) have long been researched in order to achieve cost optimization, effective material usage, and lightweighting goals. Project HyTraleicht was launched on similar motivational grounds to investigate the extent to which design freedom may be pushed by combining novel production technologies. New methods are investigated for the development and production of hybrid metal-composite joints within the context of this project. The goal here is to maximize structural performance by combining the benefits of technologies such as 3D printing and Tailored Fiber Placement (TFP). Our collaborators at the "Institute for Mechanical and Automotive Design (iMAD)" and "mawe presstec GmbH" are looking at several 3D printed metallic insert designs that provide excellent interface between the load introduction element and thecomposite structure. Leibniz-Institut für Verbundwerkstoffe GmbH, in collaboration with "Digel Sticktech GmbH & Co. KG," is actively investigating alternative ways for designing and manufacturing the load case optimized TFP preform.

Partners:

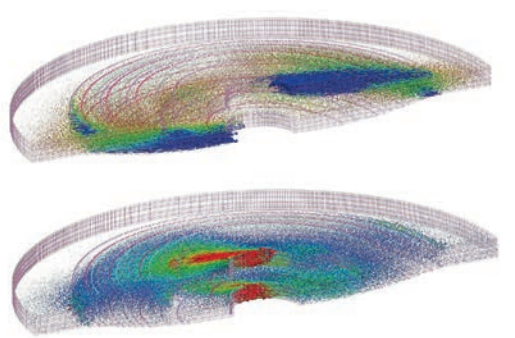
Lehrstuhl für Konstruktion in Maschinenbau und Fahrzeugtechnik (iMAD)

Digel Sticktech GmbH & Co. KG

mawe presstec GmbH

The use of finite element simulation and structural optimization is crucial in determining the appropriate fiber path for the TFP process. Structural optimization methods are used to determine optimal fiber angle and thickness combinations that result in lightweight structures with maximum stiffness, which are then conveyed into the TFP stitching program to produce the preform.

Computed first and third principal stress vectors from FE model of a bending specimen



A cut section of tensile specimen

ZIM Zentrales Innovationsprogramm Mittelstand

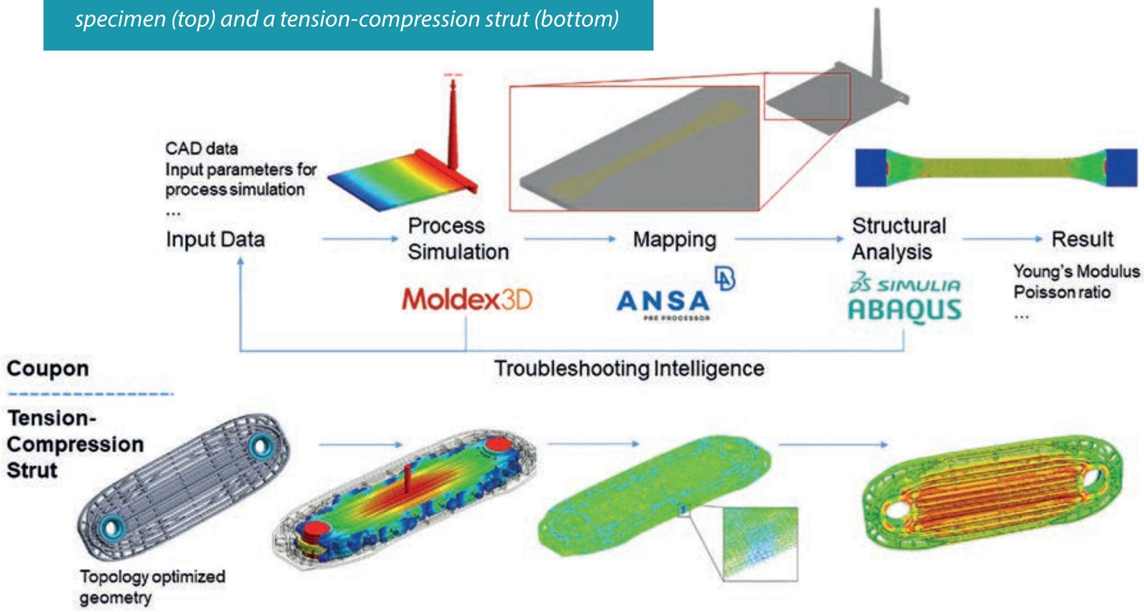
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

The project "HyTraLeicht – Hybrid Support Structures for Lightweight Construction in Vehicles" is funded by the Central Innovation Program for SMEs (ZIM) of the German Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding code ZF4052329RU9).

CirComp
A subsidiary of ALBANY Engineered Composites

InjectProfile – High Efficient Processes for Low-Cost Thermoplastic Aircraft Profiles

Digital Process Chain with an example of a tensile test specimen (top) and a tension-compression strut (bottom)



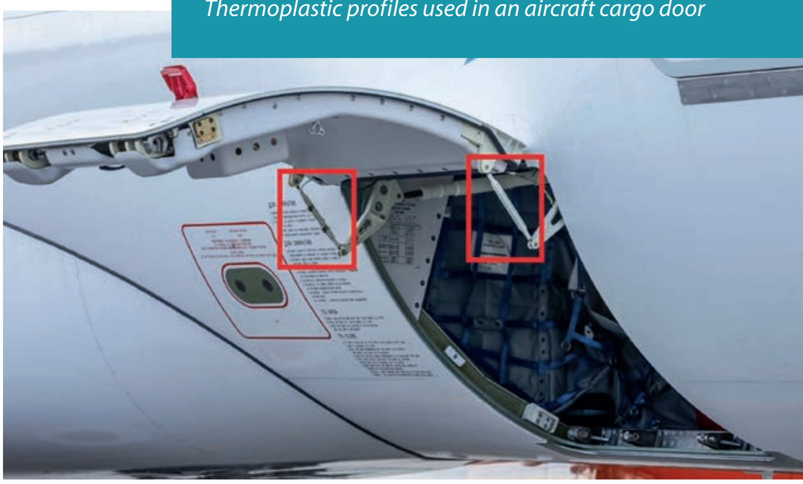
Nithya Sindhe

Dominic Schommer

dominic.schommer@ivw.uni-kl.de nithya.sindhe@ivw.uni-kl.de

The challenges for fiber reinforced plastic components in the area of tension-compression struts for the aviation sector lie within the availability of low-cost lightweight solutions. Thermoplastic semi-finished products offer high flexibility in terms of shape, function, and material arrangements, especially by combining different processes. Locally placed unidirectional continuous fiber reinforced inlays allow the struts to be optimally adapted to the structural requirements. The required process chain from semi-finished product to final component will be developed within the framework of the research project InjectProfile. In a first process step, the required fiber reinforced inlays are manufactured. An injection molding process follows, which integrates the inlays as well as further functional elements. Additionally, the bonding between the inlay and short fiber reinforced plastic is investigated by suitable experiments. Based on the results of these investigations, suitable inlay geometries are derived. Simultaneously, the process is represented digitally by implementing the developed digital process chain as shown in the figure. Starting with a topology optimization, defining the position of the continuous fibers, the subsequent injection molding simulations assess the mold filling as well as the resulting fiber orientations. The digital process chain extends beyond the manufacturing process to depict a structural mechanical model, which provides the possibility for an accurate prediction of the component's behavior.

Thermoplastic profiles used in an aircraft cargo door



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

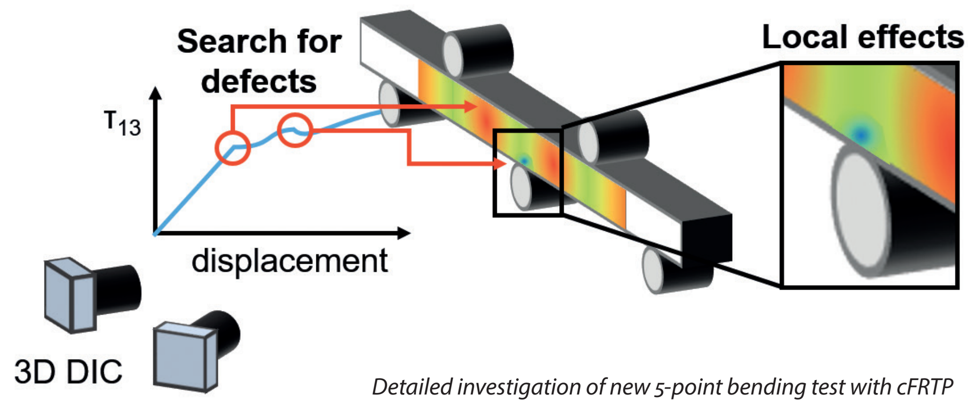
The project "InjectProfile – Development of a High Efficient Process for Thermoplastic Fiber Reinforced Composite Laminates for the Manufacture of Load and Weight Optimized Aircraft Profiles" is funded by the Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 20Q1724B).

sebastian.schmeer@ivw.uni-kl.de
florian.mischo@ivw.uni-kl.de

Management of Expert Task Force – cFRTP in Automobile Application

Sebastian Schmeer

Florian Mischo



Detailed investigation of new 5-point bending test with cFRTP

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. However, the frequent lack of fully comparable and efficiently calculated material properties are an obstacle for the application of cFRTP in industry.

Against this background, the AVK expert task force "continuous fiber reinforced thermoplastics" is developing a standardization strategy for cFRTP (organo sheets and tapes) under the direction of the IVW since its founding in June 2015, focusing on basic parameters for databases. So far, a newly developed tensile specimen geometry as well as a complete test plan are emerged from this strategy. The test plan consistently defines the minimal set of necessary material properties, test conditions and test methods.

Thermoplastic continuous fiber reinforced ultra-high-performance semi-finished products (tapes) offer a high individual design potential using innovative production processing. The determination of characteristic tape parameters, in particular the semi-product-specific measurement of the extreme tensile strength in the fiber direction, was verified by applying a ribbon fixture developed for tapes and was the focus of the working group in 2022. In addition, the determination of the interlaminar shear strength in the 5-point bending test was investigated as an Indiactor of cFRTP laminate quality and the associated characteristic failure mode was validated optically.

Working group participants

AVK
INDUSTRIEVEREINIGUNG VERSTÄRKTE KUNSTSTOFFE
FEDERATION OF REINFORCED PLASTICS

An expert task force managed by IVW and funded by industrial partners works on the efficient, robust and uniform characterization of continuous fiber reinforced thermoplastics and their implementation into standards and material databases.

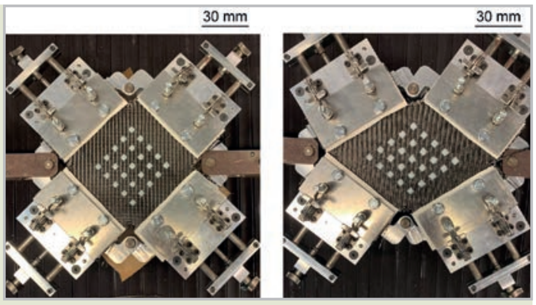
Partners

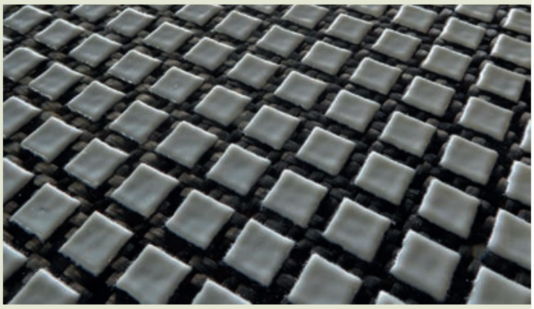
MarineCare – Sustainable Composites for Marine Applications

Jan Janzen

jan.janzen@ivw.uni-kl.de

The aim of the project is to develop a sustainable sandwich composite material with a core made of cork or recycled PET, prepreg face sheets made of recycled carbon fibers (rCF) and a bio-based epoxy powder. Using a solid resin, the aim is to replace the vacuum infusion process currently used with a more efficient one. Crucial to this is the development of prepregs at IVW. For this purpose, the rCF textiles are pre-impregnated with the resin in powder form. The important aspect here is that the textiles are not impregnated evenly over the entire surface - as is common practise - but in the form of a pattern. Pattern impregnation improves the evacuation behavior of the prepregs and enables the drape behavior to be controlled. As part of the project, IVW is researching the relationship between pattern geometry and important processing parameters. Research is also focusing on the development of rCF textiles in which the fibers are aligned. Therefore, in cooperation with Wagenfelder Spinnereien GmbH and Tissa Glasweberei AG, yarns were first produced from rCF, which were then further processed into unidirectional textiles in a weaving process. At the end of the project, the newly developed materials will be used in a demonstrator in the form of a foil sheet.





Top: Studies on the shear behavior of the patterned prepregs;
left: before shearing, right: after shearing

Middle: Manufactured powder prepreg with a squared pattern

Bottom: Sustainable composite sandwich material with unidirectional rCF top layers and a cork core, right: unidirectional rCF-textile

Target demonstrator: Sustainable foil board made by GREENBOATS GmbH, length: 1.4 m

The Eurostars project "MarineCare – Sustainable Composites from Recycled Carbon Fiber and Bio-based Powder Resin for Marine Applications" is funded by the Federal Ministry of Education and Research on the basis of a decision by the German Bundestag (funding reference 01QE2028C).

SPONSORED BY THE Federal Ministry of Education and Research

on the basis of a decision by the German Bundestag

tim.schmidt@ivw.uni-kl.de
stefano.cassola@ivw.uni-kl.de

ML4ProcessSimulation – Machine Learning for FRP Process Simulation

Tim Schmidt

Stefano Cassola

For a robust and efficient design of manufacturing processes for fiber-reinforced polymers (FRP), process simulation based on finite element (FE) models is commonly applied. The finite elements are assigned of this project is to partially substitute some of these time-intensive calculations by rapid predictions based on a trained neural network. A special focus of the project involves the exploita-

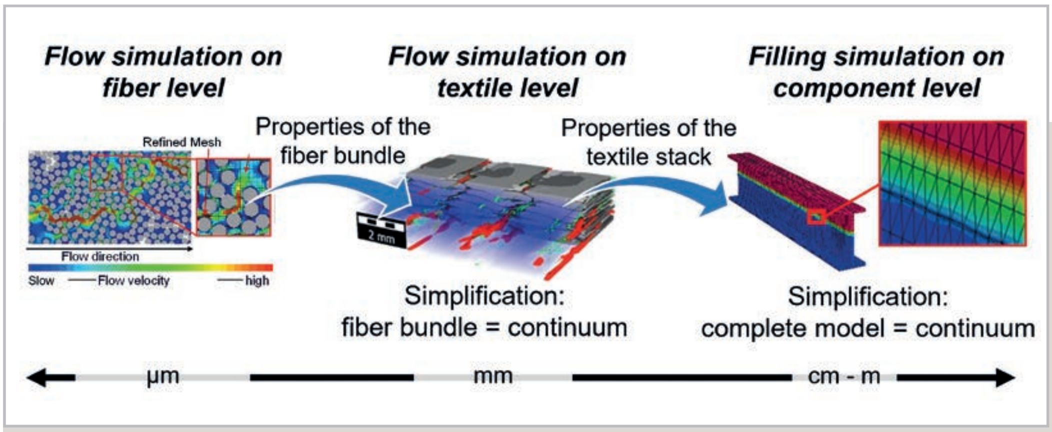


Illustration of physics at different scales for a liquid composite molding case:
An adaptive grid in a microscopic flow simulation through a fiber bundle (left),
mesoscopic flow simulation in a representative volume element of a textile stack (middle)
and macroscopic simulation of part filling (right)

physical properties that represent the processing behavior such as viscosity, permeability and thermal conductivity. To consider all relevant physical effects in detail, a very wide spatial and temporal scale from fiber level (and even lower) to component level would have to be considered. However, simulation methods are only valid for very limited spatial and temporal ranges, as the computational effort would otherwise be unmanageable. In the "ML4ProcessSimulation" project, machine learning methods are used to address this challenge. In conventional simulation methods each calculation step requires solving large systems of complex differential equations, describing the physics. The target *tion of existing process knowledge, for example in the form of analytical process models and existing process data, for efficient training of neural networks.*

The project aims to develop general methodological competence and uses liquid composite molding and the study of textile impregnation with polymer resin as an application example. The project team includes IVW, which has joined forces with WIAS, IPF Dresden, Fraunhofer ITWM and DFKI. Internationally renowned support is provided by Prof. J. Nathan Kutz (University of Washington) and Prof. Suresh Advani (University of Delaware) as mentors.

The goal of the project is to integrate machine learning methods into multiscale simulation approaches to efficiently take all relevant physical effects into account in the process simulation.

Partners:

Fraunhofer Institute for Industrial Mathematics
German Research Center for Artificial Intelligence
Leibniz-Institut für Polymerforschung Dresden
Project consortium for ML4ProcessSimulation
Weierstraß Institute for Applied Analysis and Stochastics

Leibniz-Wettbewerb

The project "ML4ProcessSimulation – Machine Learning for Simulation Intelligence in Composite Process Design" is funded by the Leibniz Association within the Leibniz Collaborative Excellence funding program (funding reference K377/2021).

Partners

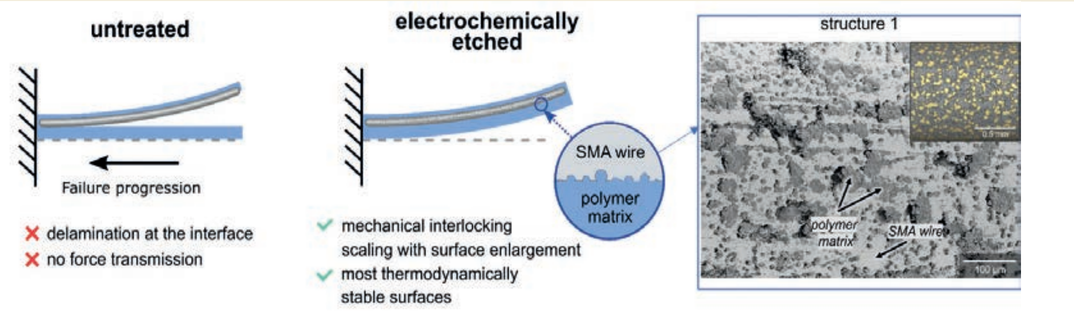
Christian-Albrechts-Universität zu Kiel

Helmholtz-Zentrum hereon

Multi-Method Approach for Characterization of SMA Wire–Polymer Interface Adhesion

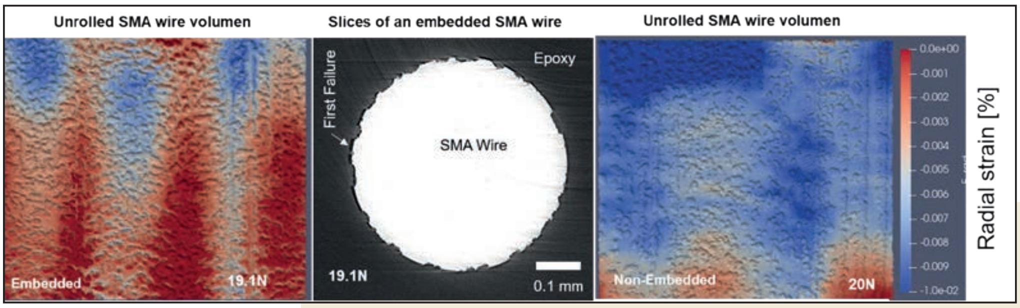
Julia Jungbluth

julia.jungbluth@ivw.uni-kl.de



Schematic description of the motivation behind the project idea

Smart materials, such as active hybrid composites (HC) made from NiTi shape memory alloy (SMA) wires and fiber-reinforced polymers (FRP), represent a novel class of materials that opens up new functionalities and application possibilities. In general, SMA materials are characterized by their ability to exhibit a mechanical response when subjected to a thermal field. Thus, by embedding an SMA in a thin-walled FRP, a tailored shape-changing surface can be designed. However, to fully exploit the actuation potential and functionality, the force transfer at every point along the interface between the SMA and the surrounding matrix is crucial since this is the performance limiting factor. A promising technique to increase the interfacial adhesion without compromising the mechanical and shape memory properties of SMA is by structuring the SMA surface using selective electrochemical etching. While the stress-strain characteristic of a pure SMA material is extensively studied and correlated to its microstructure, the interface in active HC is not well understood so far. Due to the strongly nonlinear, pseudoplastic stress-strain characteristic, the thermo-mechanical coupling of the SMA and the broad variety of possible interface morphologies, a multi-method approach for interface characterization is needed. Combining pull-out test with stress optics, fast X-ray in situ pull-out tests and different optical investigation methods of the pulled-out SMA, a detailed description of the interfacial failure progress is possible. With Digital Volume Correlation of the axial and radial strain of the SMA during pull-out test correlated with the segmented interfacial delamination area occurred during test, new insights to describe the failure driven mechanism are possible. Thus, we have the possibility to find out if its durability is limited by stress concentration or by local strain and how they can be affected.



Digital volume defomation analysis of the unrolled embedded (left) and non-embedded (right) structured SMA wire. The color map indicates the distribution of the radial strain over the structured SMA wire surface in the direction of the applied load. Slices through the tomographic reconstruction of the pulled-out structured SMA wire (middle) showing delamination and contrast obtained at the beamline P07 at the PETRA III storage ring.

The project "Functional Intrinsic Hybrid Composites with Active Elements and Structured Metal Surfaces" is funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 404403710.

DFG Deutsche Forschungsgemeinschaft

NaturePerformance – Modeling the Mechanical Properties of NFRP

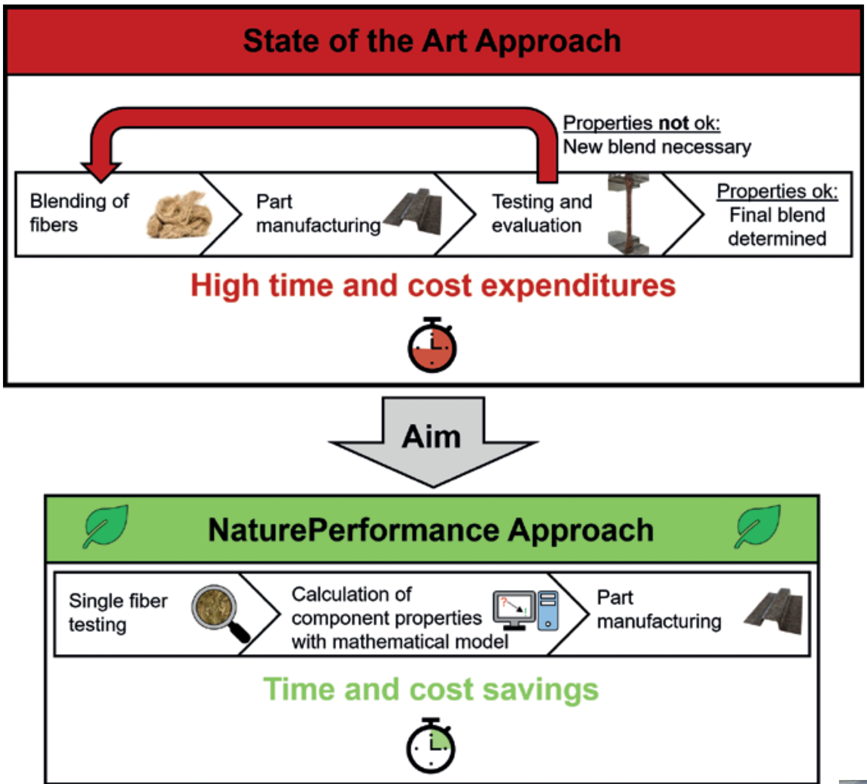
andreas.kraemer@ivw.uni-kl.de

Andreas Krämer

The research project NaturePerformance aims to develop a model for predicting the mechanical properties of natural fiber-reinforced polymers (NFRP). Input of this model are easily determinable properties of the single fibers, which are used to calculate the feasible properties on component level. Natural fibers can make an important contribution to meeting emission limits due to their neutral CO_2 balance and the low energy expenditures during processing. However, the market share of NFRP in the overall market for fiber-reinforced polymer composites is less than 5%. One of the reasons is that the property profiles of natural fibers fluctuate and thus consistent quality cannot be ensured. For NFRPs, fiber blends are therefore produced from different batches and their mechanical properties are determined by destructive tests on components. If the fiber blend does not meet the requirements, an adjustment is carried out, which must be evaluated again by means of mechanical tests. This cost-intensive iterative procedure represents an obstacle for entry into the NFRP market, especially for small and medium-sized companies.

The approach of a prediction model of the mechanical properties of NFRPs is intended to lower these barriers and enable further market development.

IVW focuses on the analysis of process parameters during the processing of NFRP in the thermoforming process and their influence on the mechanical properties of the manufactured components.



State of the art and NaturePerformance approach: Shorter material design chain through predicting the material properties by using a mathematical model

NFRP component produced by thermoforming

Industrielle Gemeinschaftsforschung

The project "NaturePerformance – Modeling the Mechanical Properties of Components made of Natural Fiber-Reinforced Plastics (NFRP)" is funded under the program for the promotion of joint industrial research (IGF) (Project No.: 21240 N/2).

Partner

NeuRecA – Development of SMC Materials Based on Recycled Carbon Fibers

Carbon fiber reinforced polymers (CFRP) play a key role in many industries with lightweight construction requirements. This applies primarily to aviation and automotive technology, but increasingly also to the leisure and sports sector. In addition to pure lightweight construction and the well-known economic challenges, ecological lightweight construction with the demands for sustainable solutions and recyclable materials has increasingly come into focus over the last few years. This goal can only be achieved for carbon fiber reinforced polymer components (CFRPC) by consistently pursuing a holistic circular economy. Therefore, in the „NeuRecA" joint project, targeted material development for reuse in new CFRPC applications is taking place both for carbon fiber production waste (off-cuts from CF textiles and residual coils) as well as for recycled and processed carbon fibers obtained from the pyrolysis of end-of-life (EoL) components. This can significantly reduce the environmental footprint of carbon fiber reinforced components and further increase the attractiveness of the material.

SMC rim

Sheet Molding Compound (SMC) is used for the production and processing of semi-finished products, as it allows a high degree of design freedom combined with economical and efficient manufacturing processes. In combination with an appropriate epoxy resin, SMC semi-finished products based on recycled carbon fibers can be therefore developed and used in structural areas that are subject to high thermal loads.

In the joint project "NeuRecA", novel and innovative SMC formulations based on recycled carbon fibers and epoxy resins will be developed for use in structural areas for high-temperature applications. This represents a first important milestone towards sustainable CFRP composites.

Florian Gortner

Stefan Buchalik-Bopp

florian.gortner@ivw.uni-kl.de
stefan.buchalik@ivw.uni-kl.de

SMC cladding component with rib

The project "NeuRecA – Material and Process Development for Novel SMC Semi-Finished Products based on Recycled Carbon Fibers for Structural High-Temperature Applications" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference KK5003707EB1).

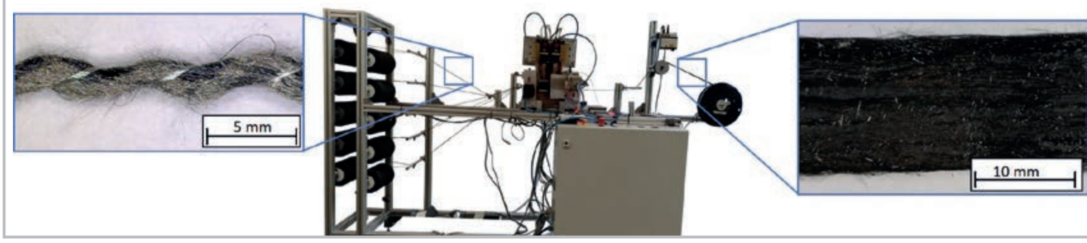
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

martin.detzel@ivw.uni-kl.de

Process Analysis of Thermoforming of Staple Fiber Organo Sheets

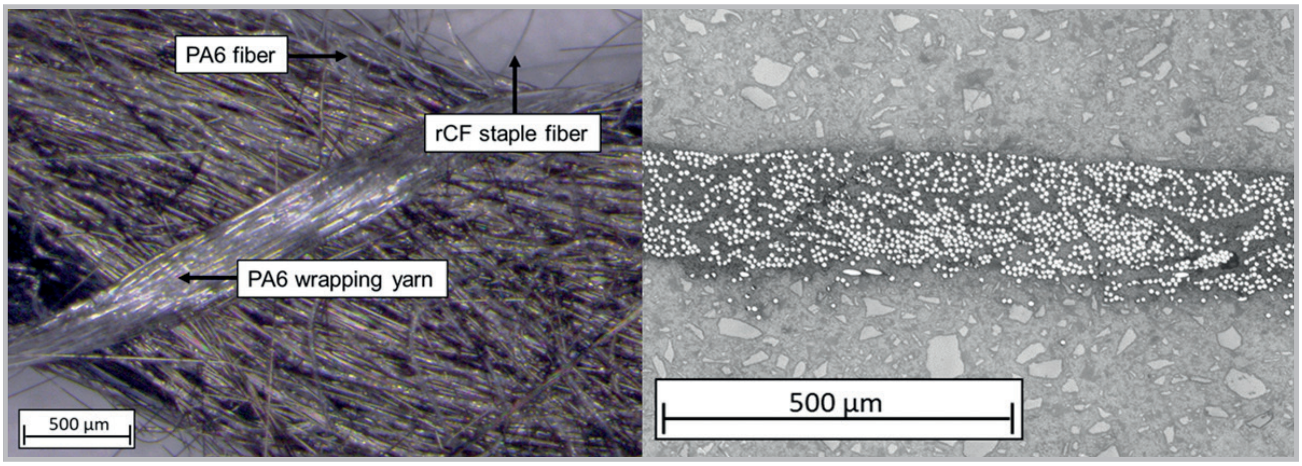
Martin Detzel

Test rig developed at IVW for the consolidation of staple fiber yarns



In this DFG project, the use of staple fiber yarns made from recycled carbon fibers (rCF-SF) for the production of organo sheets and their behavior in the thermoforming process is investigated. The staple fiber yarns made of rCF and PA6 fibers, produced by the company Wagenfelder Spinnerei GmbH, are further processed into tape products in a modified calendering process. For this purpose, the yarns are compacted in a first pair of rolls and stretched via a speed difference to a second pair of rolls. Hot gas nozzles heat the yarns above the melting temperature of the polymer, so that in the second pair of rolls the fibers are impregnated and the yarns are consolidated into a tape. The influence of the crucial process parameters (temperature, consolidation pressure, process speed and stretching) on the resulting width and thickness of the tape as well as the degree of consolidation is analyzed by optical methods and with the aid of image processing. The produced rCF-SF tapes are further processed into organo sheets in the tape laying process and post-consolidated in the autoclave. Subsequently, these are analyzed in detail in tensile tests with regard to their pseudo-plastic material behavior. Based on these results, an existing description model for process behavior in the thermoforming process will be calibrated.

The overall objective of the project is to enable both the recycling of CF primary waste through an innovative process chain as well as opening up new fields of application through a new type of pseudo-plastic deformation behavior in thermoforming.



Left: Staple fiber yarn made from PA6 fibers, rCF staple fibers and PA6 wrapping yarn; right: Cross-section micrograph of a staple fiber tape

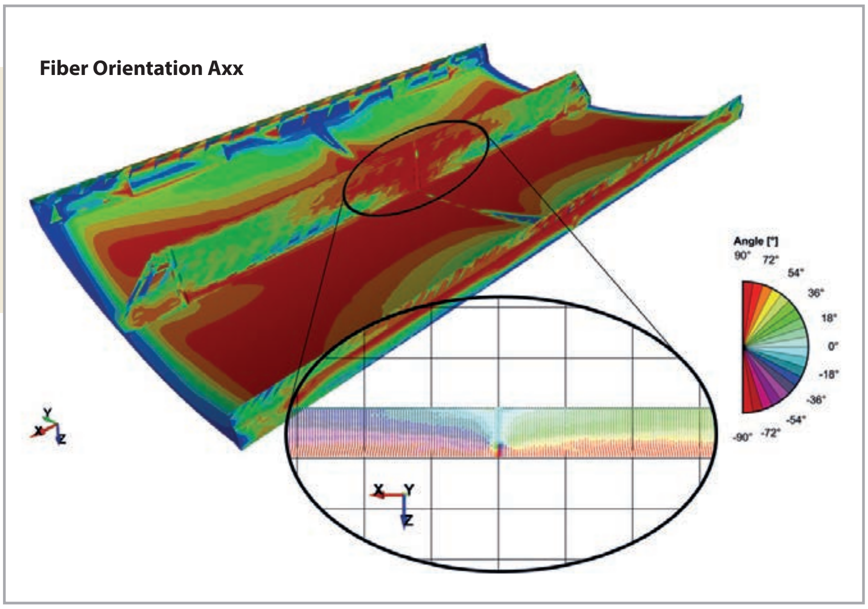
Deutsche Forschungsgemeinschaft

The project "Process Analysis of the Pseudo-Plastic Deformation Behavior of Unidirectional Reinforced Staple Fiber Organic Sheets" is funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 471480678.

Partner Fraunhofer ITWM

Process Digitalization of Carbon Fiber Reinforced Sheet Molding Compounds (C-SMCs)

Analysis of resulting fiber orientation in a filling simulation



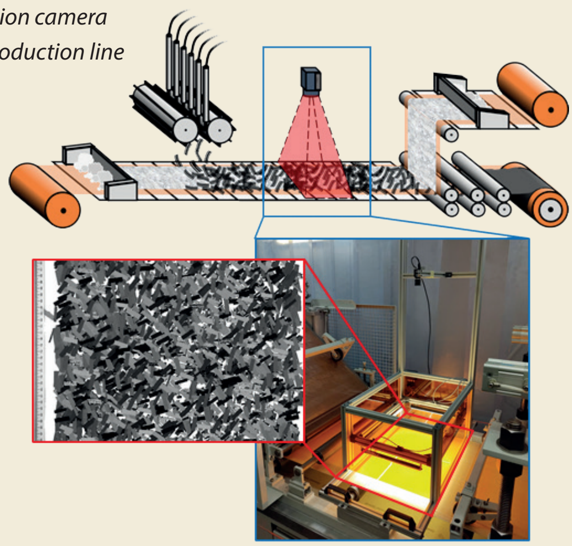
Miro Duhovic

Dominic Schommer

dominic.schommer@ivw.uni-kl.de miro.duhovic@ivw.uni-kl.de

This research project deals with the development of characterization and digitalization techniques for carbon fiber reinforced sheet molding compounds (C-SMCs). Special attention is given to the investigation of fiber orientation, length and content, as well as the interaction between the fibers and the resin. By exploiting the polarizing effect when incident light is reflected from the surfaces of carbon fibers, the fiber orientation distribution can be captured in real time using a polarization camera. The camera is directly integrated on an SMC production line, where it is used to detect the 2D fiber orientation distribution in the resulting C-SMC semi-finished product. In this way, the fiber orientation information for an entire roll of semi-finished product is known at the end of production. This information allows the creation of a digital representation of the material which can be used to create more accurate input data for compression molding simulations. Using the real material and its digital representation, experimental and virtual material characterization can be performed simultaneously. This includes press rheometer tests and simulations to characterize the behavior of the C-SMC material during compression molding to investigate the resulting fiber behavior, which includes permeability to analyze the resin flow through the fiber reinforcement and draw conclusions on possible fiber-resin separation behavior. The combination of experimental and virtual tests leads to a better understanding of internal material interaction of C-SMCs during manufacturing processes leading to improved prediction of structural properties of final components in service.

Determination of fiber orientation by means of a polarization camera in a C-SMC production line



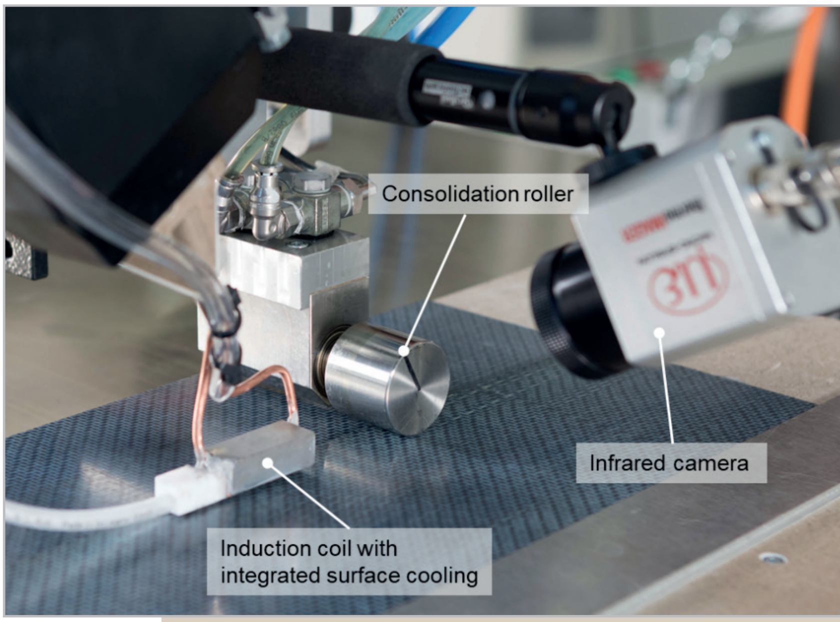
This project is being carried out in close collaboration with the Fraunhofer Institute for Industrial Mathematics (ITWM) within the framework of the High Performance Center Simulation and Software Based Innovation.

thomas.hoffmann@ivw.uni-kl.de

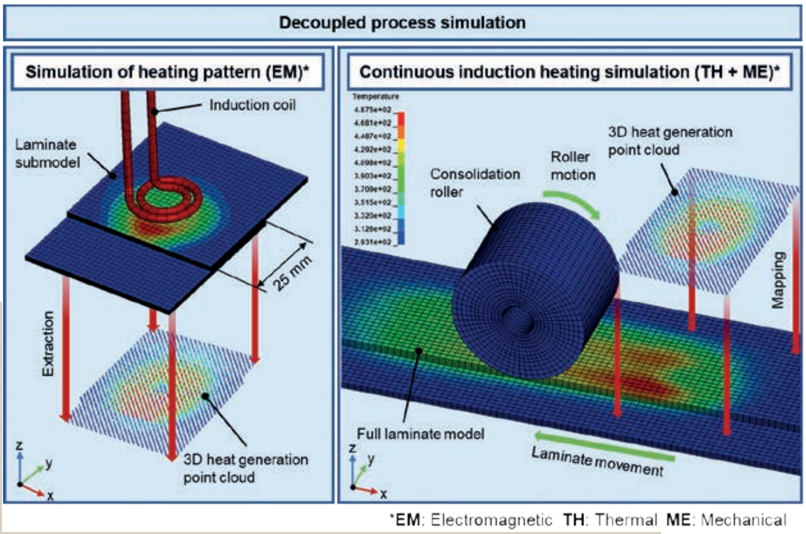
Process Optimization of Induction Welding of CFRPC Organo Sheets

Thomas
Hoffmann

In the previous project phases, a finite element model for the calculation of the static inductive heating behavior of fabric-based laminates was developed and successfully validated by means of static heating experiments. Additionally, an FE model for the calculation of the temperature dependent pressure distribution under the consolidation roller in the joining zone during induction welding was created. In the current, final phase of the project, these two models will be combined into one FE model that covers the entire continuous induction welding process. For this purpose, the induction heating behavior is characterized in a static, electromagnetic simulation with the already existing static heating simulation model. The resulting heating pattern will then be transferred to a thermal-mechanical simulation and moved through the laminate. From the resulting pressure and temperature distributions in the joining zone, an analytically supported prediction of the joint strength will be made possible. In order to achieve a wider pressure distribution and thereby optimize the pressure distribution in the joining zone, an elastomer-coated consolidation roller is being developed in parallel, optimized experimentally and also integrated into the continuous induction welding simulation model. The temperature and strength predictions will be validated via welding tests and mechanical tests. After successful validation, the simulation model will then be used to optimize the strength of the welded joint by adjusting various process parameters of the induction joining process. The long-term objective is to increase the process speed of the continuous induction welding process of CFRP organo sheets in connection with a resulting joining quality at autoclave level.



The specimens being used for the validation of the simulation model will be welded by means of the induction welding robot of IVW



The decoupled finite element simulation model of the continuous induction welding process using the example of a lap shear specimen

DFG Deutsche Forschungsgemeinschaft

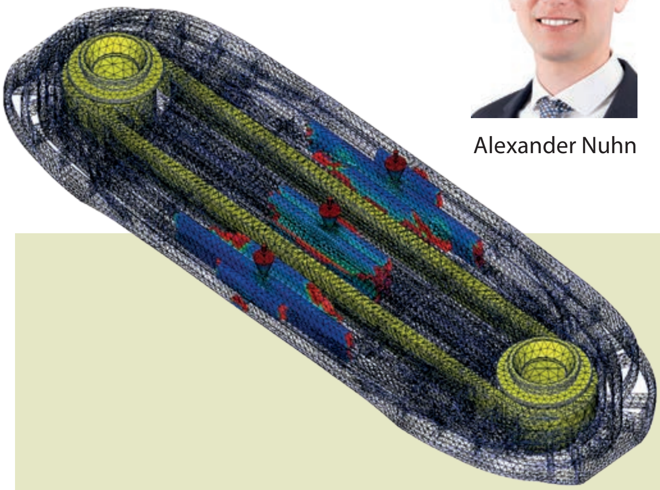
The project "Process Optimization of Induction Welding of Continuous Carbon-Fiber Reinforced Thermoplastics by Process Simulation" is funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 272768988.

alexander.nuhn@ivw.uni-kl.de

pro-TPC-Structure – Truck Components in 90 Seconds

Alexander Nuhn

Fiber reinforced polymer (FRP) composites have high specific strength and stiffness, but often also economic disadvantages compared to metallic materials. A promising strategy for obtaining an attractively priced final product with an increased performance spectrum is the combination of short and continuous fiber-reinforced thermoplastics (TP) in a highly efficient injection molding process. Here, continuous fiber reinforcement is only used locally in highly stressed areas along the main load paths. Highly loaded areas are determined within the project by topology optimization and finite element (FE) simulations. By methodically developing a simulation chain to link different design tools (CAD, FE, topology optimization, process simulation), the aim of receiving a comprehensive virtual design of hybrid thermoplastic FRP structural components is pursued. Due to the fusibility of TP, it is possible to use efficient and economical processing methods, which are mainly characterized by short cycle times and therefore high output. This includes the injection molding process, which contributes significantly to the economic efficiency of the concept through automation technology. During the project, the existing injection molding plant technology is adapted to the special requirements of hybrid thermoplastic FRP structural components.



Filling simulation of the hybrid coupling rod

In addition to the novel calculation of a hybrid assembly made of anisotropic materials and the interaction between the insert and the injection molding compound, the production of a sufficiently strong boundary layer between the insert and the injection molding compound in terms of process technology is the main challenge in the project.

Front and rear side of the "Hybrid coupling rod" assembly with aluminum sleeves as bearing housing for ball studs

RheinlandPfalz

Das Projekt zu Investitionen in Wachstum und Beschäftigung
pro-TPC-Struktur
wurde von der Europäischen Union aus dem Europäischen Fonds für regionale Entwicklung und dem Land Rheinland-Pfalz gefördert.

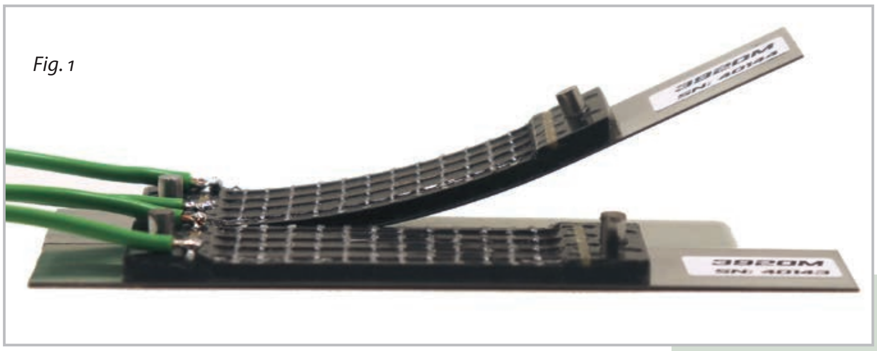
The project "pro-TPC-Structure – Development Process Chain for the Optimized Use of Fiber Reinforced Thermoplastics in Functionalized Structural Components" (funding reference: 84002807) is supported by the European Regional Development Fund (ERDF) and the Ministry of Economic Affairs, Transport, Agriculture and Viniculture (MWVLW).

max.kaiser@ivw.uni-kl.de

Shape Adaptive Shape Memory Alloy Hybrid Composites

Max Kaiser

Fig. 1

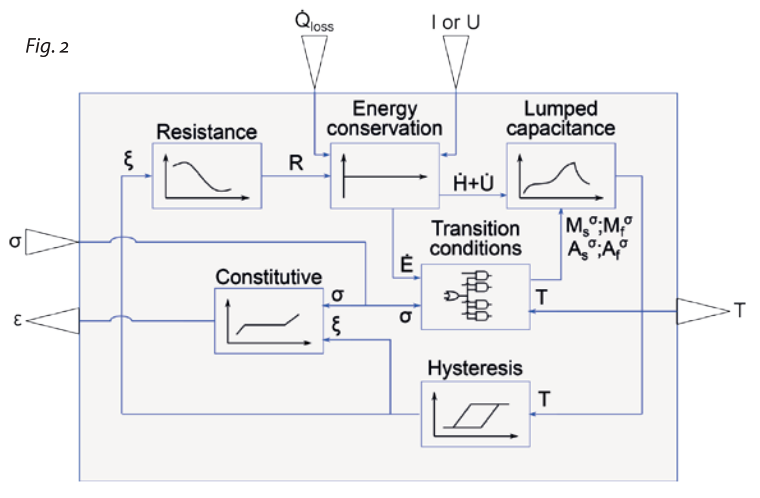


Shape memory alloy hybrid composite in initial and activated state

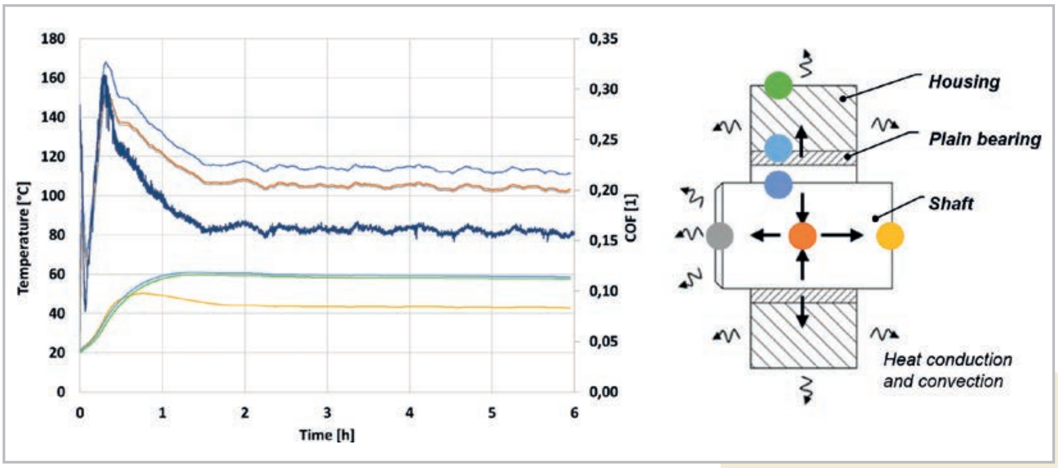
Actuators offer the possibility to convert different forms of energy into each other. The material that makes the hybrid composite an actuator is the shape memory alloy which converts thermal energy into mechanical energy. In a technically usable temperature range, the lattice structure undergoes a thermoelastic phase transformation which is accompanied by a macroscopic contraction. Since the substrate retains its length, a bending motion results as can be seen in figure 1. This actuator concept offers great potential for opening up applications in a wide range of sectors, such as consumer goods, aviation and automotive. In the past, applications, such as a morphing trailing edge, active vortex generators or smart air-vents have already been developed in numerous projects. This class of actuators offers advantages over other actuators, especially when lightweight design concepts and compact installation space are in the foreground. They are also often superior to other actuators when noiseless activation is required or when many individual distributed actuators are to be controlled. In order to accelerate the development process and thus open up new applications even faster, engineers lack tools for designing hybrid actuators. The objective of this work is to develop a tool that allows engineers to estimate whether the actuator is suitable for their application and how it should be designed. On the basis of comprehensive experimental investigations of the actuator properties of the hybrid composites with different geometric designs, a multiphysics model was developed which reproduces their behavior. The focus of the experiments and modeling thereby was on the influence of material and geometry parameters of the hybrid actuator as well as on external influences, such as ambient temperature and external loads. Figure 2 shows the schematic of the lumped model of the shape memory alloy.

Lumped model scheme of hybrid composite for shape adaption

Fig. 2



Slide Bearing Design via Hardware-in-the-Loop



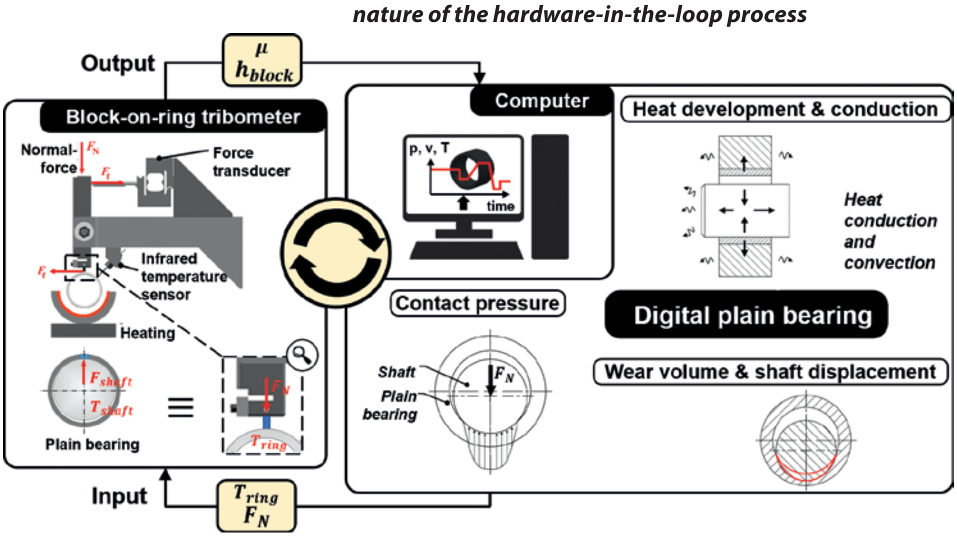
Coefficient of friction and selected temperatures of a journal bearing setup during a hardware-in-the-loop experiment

Andreas Gebhard

andreas.gebhard@ivw.uni-kl.de

Determining correct dimensions of shaft, housing and bearing is a critical step in the design of journal bearings. Due to limited thermal conductivity, together with material-dependent thermal expansion, geometric changes of these three components are highly asynchronous and variable in their extent, which easily leads to jamming when the bearing clearance is not set properly. While in hydrodynamic lubrication heat is generated at low levels and dissipated quickly, dry running bearings exhibit high levels of friction and thermal expansion. Additionally, in contrast to hydrodynamic lubrication, friction in dry sliding is subject to high dispersion between parts, to temporal fluctuation during operation and to hardly predictable dependency on operating conditions. Thus, only very coarse theoretical design procedures are available for dimensioning dry-running bearings and any precise design requires extensive experimental effort. Therefore, a novel design process for such bearings is being developed at IVW. At its core, it features a computerized simulation of a plain bearing which is coupled with a block-on-ring tribometer via a control loop ("hardware-in-the-loop"). While the tribometer simulates the bearing/shaft-setup by executing a block-on-ring test, it continually sends recorded data to the computer where it is used to drive the simulation. The output of the simulation is fed back to the tribometer, which continually re-adjusts loading, sliding speed and temperature to match the test to the current operating conditions of the virtual slide bearing. This procedure solves the classical issue of dry friction being hard to predict, especially at the early stage of operation, and has therefore significantly reduced the experimental effort that is needed for verifying any set of geometric dimensions for shaft, bearing and housing. It has been awarded a patent in June 2022 (DE 10 2021 109 854).

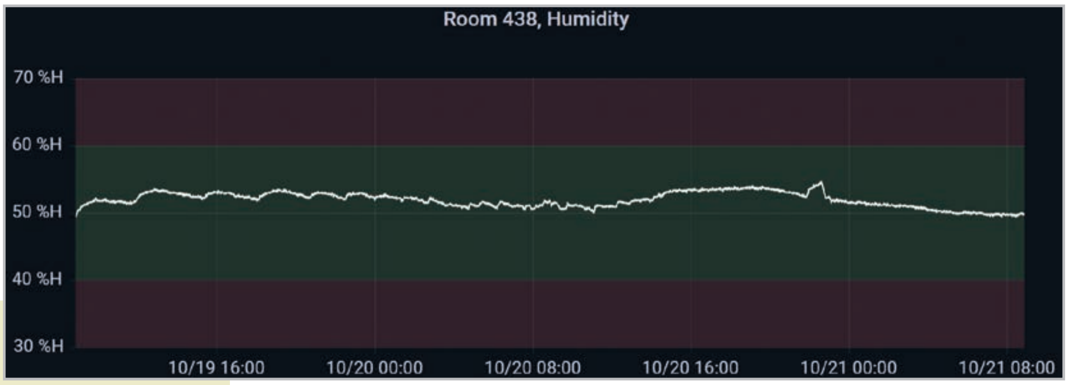
Schematic of the components and the iterative nature of the hardware-in-the-loop process



andreas.gebhard@ivw.uni-kl.de

Smart Data

Andreas Gebhard



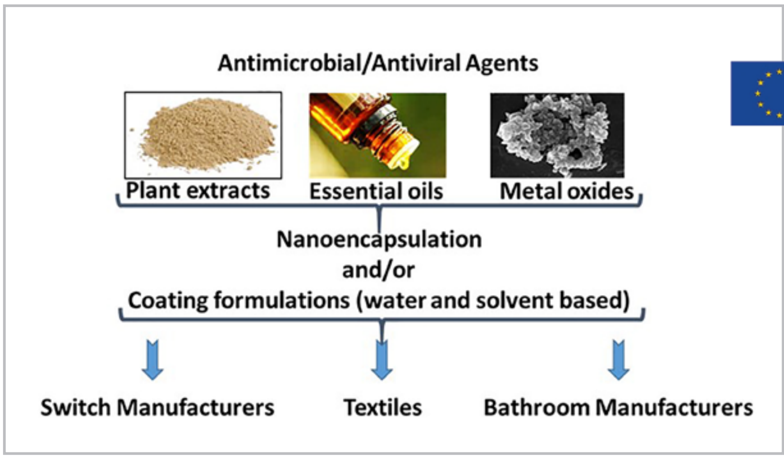
Data visualization and automatic threshold monitoring: ambient humidity in one of IVW's laboratories

In-specimen and ambient humidity significantly impact the results of a wide range of experiments at IVW. For ensuring the quality of academic research it is therefore critical to properly control temperature and humidity of the atmosphere in which specimens are stored and experiments are conducted. Equally important is the measurement and documentation of the ambient conditions of laboratory rooms and of test chambers of test devices. While local climate data loggers are readily available, their usage would have resulted in a collection of isolated, locally stored data. Therefore, IVW staff designed, set-up and put into operation "IVW Climate Data" (ICD) which uses a network of specifically designed climate data loggers, that send their data to a server where it is stored in a database. ICD then offers an application programming interface (API) for computerized access to the data. Data retrieved this way can be easily joined with other experimental data, thereby improving its quality and validity. Additionally, ICD provides a graphical user interface (GUI) for visualizing recorded climate data. For the efficient monitoring of air conditioning, it offers an automated system, which alarms designated people when climates get out of their specified boundaries. ICD uses open source software together with code written and hardware curated by IVW staff for ensuring the highest possible long-term maintainability, interoperability and availability of the recorded data. Beyond ICD novel, data model for thermo-mechanical tests on wires made from shape memory alloys and for infrared thermography tests have been added to Smart Data in 2022.

Queries to ICD's API yield machine readable data that complies with the latest JSON:API standard


```
{ "data": {
    "id": 1,
    "type": "Api::V1::ClimateDatum",
    "attributes": {
      "ambient_temperature": 20.0,
      "ambient_humidity": 50.0,
      "atmospheric_pressure": 952.0,
      "room_no": 438,
      "position": "windows",
      "sensor_id": "79c53545-4e2a-4fa4-a880-0340c023a5de",
      "measured_at": "2022-07-22T14:31:20Z"
    },
    "links": {
      "self": "http://icd.ivw.uni-kl.de/api/v1/climate_data/1.json"
    },
    "meta": {
      "received_at": "2022-07-22T14:38:11Z"
    }
  },
  "links": {
    "http://192.168.0.123:3000/api/v1/climate_data.json"
  }
}
```

SUSAAN – SUStainable Antimicrobial and Antiviral Nanocoating



Funded by the European Union

Liudmyla
Gryshchuk

liudmyla.gryshchuk@ivw.uni-kl.de

The spread of emerging infectious diseases, including COVID-19, and their negative influence on the economy and society requires antimicrobial and antiviral (AM/AV) products for effective protection in manifold locations, not only hospitals or public facilities. According to Handwashing Facts and Statistics [1] each person comes into contact with averagely 300 surfaces every 30 minutes and is exposed to 840,000 germs. Up to 80% of communicable diseases are thus transferred by touch. IVW's main project aim is the development of environmentally and human friendly AM/AV nanoparticles, nanocapsules, nanofibers (NPs, NCs, NFs) of inorganic, organic or hybrid nature, while avoiding safety issues and human skin irritation. They are introduced into coating formulations for plastics, metal substrates, and textiles. This generation of NPs employs eco-friendly synthetic methods. The selection of the processing route, the type of particle modification and AM/AV-components formulation are exclusively targeted to the functionality and effectiveness of the sustainable end-material for different coating types and substrates. SUSAAN will run for 42 months involving an international, interdisciplinary team with 14 technological and scientific partners from France, Germany, Italy, Spain, Belgium, Turkey, and Greece. Their expertise covers the development of bio-based NPs/NCs/NFs, coatings, pre-treatment processes, and toxicity assessment. The project focusses on the whole value chain for achieving bio-based products, and the industrial partners include coatings production, bathroom manufacturing, home appliances and textiles. Processes for Biocidal Products Regulation and sustainability assessments are addressed at all stages. For technology demonstration, concealed cistern panels, switches, sockets, woven and knitted textiles for food industry and home will be produced and evaluated.

Source:
1 https://www.ccmhhealth.com/national-handwashing-awareness-week/

SUSAAN
SUStainable Antimicrobial and Antiviral Nanocoating

Partners:

Almaxtex Tekstil Sanayi Ve Ticaret Anonim Sirketi (TR)

Association Pour La Recherche Et Ledeveloppement D'innovations Et Detechnologies Pour La Protection Del'heritage Environnemental, Social (FR)

Asociacion Centro Tecnologico Ceit (ES)

Celabor Scrl (BE)

Eczacibasi Yapi Gerecleri Sanayi ve Ticaret A.S. (TR)

Instituto Tecnologico Del Embalaje, Transporte Y Logistica (ES)

Intertek Iberica Spain Sa (ES)

Intertek Italia Spa (IT)

L'UREDERRA, Fundacion Para El Desarrollo Tecnologico Y Social (ES)

National Center For Scientific Research „Demokritos" (Greece)

Panasonic Life Solutions Elektrik Sanayi Ve Ticaret Anonim Sirketi (TR)

Tecnologia Navarra De Nanoproductos Sl (ES)

Virhealth (FR)

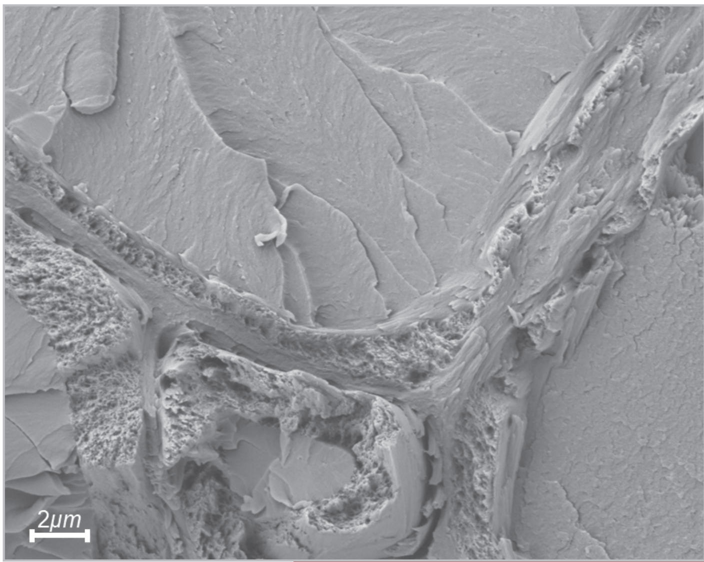
The project "SUSAAN – SUStainable Antimicrobial and Antiviral Nanocoating" is funded by the European Union (GA No 101057988).
Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA.
Neither the European Union nor the granting authority can be held responsible for them.

emmanuel.akpan@ivw.uni-kl.de

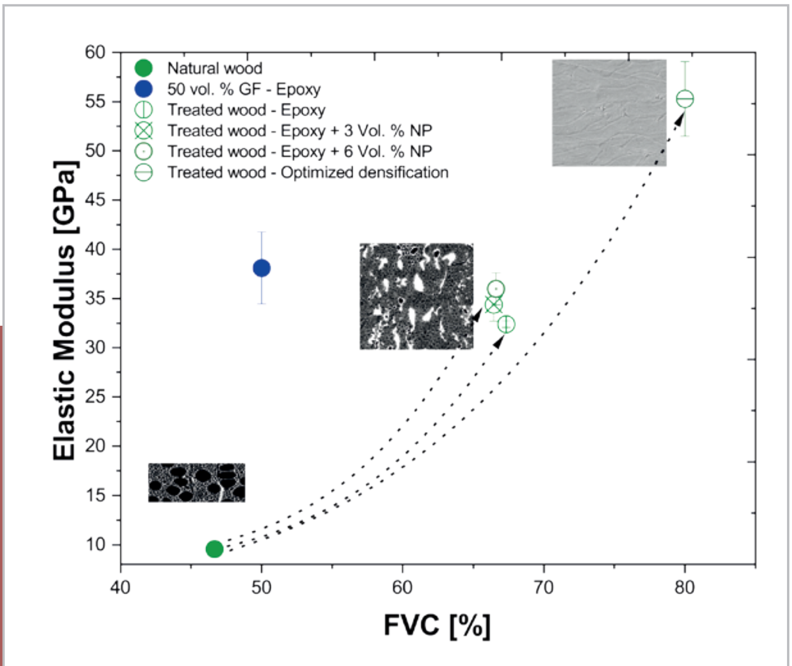
Sustainable and Energy Efficient Wood-Based Structural Materials

Emmanuel
Akpan

Sustainability, reduction in CO_2 emission, environmental protection and efficient use of resources are critical global issues for researchers, governments, and industries. An appealing solution will be the replacement of non-environmentally friendly materials with bio-based materials, which have almost zero-negative biodiversity impact. Wood is the most valued renewable and sustainable bio-based structural material on earth. It is a natural carbon sink with an excellent performance-to-weight ratio. Hence, replacing materials such as steel, concrete, and synthetic polymers with wood-based materials will reduce energy consumption and global warming. It is possible to process wood into high-performance materials by manipulating the cellular and molecular structures. The process involves an initial chemical treatment to remove lignin, followed by functionalization and subsequent consolidation of the wood structure. However, achieving cost-effective, green and scalable processing without reducing the properties is challenging. IVW develops high-performance, energy-efficient structural materials with multi-functionality using eco-friendly and sustainable modification techniques. Apart from research in biotechnological methods and green solvents for wood modification, we investigate cost-effective and energy-efficient routes to arrive at a scalable production process. Also, we deploy interface engineering to control wood's structural and light scattering behavior. By systematically regulating vital factors, such as lignin content, nano reinforcement and process parameters, a higher volume fraction of wood fibers in the final material is realized, translating to improved performance. A suitable selection of nanoparticles for bio-based optically transparent wood results in improved interface adhesion and offers a 15% reduction in Haze with a slight increase in transmittance, making it suitable for energy-saving applications



Nano-engineered interface in transparent wood



Regulation of wood's microstructure and fiber volume fraction (FVC) for improved performance

Partner

CirComp
A subsidiary of ALBANY Engineered Composites

ThermoStrut – Novel Thermoplastic Aviation Struts

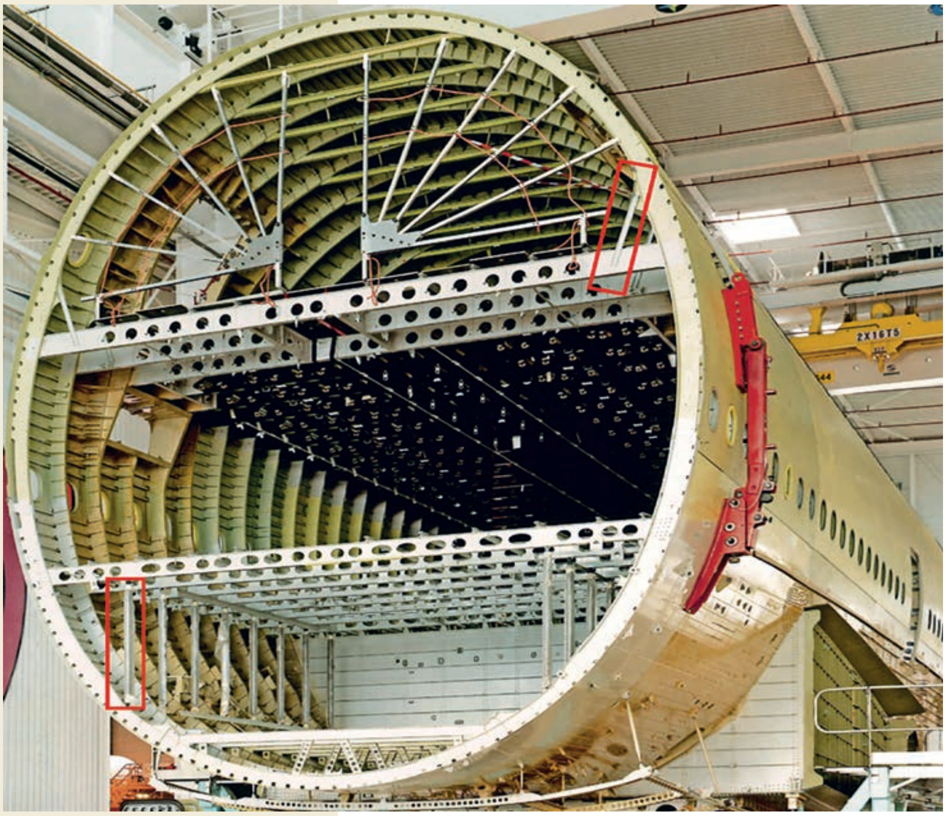
The goal of the project ThermoStrut is the development of thermoplastic (TP) tension-compression struts with integrated load introduction for applications in the aviation industry. The load introduction in the pultruded fiber-reinforced strut can be integrated using either a subsequent injection molding process or a combined forming/winding process. The combination of different TP processes yields a highly efficient and low-cost design. The production of the strut by the pultrusion process results in the orientation of the fibers in the axial direction in line with the load path. This, in conjunction with the high impact resistance of the thermoplastic matrix, results in an application-specific lightweight design. By a digitalization of the process chain including design and manufacturing processes, a virtual investigation of the influence of various process parameters on design characteristics is possible. As a result, the optimal process and resulting process parameters can be determined with simultaneous reduction of experimental efforts.

Ulrich Blass

Nithya Sindhe

ulrich.blass@ivw.uni-kl.de
nithya.sindhe@ivw.uni-kl.de

Aircraft struts in different positions



Thermoplastic tension-compression strut

The project "ThermoStrut – Development of a Digitized Process for the Production of Function-Integrated Thermoplastic Aerospace Struts" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 20Q1926B).

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

Partner AFPT

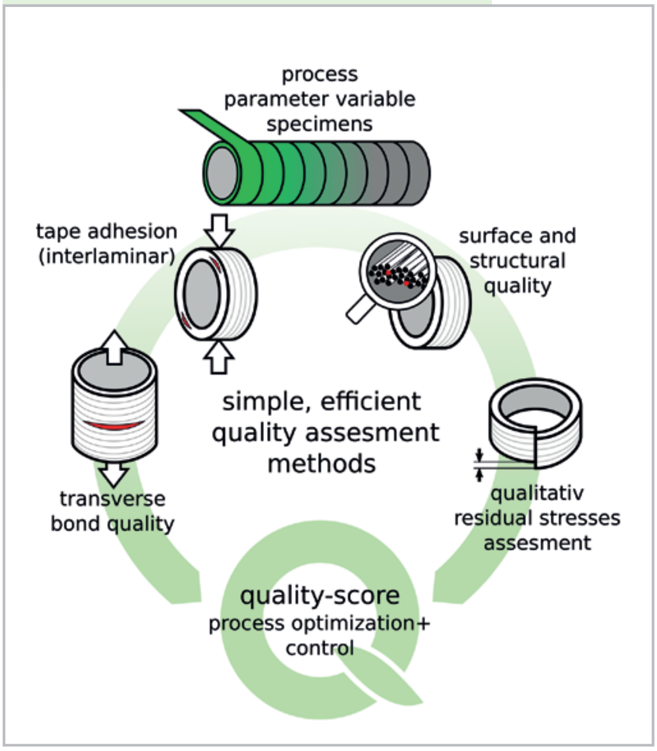
TopTape – Tape Winding Process with integrated Quality Control

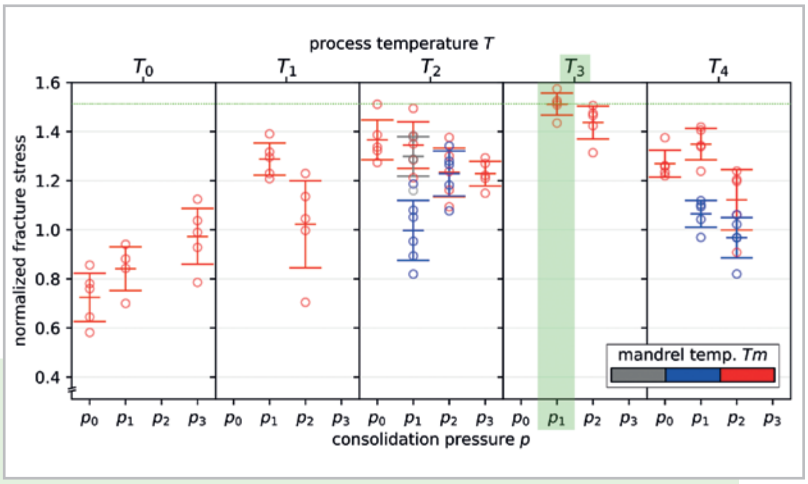
andreas.kenf@ivw.uni-kl.de

Andreas Kenf

Laser-assisted tape winding offers a great potential for fiber reinforced plastic components in e.g. automotive, aviation and oil & gas industry. The fully automatic winding process was brought to a high level of maturity in recent years and due to the integrated sensors and thermography it offers the base for a complete process monitoring in the sense of Industry 4.0. As a result of many manual process steps there is currently a need for improvement in system engineering and quality control that leads to limited application of large-scale production and an increased rejection rate. The determination of optimal process parameters is a complex task, due to many influencing factors. To make this mainly manual process more efficient and operator-independent, new test- and assessment methods were designed.

Simple and efficient test methods for the integration in the laser-assisted tape winding process as a means of process optimization and quality control





Process parameter optimization results for a carbon fiber-polycarbonate-composite, aimed to improve the mechanical properties of wound structures using newly developed test and assessment methods

Therefore, the process setup time can be reduced while improving the component quality. Within this project a carbon fiber-polycarbonate-composite was used to test these new methods. Combined with the also further improved process control, an improvement of the mechanical properties of up to 50% were reached. In this research project an efficient quality assessment process based on simple test methods was developed, improving determination of optimal process parameters and supporting quality control during production.

ZIM Zentrales Innovationsprogramm Mittelstand

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

The project "TopTape – Fully Automated, Laser-Assisted Tapewinding Process with Integrated Quality Control Program" is funded by the Federal Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding ZF4052325).

TPC-H2-Storage – Pressure Vessels for Hydrogen Storage and Transport

christian.becker@ivw.uni-kl.de

Christian Becker

With the project TPC-H2-STORAGE, IVW will open up the growth potential of the hydrogen economy both technically and through an expanded institute infrastructure for the industry, and thus become a competent and central development partner and application center for regional and national companies. The research focuses on the development of a novel hydrogen pressure vessel in thermoplastic design. Figure 1 shows the design of the mold for the production of three pressure vessels and the structure of the pressure vessels. Color-coded are the 0° fiber layers (yellow, green and blue) and the circumferential (90°) fiber layers (red) at different stages of part manufacturing. The axially reinforced plies are manufactured using the 2D tape laying process and subsequent forming into a shell, whereby three shells form a cylindrical part. By wide-ranging investments the project focusses also on specific testing and further development of the thermoplastic reinforced material. This includes expanded process capabilities (i.e. highly functional laboratory heating press, industrial-scale injection molding unit), novel testing equipment (i.e. cyclic tension-compression-torsion testing device (Figure 2)) and advanced analysis capabilities (broadband 2.5D scanning ultrasonic system, Fourier Transformed Infrared Spectroscopy with Thermal Analysis). To achieve a quality-proofed component with continuous optimization, a digital twin of the storage system is developed out of the measured data in this project to display all aspects from the material level up to the component over the entire lifetime. The objective of the TPC-H2-STORAGE project is to establish a suitable infrastructure and fundamental knowledge to enable the future development of particularly efficient mobile as well as stationary hydrogen storage systems on a large scale using thermoplastic fiber composite structures.

Design version of the thermoplastic hydrogen pressure vessel

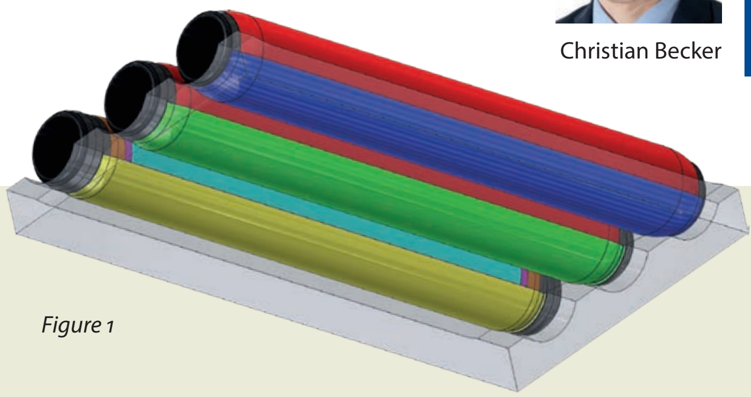


Figure 1

Cyclic tension-compression-torsion testing device: Final design for cyclic testing of laminates under multi-axial stress states

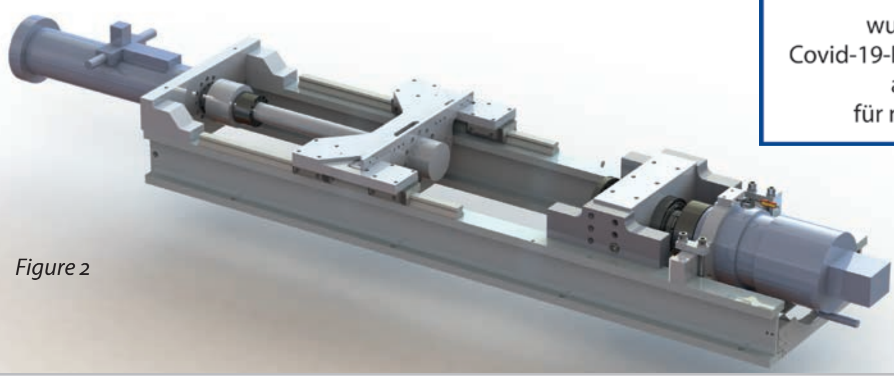


Figure 2

Das Projekt zum Auf- und Ausbau von technologieorientierten Kompetenzfeldern

TPC-H2-Storage

wurde als Teil der Reaktion auf die Covid-19-Pandemie von der Europäischen Union aus dem Europäischen Fonds für regionale Entwicklung gefördert.

The project "TPC-H2-Storage – Infrastructure Development for Thermoplastic Fiber Composite Pressure Vessels for Hydrogen Storage and Hydrogen Transport" is funded by the European Regional Development Fund (ERDF) and the Ministry of Science and Health (MWG) (funding reference 84009883).

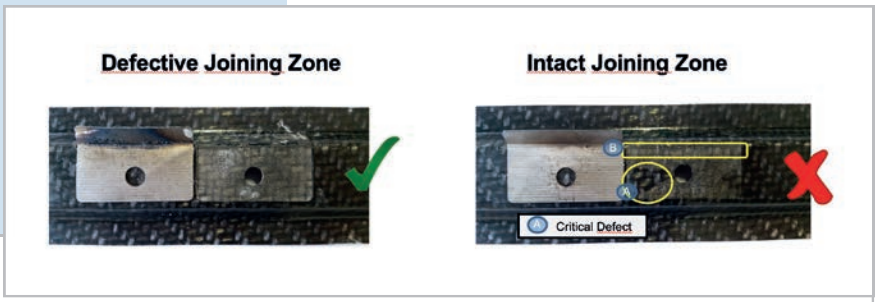
harutyun.yagdjian@ivw.uni-kl.de

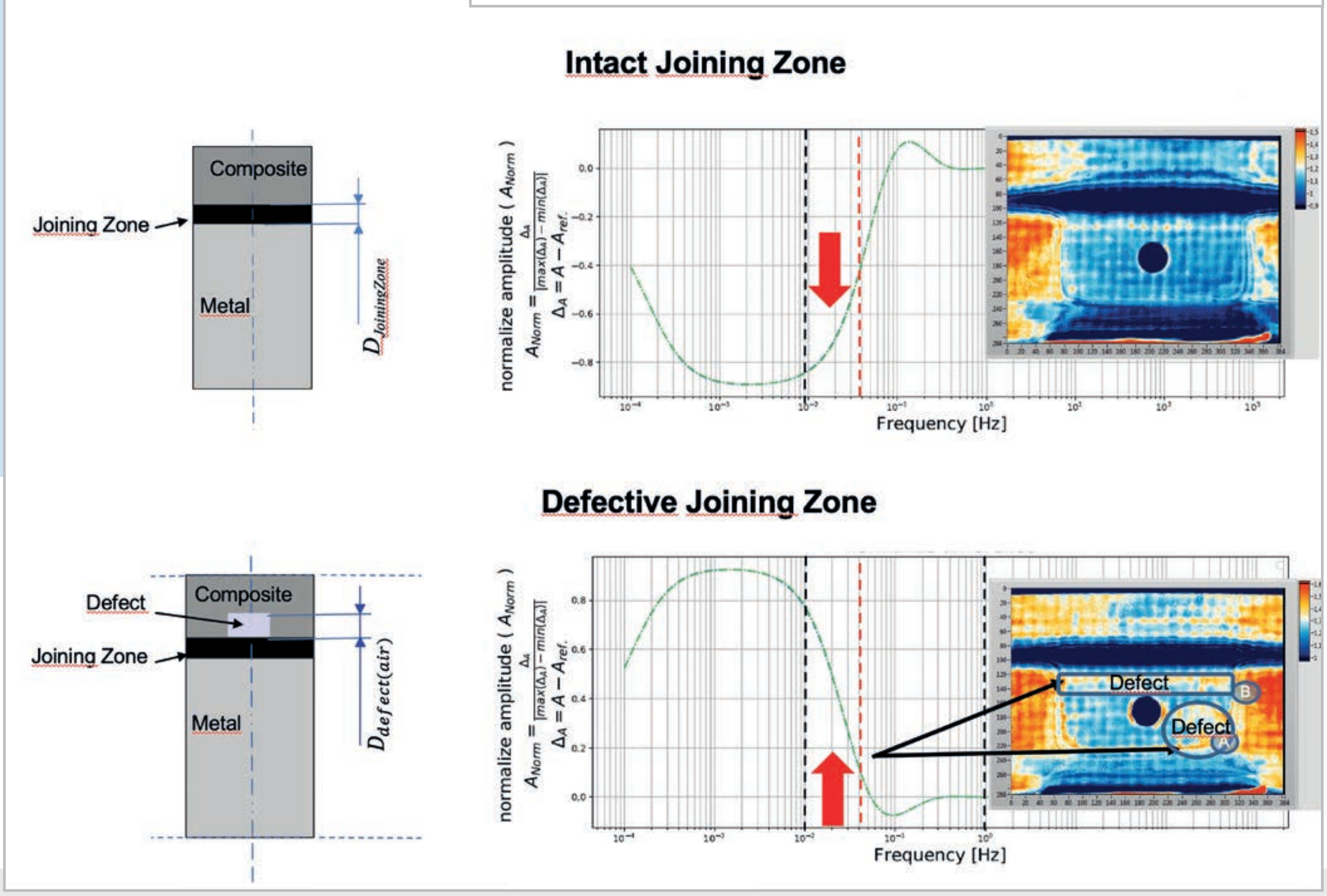
Harutyun
Yagdjian

Model-Based Infrared-Thermography on Hybrid Composite Structures

Non-destructive component testing using infrared thermography (IRT) is a widely used method for examining fiber composite structures for internal defects. The inspection of joints in hybrid structures e.g. made of a thermoplastic continuous fiber reinforced component with a metallic force introduction element by means of lock-in or pulse-phase thermography provides fast, contact-free and imaging information from the hidden joining zone. For a detailed interpretation of the results to decide whether an intact joining zone is present or whether the process was faulty, a quantitative evaluation, together with an analytical model, which quantitatively maps the thermal properties of the component, is essential. Based on measurement data of different material combinations and artificial as well as real defects, multilayer models are developed and validated in this project, which can be used not only to support manual component inspection, but also to develop new, AI-based evaluation algorithms for automated testing.

Analytical n-layers model for quantitative characterization of joining zone in a thermoplastic welding





Waste2BioComp – Converting Organic Waste into Sustainable Bio-Based– Components

Since most plastics are not biodegradable, primary and secondary microplastics (MPs) accumulate and persist in the environment. MPs have been found in a variety of environments, including oceans, freshwater ecosystems, soil and air. As a result, MPs have also been detected in drinking water, beer, food products (e.g., seafood and table salt), as well as in human tissues and organs [1]. To at least partially overcome this problem, a significant decrease in the elimination of the generation of new MPs is required. Since MPs result from a variety of applications, including shoe abrasion, plastic packaging and textiles [2], the Waste2BioComp project is going to develop bio-based and biodegradable polyester polyhydroxyalkanoates from biomass waste streams for applications in these sectors. The aim of this project is the demonstration of relevant scale production of bio-based materials and products as alternatives to conventional fossil derived materials by using innovative manufacturing technologies. The project addresses all steps of a products' life cycle and includes special focus on the feedstock sources for the development of bio-based precursors and intermediate materials. Furthermore, smart inkjet printing and manufacturing technologies, remanufacturing, bio-technological and chemical recycling, and reuse of recyclates are also activities during this project to close the material loop. During all stages of the products development, sustainability and toxicity assessments will be performed. At the final stage of the project, three demonstrators will be manufactured: bio-based films for packaging, textiles/nonwovens for clothing/face masks, and foams for shoe soles, including sandwich shoe insoles.

Source:
1 https://www.britannica.com/technology/microplastic
2 https://www.forschung-und-lehre.de/forschung/fraunhofer-identifiziert-quellen-von-mikroplastik-983

Liudmyla Gryshchuk

liudmyla.gryshchuk@ivw.uni-kl.de

waste2 biocomp

Funded by the European Union

Partners:

Centro Tecnologico das Industrias Textil e do Vestuario de Portugal (PT) Coordinator

GR3N SAGL (CH)

Hochschule Kaiserslautern (DE)

INESC TEC - Instituto de Engenhariade Sistemas de Computadores, Tecnologia da Ciencia (PT)

MAGELLAN – Associacao para a Representacao dos Interesses Portugueses no Exterior (PT)

MTEX New Solution SA (PT)

NIXKA (FR)

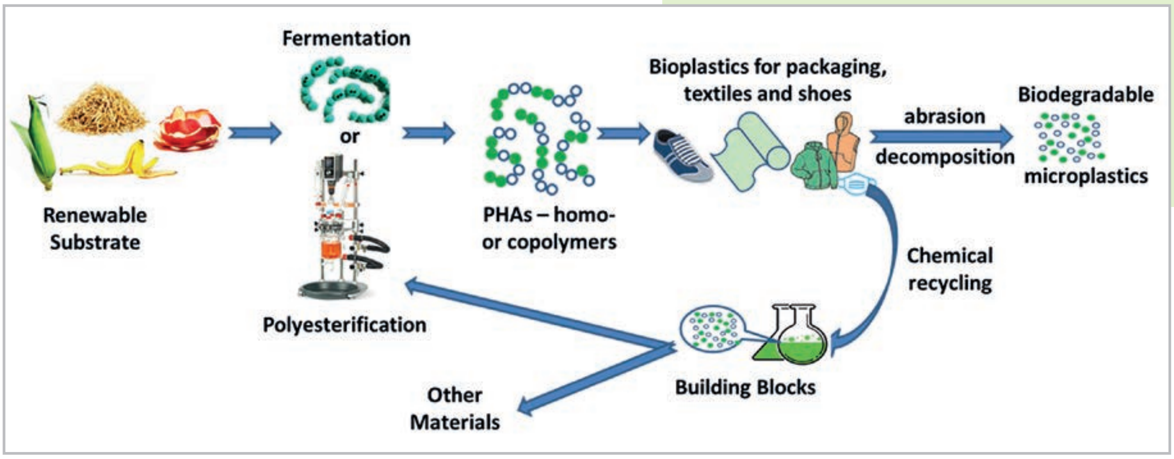
Nora systems GmbH (DE)

PILI (FR)

Propagroup SPA (IT)

Riopele – Têxteis, SA (PT)

Universidade da Coruna (ES)



The project "Waste2BioComp – Converting Organic Waste into Sustainable Bio-Based Components" is funded by the European Union (GA No 101058654).
Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

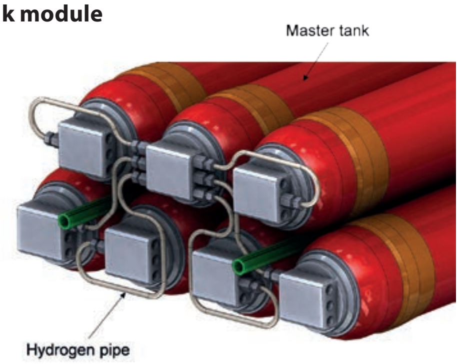
nicole.motsch@ivw.uni-kl.de
thomas.pfaff@ivw.uni-kl.de

WaVe – Innovative FRP Tank Structure for Hydrogen Storage

Nicole
Motsch-Eichmann

Thomas Pfaff

7-tank module



Within the project WaVe, IVW is developing a lightweight optimized FRP pressure vessel tank for the storage of gaseous hydrogen. The tank will be used for the novel hydrogen combustion engine for commercial vehicles in the medium-duty segment. In deviation from FRP pressure tank designs, which are manufactured using a conventional winding process, the optimized tank design can be manufactured very narrowly with maximum lightweight quality and makes optimal use of the installation space thanks to the high packing density. The transfer of the load from the cylindrical FRP area into the metallic dome or fitting is realized by means of the so-called "IVW load introduction". The load is transferred from the longitudinal fiber layers (0° layers) into grooves of the metallic component layer by layer. Circumferential layers press the longitudinal layers into the grooves by means of a preload applied during manufacture and by minimal "sliding" during operation. The tensile stress in the circumferential layers increases by "sliding" onto the larger cross-section of the grooves under both compressive and tensile loads. This likewise increases the compression of the longitudinal layers when load increases. The design allows the load multiplication factor in the load introduction to be minimized to about 1.4 compared to about 3-10 for conventional load introduction variants, enabling enables maximum lightweight construction. The aim of the WaVe project is to transfer this principle to the manufacture of FRP hydrogen tanks. In parallel, a manufacturing process will be developed in which, in contrast to the conventional winding process, only 0° and 90° layers are present without undulation. The tanks will be used in a so-called 7-tank module, where one master tank will be equipped with an On Tank Valve (OTV) for refueling. The master tank will subsequently hydrogen to the connected tanks.

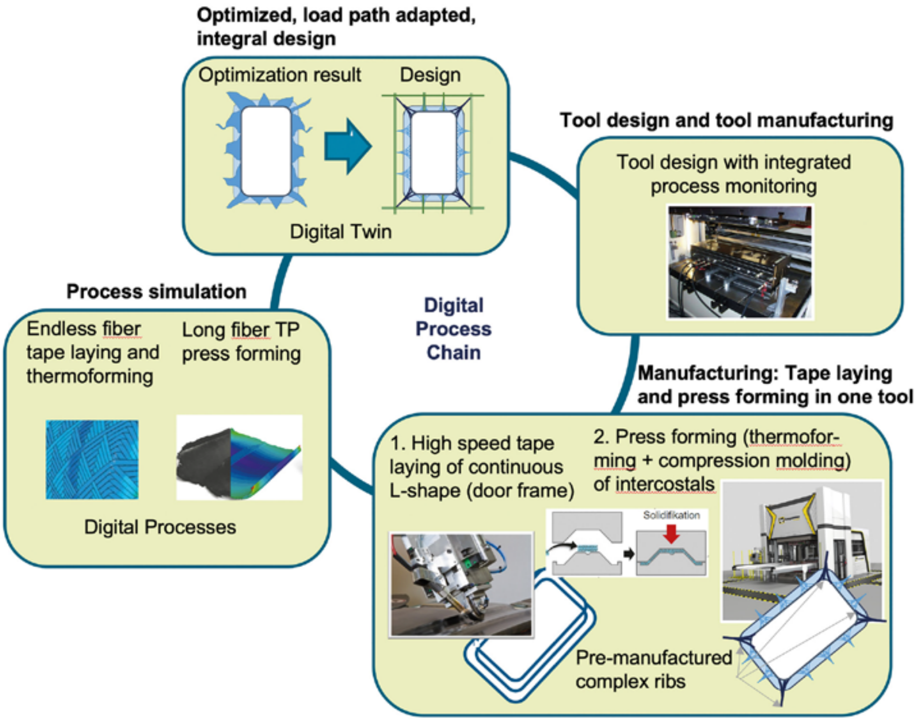
First Demonstrator: Unimog with conventional hydrogen tank system (type 4 pressure vessels)

Partners:
comlet Verteilte Systeme GmbH
Commercial Vehicle Cluster – Nutzfahrzeug GmbH
Daimler Truck AG
HYDAC Process Technology GmbH.
Institut für Oberflächen- und Schichtanalytik GmbH
Photonik-Zentrum Kaiserslautern e. V.
Thomas Magnete GmbH

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

The project "WaVe – Development and Prototype Testing of Hydrogen Combustion Engines as Emission-Minimizing Drive Systems for Commercial Vehicles in the Medium-Duty Segment" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 19I21028K).

ZEUS – Integral Thermoplastic Design Concepts and Processes



Peter Mitschang

peter.mitschang@ivw.uni-kl.de

Concept for the development of a door surround structure made of thermoplastic fiber reinforced polymer composites

As part of the LuFo project ZEUS, IVW is working on the development of integral design concepts, simulation methods and manufacturing processes for thermoplastic (TP) fuselage components of the future, such as the thermoplastic door surround structure and thermoplastic profiles. The main innovation on the part of IVW is the development of the closed chain of component design, process simulation and process development including the validation of the design methods and processes using the manufactured verification structures. The novel integral design of the door surround structure exhibits high lightweighting potential through the implementation of a topology-optimized design and cost efficiency through the combination of fast tape laying and thermoforming processes as well as the integration of connecting and stiffening elements in one step (over injection + co-consolidation). Simulative design of the manufacturing process for thermoplastic profiles also enables quality improvements and allows continuous digitalization of the process chain. The planned process developments futher enable the application of local reinforcements and changes to the profiles at any point. In addition to technological innovations, the production of components with thermoplastic materials offers the opportunity to reduce the ecological footprint through resource-saving processes with low energy consumption and waste minimization. In addition, the digitalization of processes (digital twin, process simulation) offers a variety of approaches to scrap reduction, energy-related process optimization, and reduced tests and NDT inspections.

Partners:
Airbus Operations GmbH
Airbus Aerostructures GmbH
CirComp GmbH
Deutsches Zentrum für Luft- und Raumfahrt e.V.
Fraunhofer-Gesellschaft e.V.
XELIS GmbH
FRIMO GmbH

The project "LuFo-ZEUS – Zero Emission Aircraft with Sustainable Fuselage Concept and Technology" is funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (funding reference 20W2106F).

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

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*

Property rights

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

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

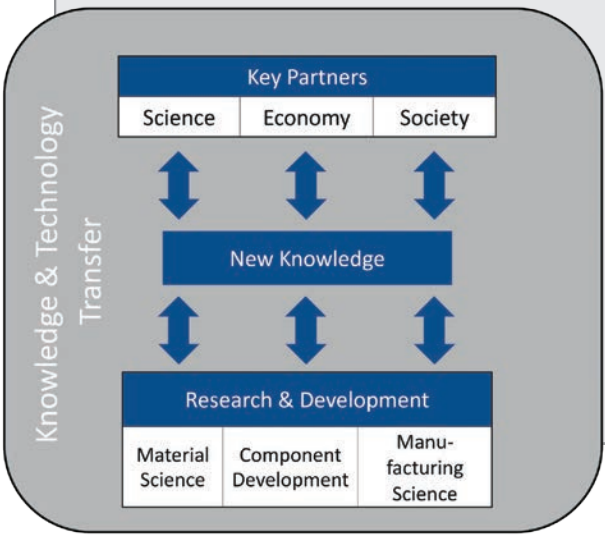
- *Technology is in the mind: We organize the right technical seminars for you*
- *We educate: Our graduates are bearers of advanced technology*

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*

Science communication

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



Contact us!

Dr.-Ing. Robert Lahr
Manager
✆ +49 631 2017 448

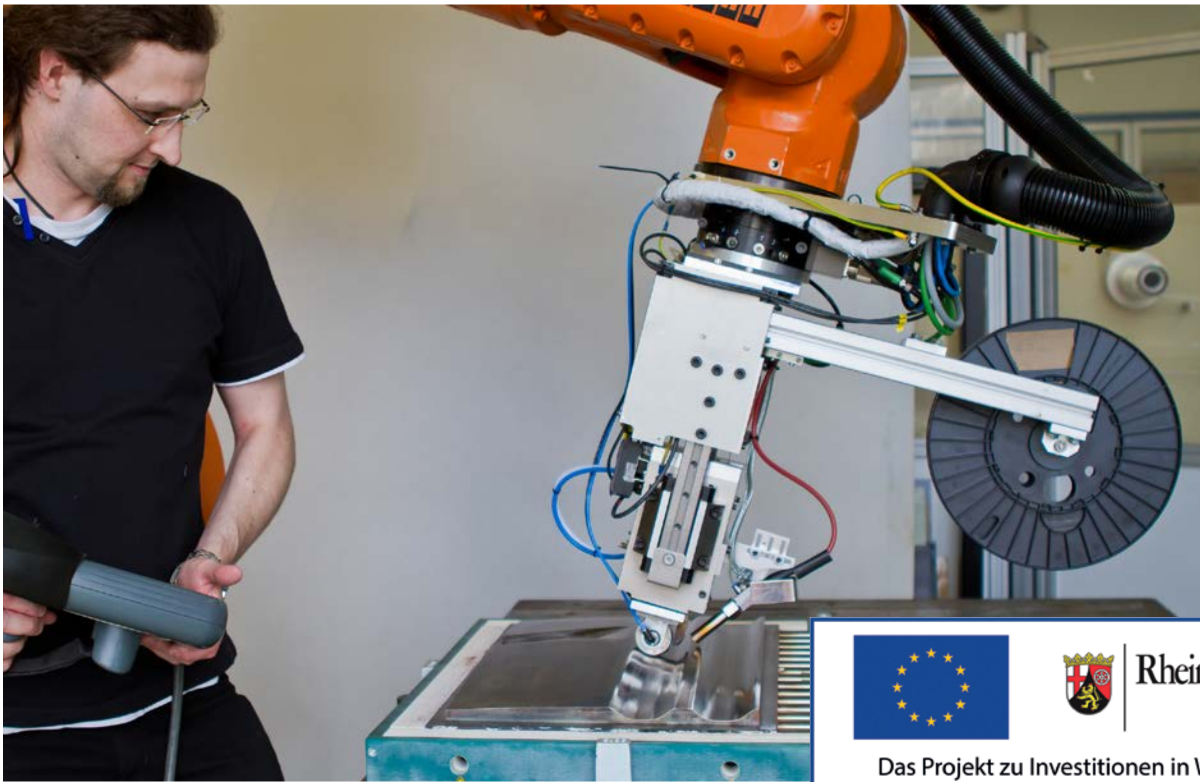
Regina Köhne
Secretary
✆ +49 631 2017 429

Dipl.-Betriebwirtin (FH) Nora Feiden
International funding programs
✆ +49 631 2017 249

Dr.-Ing. Birgit Bittmann-Hennes
International funding programs
✆ +49 631 2017 427

Dipl.-Sporting. Matthias Bendler
National funding programs
✆ +49 631 2017 339

Innovation Center Thermoplastics



Das Projekt zu Investitionen in Wachstum und Beschäftigung
TTC – Technologiezentrum Thermoplastische Composites
wurde von der Europäischen Union aus dem Europäischen Fonds für regionale Entwicklung und dem Land Rheinland-Pfalz gefördert.

Since its foundation, IVW has placed a particular focus on the field of thermoplastic fiber reinforced composites. In the past years, this orientation has been consistently strengthened and further developed for thermoplastic composites of more than regional significance. The expertise built up over many years is incorporated into new developments along the entire process chain of thermoplastic FRP. In 2018, the state of Rhineland-Palatinate has awarded a grant to IVW for a EFRE project titled „TTC – Technology Center for Thermoplastic Composites. From semi-finished product to molded part – highly efficient". With this project, which forms the structure for the technology location Kaiserslautern, the institute is given the opportunity to procure an innovative research infrastructure that will enable its scientists – together with the Science Alliance – to conduct research for the composite materials of the future at the highest level in the coming years. The first technical equipment, such as the world's fastest tape layer or a laser cutting system for thermoplasltic FRP have already been installed. The scientific processing of a large number of public and bilateral projects with the focus on „Thermoplastic FRP" also provides the basis for the further expansion of our expertise. The work in the field of standardization of test methods for thermoplastic FRP should also be emphasized here. Since April 2020, IVW is represented by Dr. Sebastian Schmeer as head of Department 2 (Thermoset and Thermoplastic Molding Compounds) of the Plastics Standards Committee (FNK) of the German Institut for Standardization (DIN). The aim is to introduce a national and international standard for thermoplastic FRP. IVW plays a leading role in research projects in this field as well as in working groups and networks, e.g. the working group for the characterization of UD tapes and organo sheets of the AVK and the working group „Thermoplastics" of the Composite United e.V.. Together with our spin-offs we are also working in the area of tape processing. In addition, the institute's competencies are incorporated into the teaching of the University of Kaiserslautern as well as into supra-regional teaching and further education events. For example, IVW employees regularly conduct further training courses in the field of thermoplastic testing in Augsburg and Stade.

Equal Opportunities at IVW

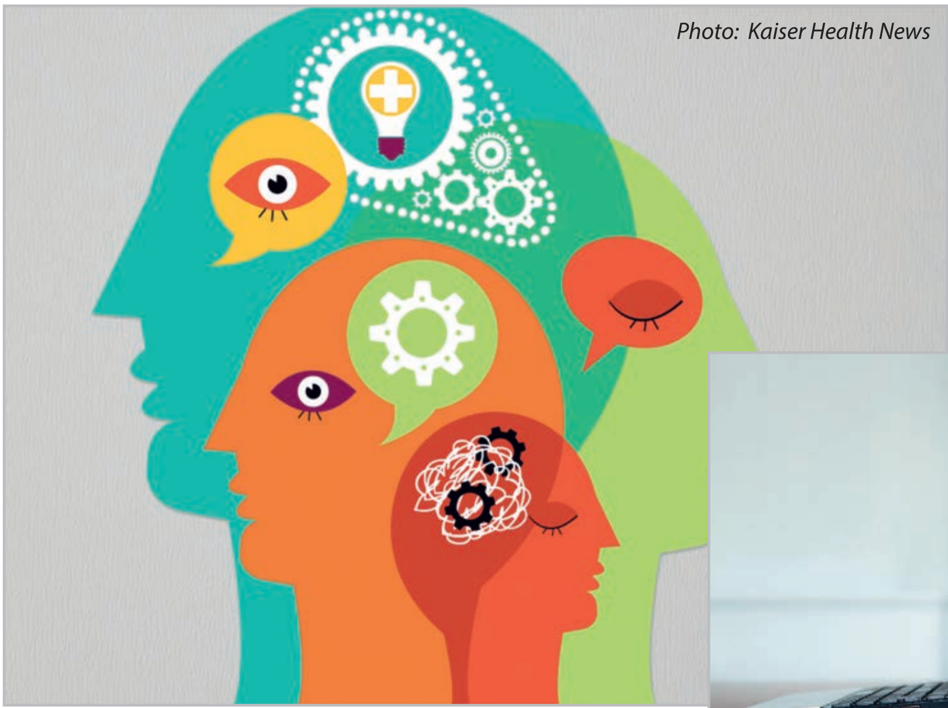
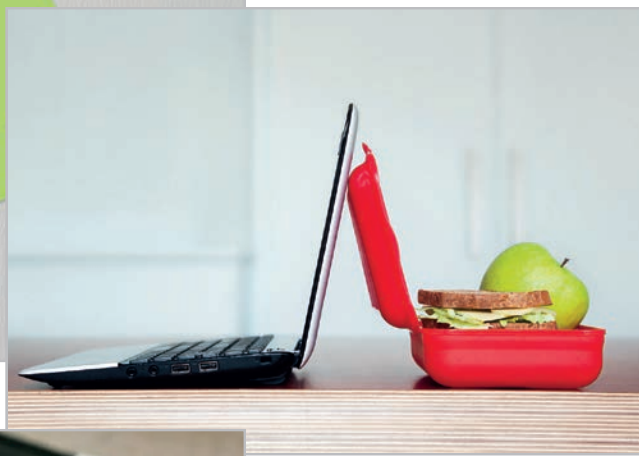


Photo: Kaiser Health News



Photos: Erfolgsfaktor Familie

The year 2022 was dominated by the current crises and resulting challenges. The return from full home office and the transition from pure online meetings to a more balanced daily routine is still ongoing.

Sufficient childcare options for our employees' children remain a daily challenge. Equally important for our employees is the issue of care for the elderly. These and many other issues are discussed and addressed in close cooperation between the Equal Opportunity Officer, Management and the Works Council. Both company agreements and individual regulations are developed that give employees the necessary flexibility in working hours and adapt the working environment as far as possible to the respective to their respective needs.

To keep up to date in the field of equal opportunities we continued and expanded our collaboration and participation in various networks such as the working group Equal Opportunities and Diversity of the Leibniz Association, Erfolgsfaktor Familie corporate network, Total E-Quality association, berufundfamilie Service GmbH, the European Institute for Gender Equality (EIGE), Gender Equality Academy and many more. A tailored workshop on unconscious bias for management and staff was held this year aiming to raise awareness for this particular topic.

Furthermore, IVW participated in specific events to address STEM topics for female students. The Girls' Day and the visits of high school students as well as mentees from the local mentoring network of the SIAK e.V. were highlights in our ongoing activities to promote STEM subjects and present our institute and work environment.

To round off this past year, we were happy again to welcome our staffs' newborns with our special giveaways and congratulate this year's winner of the gender equality award.

Further information can be found on our website under the "Equality & Equal Opportunities" section.

STAFF

In 2022, an average of 119 dedicated employees (FTE) were responsible for outstanding and innovative work, combined with a great deal of scientific knowledge and experience, which again generated valuable research results. They were actively supported by 37 student and research assistants.
Our scientific guests, doctoral students, interns and students in the context of study, diploma, bachelor and master theses also made an important contribution to our research and development work.
Around 270 people from 27 nations were active in a wide variety of positions at the institute this year. The proportion of foreign scientists was around 19%.
Women accounted for around 26% of the staff on average over the year, and around 18% of the scientific staff.
We are happy for Stephan Becker, Andreas Gebhard, Bai-Cheng Jim, Janna Krummenacker, Jan Rehra and Florian Schimmer for successfully completing their doctorates this year. In addition, Dr. Martin Gurka completed his habilitation in 2022.

Congratulations!

Stephan Becker

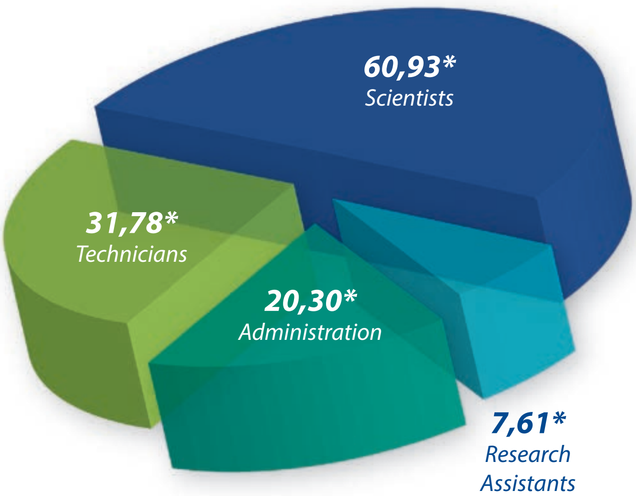
Andreas Gebhard

Bai-Cheng Jim

Janna Krummenacker

Jan Rehra

Florian Schimmer



**Number of full-time equivalents*

In addition

PhD students	*3*
Guest scientists	*6*
Students (theses)	*82*
Trainees	*9*

(Status 03/23)

Pascal Sadaune, M.A.
Administrative Director
pascal.sadaune@ivw.uni-kl.de

Ariane McCauley
Management Assistant
ariane.mccauley@ivw.uni-kl.de

Sylke Fols
Human Resources Manager
sylke.fols@ivw.uni-kl.de

Nina-Sophie Schläfer
Human Resources
nina-sophie.schlaefer@ivw.uni-kl.de

Dipl.-Wirtsch.-Ing. Uwe Schmidt
Head of Finance
uwe.schmidt@ivw.uni-kl.de

Olena Kovalska, M.Sc.
Controlling
olena.kovalska@ivw.uni-kl.de

Meike Lind, B.A.
Head of Accounting
meike.lind@ivw.uni-kl.de

Julia Deubel
Accounting
julia.deubel@ivw.uni-kl.de

Daniela Klaus
Accounting
daniela.klaus@ivw.uni-kl.de

Holger Mann
Accounting
holger.mann@ivw.uni-kl.de

Alina Spitz
Accounting
alina.spitz@ivw.uni-kl.de

Gerhard Wilkens
Accounting
gerhard.wilkens@ivw.uni-kl.de

Dr.-Ing. Jörg Blaurock
Head of Purchasing
joerg.blaurock@ivw.uni-kl.de

Sigrid Bastian
Purchasing
sigrid.bastian@ivw.uni-kl.de

Dr.-Ing. Robert Lahr
Manager KTT
robert.lahr@ivw.uni-kl.de

Regina Köhne
Secretary
regina.koehne@ivw.uni-kl.de

Dipl.-Sporting. Matthias Bendler
KTT
matthias.bendler@ivw.uni-kl.de

Dr.-Ing. Birgit Bittmann-Hennes
KTT
birgit.bittmann@ivw.uni-kl.de

Dipl.-Bw. (FH) Nora Feiden
KTT
nora.feiden@ivw.uni-kl.de

Ina Klemm
Print Media
ina.klemm@ivw.uni-kl.de

Dipl.-Des. (FH) Silvia Hochstätter
Graphic Design
silvia.hochstaetter@ivw.uni-kl.de

Harald Weber
Mechanical Shop
harald.weber@ivw.uni-kl.de

Christian Ackel
Mechanical Shop
christian.ackel@ivw.uni-kl.de

Markus Hentzel
Electrical Shop
markus.hentzel@ivw.uni-kl.de

Bertin Kamdem
Electrical Shop
bertin.kamdem@ivw.uni-kl.de

Dipl.-Ing. (FH) Thomas Schütz
IT
thomas.schuetz@ivw.uni-kl.de

Tobias Neisius
IT
tobias.neisius@ivw.uni-kl.de

Dipl.-Ing. (FH) Hans-Peter Feldner
Facility Management
hans-peter.feldner@ivw.uni-kl.de

Supervisory Board

Dr. Carola Zimmermann
(Chairwoman)
Ministerium für Wissenschaft und Gesundheit, Mainz

Dirk Rosar
(Vice Chairman)
Ministerium für Wirtschaft, Verkehr, Landwirtschaft und Weinbau, Mainz

Susanne Hemer (til March 23)
Ministerium für Wissenschaft und Gesundheit, Mainz

Prof. Dr. Michael Kupke (since March 23)
Deutsches Zentrum für Luft- und Raumfahrt (DLR), Augsburg

Prof. Dr. Werner Thiel
Vice President for Research and Technology, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau

Dr. Bärbel Wernicke (since March 23)
Deutsches Institut für Normung, Berlin

Dr. Petra Wriedt
Ministerium der Finanzen, Mainz

Industrial User Advisory Board

Dr. Guiscard Glück
(Chairman)
BASF SE

Patricia Stöbe, M.Sc.
(Vice Chairwoman)
CompActive GmbH

Dr. Veronika Bühler
SGL TECHNOLOGIES GmbH

Dr. Christina Hack
Brose Fahrzeugteile GmbH & Co. KG

Dr. Martin Hillebrecht
EDAG Engineering AG

Dipl.-Ing. Bernd Räckers
Airbus Operations GmbH

Dipl.-Ing. Barbara Schweickert
BMW AG

Dr. Elmar Witten
AVK – Industrievereinigung faserverstärkte Kunststoffe

Scientific Advisory Board

Prof. Dr. Anita Schöbel
(Chairwoman)
Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Prof. Dr. Paolo Ermanni
(Vice Chairman)
ETH Zürich

Prof. Clemens Dransfeld
TU Delft

Prof. Dr. Katharina Landfester
Max-Planck-Institut für Polymerforschung

Univ.-Prof. Dr. Martin Schagerl
Johannes Kepler Universität Linz

Prof. Dr. rer. nat. Christiane Ziegler
Institut für Oberflächen- und Schichtanalytik GmbH IFOS


Prof. Dr.-Ing. Ulf Breuer
Scientific Director
ulf.breuer@ivw.uni-kl.de


Ariane McCauley
Management Assistant
ariane.mccauley@ivw.uni-kl.de


Dr.-Ing.
Bernd Wetzel
Research Director
Materials Science
bernd.wetzel@ivw.uni-kl.de


Prof. Dr.-Ing.
Joachim Hausmann
Research Director
Component Development
joachim.hausmann@ivw.uni-kl.de


Prof. Dr.-Ing.
Peter Mitschang
Research Director
Manufacturing Science
peter.mitschang@ivw.uni-kl.de


PD Dr.-Ing. habil.
David May
Research Director
Digitalization
david.may@ivw.uni-kl.de


Silke Fischer
Secretary
silke.fischer@ivw.uni-kl.de


Regina Köhne
Secretary
regina.koehne@ivw.uni-kl.de


Karin Assahli
Secretary
karin.assahli@ivw.uni-kl.de


Karin Assahli
Secretary
karin.assahli@ivw.uni-kl.de


PD Dr. rer. nat. habil.
Martin Gurka
Deputy
Research Director
martin.gurka@ivw.uni-kl.de


Dr.-Ing.
Sebastian Schmeer
Deputy
Research Director
sebastian.schmeer@ivw.uni-kl.de


Dr.-Ing.
Jens Schlimbach
Deputy
Research Director
jens.schlimbach@ivw.uni-kl.de


Dipl.-Ing. (FH)
Thorsten Becker
Tailored & Smart Composites
thorsten.becker@ivw.uni-kl.de


Lars Bolzer
Press & Joining Technologies
lars.bolzer@ivw.uni-kl.de


Steven Brogdon
Roving & Tape Processing
steven.brogdon@ivw.uni-kl.de


Stefan Brunner
Tribology
stefan.brunner@ivw.uni-kl.de


Volker Disandt
Digitalized Process &
Material Development
volker.disandt@ivw.uni-kl.de

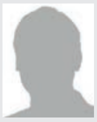

Dipl.-Laborchem.
Pia Eichert
Material Cycles
pia.eichert@ivw.uni-kl.de


Dipl.-Ing. (FH)
Holger Franz
Digitalized Process &
Material Development
holger.franz@ivw.uni-kl.de


Stefan Gabriel
Mechanical
Characterization & Modeling
stefan.gabriel@ivw.uni-kl.de


Dipl.-Ing. (FH)
Stefan Giehl
Press & Joining Technologies
stefan.giehl@ivw.uni-kl.de


Werner Gölzer
Design of Composite Structures
werner.goelzer@ivw.uni-kl.de


Dr.
Marc Hein
Material Cycles
marc.hein@ivw.uni-kl.de


Dipl.-Wirtsch.-Ing. (FH)
Sven Hennes
Roving & Tape Processing
sven.hennes@ivw.uni-kl.de


Dipl.-Ing. (FH)
Peter Mang
Press & Joining Technologies
peter.mang@ivw.uni-kl.de


Erhard Natter
Press & Joining Technologies
erhard.natter@ivw.uni-kl.de


Dipl.-Ing. (FH)
Michael Päßler
Roving & Tape Processing
Press & Joining Technologies
michael.paessler@ivw.uni-kl.de


Dipl.-Ing. (FH)
Thomas Pfaff
Design of Composite Structures
thomas.pfaff@ivw.uni-kl.de


Heidrun Plocharzik
Tailored Thermosets & Biomaterials
heidrun.plocharzik@ivw.uni-kl.de


Christoph Queck
Tailored & Smart Composites
christoph.queck@ivw.uni-kl.de


Ralf Schimmele
Tailored Thermosets & Biomaterials
ralf.schimmele@ivw.uni-kl.de


Dipl.-Ing. (FH)
Uwe Schmitt
Roving & Tape Processing
uwe.schmitt@ivw.uni-kl.de


Dipl.-Ing. (FH)
Ralph Schneider
Fatigue & Life Time Prediction
ralph.schneider@ivw.uni-kl.de


Eric Schott
Press & Joining Technologies
eric.schott@ivw.uni-kl.de


Joachim Stephan
Tribology
joachim.stephan@ivw.uni-kl.de


Dipl.-Ing. (FH)
Petra Volk
Tailored Thermosets & Biomaterials
petra.volk@ivw.uni-kl.de


Dipl.-Ing. (FH)
Rolf Walter
Tailored & Smart Composites
rolf.walter@ivw.uni-kl.de


Torsten Weick
Roving & Tape Processing
torsten.weick@ivw.uni-kl.de

(Status 3/23)

RESEARCH MANAGERS

Prof. Dr.-Ing. Ulf Breuer
Scientific Director
ulf.breuer@ivw.uni-kl.de

Dr. Miro Duhovic
Process Simulation
miro.duhovic@ivw.uni-kl.de

Dr.-Ing. Andreas Gebhard
Tribology
andreas.gebhard@ivw.uni-kl.de

PD Dr. rer. nat. habil. Martin Gurka
Tailored & Smart Composites
martin.gurka@ivw.uni-kl.de

Dr. Barbara Güttler
Material Cycles
barbara.guettler@ivw.uni-kl.de

Prof. Dr.-Ing. Joachim Hausmann
Fatigue & Life Time Prediction
joachim.hausmann@ivw.uni-kl.de

PD Dr.-Ing. habil. David May
Digitalized Process & Material Development
david.may@ivw.uni-kl.de

Prof. Dr.-Ing. Peter Mitschang
Press & Joining Technologies
peter.mitschang@ivw.uni-kl.de

Dr.-Ing. Nicole Motsch-Eichmann
Design of Composite Structures
nicole.motsch@ivw.uni-kl.de

Dr.-Ing. Jens Schlimbach
Roving & Tape Processing
Cost Analysis
jens.schlimbach@ivw.uni-kl.de

Dr.-Ing. Sebastian Schmeer
Mechanical Characterization & Modeling
sebastian.schmeer@ivw.uni-kl.de

Dr.-Ing. Bernd Wetzel
Tailored Thermosets & Biomaterials
bernd.wetzel@ivw.uni-kl.de

A

Sonja Adler, M.Sc.
Material Cycles
sonja.adler@ivw.uni-kl.de

Dr. Emmanuel Isaac Akpan
Tailored Thermosets & Biomaterials
emmanuel.akpan@ivw.uni-kl.de

Christian Andriß, M.Sc.
Mechanical Characterization & Modeling
christian.andriß@ivw.uni-kl.de

Dr.-Ing. Peter Arrabiyeh
Digitalized Process & Material Development
peter.arrabiyeh@ivw.uni-kl.de

B

Andreas Baumann, M.Sc.
Fatigue & Life Time Prediction
andreas.baumann@ivw.uni-kl.de

Christian Becker, M.Sc.
Design of Composite Structures
christian.becker@ivw.uni-kl.de

Dipl.-Ing. Benedikt Bergmann
Roving & Tape Processing
benedikt.bergmann@ivw.uni-kl.de

Dipl.-Ing. Benedikt Boos
Tailored & Smart Composites
benedikt.boos@ivw.uni-kl.de

Jonas Bernhart, M.Sc.
Mechanical Characterization & Modeling
jonas.bernhart@ivw.uni-kl.de

Dipl.-Ing. Ulrich Blass
Design of Composite Structures
ulrich.blass@ivw.uni-kl.de

Stefan Buchalik-Bopp, M.Sc.
Material Cycles
stefan.buchalik@ivw.uni-kl.de

C

Dipl.-Ing. Stefano Cassola
Process Simulation
stefano.cassola@ivw.uni-kl.de

D

Martin Detzel, M.Sc.
Press & Joining Technologies
martin.detzel@ivw.uni-kl.de

Anna Maria Dlugaj, M.Sc.
Digitalized Process & Material Development
anna.dlugaj@ivw.uni-kl.de

Dr.-Ing. Tobias Donhauser
Mechanical Characterization & Modeling
tobias.donhauser@ivw.uni-kl.de

E

Dipl.-Ing. Maximilian Eckrich
Digitalized Process & Material Development
maximilian.eckrich@ivw.uni-kl.de

Esha, M.Sc.
Fatigue & Life Time Prediction
esha@ivw.uni-kl.de

F

Alexander Faas, M.Sc.
Digitalized Process & Material Development
alexander.faas@ivw.uni-kl.de

G

Francis Gonzalez Ramirez, M.Sc.
Fatigue & Life Time Prediction
francis.gonzalez-ramirez@ivw.uni-kl.de

Dr.-Ing. Florian Gortner
Press & Joining Technologies
florian.gortner@ivw.uni-kl.de

Dr. Liudmyla Gryshchuk
Tailored Thermosets & Biomaterials
liudmyla.gryshchuk@ivw.uni-kl.de

Dipl.-Chem. Maurice Gilberg
Tailored Thermosets & Biomaterials
maurice.gilberg@ivw.uni-kl.de

H

Thomas Hoffmann, M.Sc.
Press & Joining Technologies
thomas.hoffmann@ivw.uni-kl.de

Alexander Huf, M.Sc.
Mechanical Characterization & Modeling
alexander.huf@ivw.uni-kl.de

Jannis Hüppauff, M.Sc.
Design of Composite Structures
jannis.hueppauff@ivw.uni-kl.de

J

Jan Janzen, M.Sc.
Digitalized Process & Material Development
jan.janzen@ivw.uni-kl.de

Dipl.-Ing. Julia Jungbluth
Tailored & Smart Composites
julia.jungbluth@ivw.uni-kl.de

K

Dipl.-Ing. Max Kaiser
Tailored & Smart Composites
max.kaiser@ivw.uni-kl.de

Andreas Kenf, M.Sc.
Mechanical Characterization & Modeling
andreas.kenf@ivw.uni-kl.de

Dr.-Ing. Andreas Klingler
Tailored Thermosets & Biomaterials
andreas.klingler@ivw.uni-kl.de

Dipl.-Ing. Robert Köhler
Press & Joining Technologies
robert.koehler@ivw.uni-kl.de

Andreas Krämer, M.Sc.
Press & Joining Technologies
andreas.kraemer@ivw.uni-kl.de

Dr.-Ing. Janna Krummenacker
Fatigue & Life Time Prediction
janna.krummenacker@ivw.uni-kl.de

Ilona Kunzler, M.Sc.
Mechanical Characterization & Modeling
ilona.kunzler@ivw.uni-kl.de

Dipl.-Ing. Manuel Kunzler
Tailored & Smart Composites
manuel.kunzler@ivw.uni-kl.de

M

Konstantin Mehl, M.Sc.
Mechanical Characterization & Modeling
konstantin.mehl@ivw.uni-kl.de

Dipl.-Ing. Florian Mischo
Mechanical Characterization & Modeling
florian.mischo@ivw.uni-kl.de

Martin Müller, M.Sc.
Roving & Tape Processing
martin.mueller@ivw.uni-kl.de

N

Mohamadreza Nasirzade Tabrizi, M.Sc.
Tailored & Smart Composites
mohamadreza.tabrizi@ivw.uni-kl.de

Alexander Nuhn, M.Sc.
Roving & Tape Processing
alexander.nuhn@ivw.uni-kl.de

Vinay Nagaraj, M.Sc.
Design of Composite Structures
vinay.nagaraj@ivw.uni-kl.de

P

Claudius Pirro, M.Sc.
Tailored Thermosets & Biomaterials
claudius.pirro@ivw.uni-kl.de

R

Jan Rehra, M.Sc.
Mechanical Characterization & Modeling
jan.rehra@ivw.uni-kl.de

Fabian Röder, M.Sc.
Digitalized Process & Material Development
fabian.roeder@ivw.uni-kl.de

S

Dipl.-Ing. Maximilian Salmins
Press & Joining Technologies
maximilian.salmins@ivw.uni-kl.de

Stefan Schmidt, M.Eng.
Mechanical Characterization & Modeling
stefan.schmidt@ivw.uni-kl.de

Tim Schmidt, M.Sc.
Digitalized Process & Material Development
tim.schmidt@ivw.uni-kl.de

Dominic Schommer, M.Sc.
Process Simulation
dominic.schommer@ivw.uni-kl.de

Nithya Sinde Narayana Rao, M.Sc.
Design of Composite Structures
nithya.sinde@ivw.uni-kl.de

W

Dipl.-Ing. Stefan Weidmann
Press & Joining Technologies
stefan.weidmann@ivw.uni-kl.de

Marvin Wolf, M.Sc.
Roving & Tape Processing
marvin.wolf@ivw.uni-kl.de

Y

Harutyun Yagdjian, M.Sc.
Tailored & Smart Composites
harutyun.yagdjian@ivw.uni-kl.de

Memberships in Associations & Federations

IVW is actively represented in regional, national and international networks, industry associations and scientific associations.
The aims are to improve technology transfer in all the essential future fields of composites, to ensure supra-regional training and education, and to promote the use of new technologies. Continuing education at the highest level and optimal networking with industrial and research partners.
For Composites United e.V., the leading association of companies and research institutions in the field of composites, the institute is represented in executive committee of the regional section CU West.

AVK Industrievereinigung Verstärkte Kunststoffe e.V., www.avk-tv.de
AiF InnovatorsNet www.aif-ftk-gmbh.de/index.html
CUeV Composites United e.V., www.composites-united.com
CU WEST Regionalabteilung des Composites United e.V.
CVC Commercial Vehicle Cluster – Nutzfahrzeug GmbH, www.cvc-suedwest.com
DGLR Deutsche Gesellschaft für Luft- und Raumfahrt e.V., www.dglr.de
DGM Deutsche Gesellschaft für Materialkunde e.V., www.dgm.de
DGZfP Deutsche Gesellschaft für zerstörungsfreie Prüfung e.V., www.dgzfp.de
Diemersteiner Kreis www.human-solutions.com/diemersteiner_kreis/cms/
DIN Deutsches Institut für Normung e.V., www.din.de
European Alliance for SMC/BMC www.smcbmc-europe.org
FGW Forschungsgemeinschaft Werkzeuge und Werkstoffe e.V., www.fgw.de
fimatec fiber materials technology network, www.iws-nord.de/foerdermittelberatung/zim-netzwerke
GfT Gesellschaft für Tribologie e.V., www.gft-ev.de
IASB Industrieausschuss Strukturberechnungsunterlagen, www.lth-online.de
Kompetenznetz Adaptronik e.V. www.kompetenznetz-adaptronik.de
Kunststoffe in der Pfalz www.kunststoffmanagement.de
RCI - RENEWABLE CARBON INITIATIVE www.renewable-carbon-initiative.com
SAMPE Europe Society for the Advancement of Material and Process Engineering, www.sampe-europe.org
Science and Innovation Alliance Kaiserslautern e.V. www.science-alliance.de
Unternehmensnetzwerk Erfolgsfaktor Familie www.erfolgsfaktor-familie.de
VDI Verein Deutscher Ingenieure e.V., www.vdi.de
Zukunftsregion Westpfalz e.V. www.zukunftsregion-westpfalz.de

Regional Division CU West of Composites United e.V.

COMPOSITES UNITED

The CU West cluster aims to make a decisive contribution to strengthening regional competencies in the field of of high-performance fiber composite technology. With the Leibniz-Institut für Verbundwerkstoffe (IVW), future technologies are being developed in the working groups: "Thermoplastics - from material to automated production", "Smart Structures - multifunctional composites", "Composite Fatigue", "Bio Composites" and "Orthopedic Technology" are being worked on. "With fiber composites, we can provide solutions for applications in crucial industries such as in mobility, energy and health, we can create great added value, both economically and ecologically. This is precisely the reason why we are involved in the CU," says Professor Ulf Breuer, Scientific Director of IVW.

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. The "Composites meet User Industries" series takes place quarterly and addressed the topics of orthopedic technology, shipbuilding, wood industry, cycling and hydrogen technology in 2022.
Composites United e.V. is one of the largest global networks for fiber-based, multi-material lightweight construction with international representatives in Switzerland, Austria, Belgium, Japan, South Korea, China and India.
The headquarters of the association is in Berlin.
IVW is represented on the CU West Executive Committee.

Dr. Heinz Kolz
Managing Director CU West
✆ +49 175 2141051 | heinz.kolz@composites-united.com
https://composites-united.com/cluster/cu-west/

Science & Innovation Alliance Kaiserslautern e.V.

www.siak-kl.com

SIAK
SCIENCE & INNOVATION
ALLIANCE KAISERSLAUTERN

SIAK Review 2022

SIAK is the effective network in the extended science and innovation region of Kaiserslautern on the topics of science, technology, engineering and mathematics (STEM) and their application in transformation processes of digitalization and sustainability.
To master the challenges of digital transformation and especially the challenges of the pandemic, we united numerous partners from science, industry, politics, and society, informed about future research trends, organized online events, and initiated projects and collaborations.
In addition to organizing platforms and task forces and working on technology projects, our members also collaborated in cross-cutting areas such as public relations, recruitment and retention of qualified employees and knowledge transfer.

© Martin Koch Photography

Network Meeting 2022

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

Diemersteiner Kreis

Diemersteiner Kreis is a network of decision-makers from universities, research institutes, business development agencies and enterprises, targeting to increase the numbers of high-tech start-ups in the area of Kaiserslautern. The circle is aiming at a positive change of the start-up climate in the region and sees itself as a forum for a successful implementation.

Objectives:

- *Increase of number and success of high-tech start-ups*
- *Increase of Kaiserslautern's visibility as a business and science location*
- *Support of the economic development of the region*
- *Commitment of professors for business start-ups*
- *Employment creation*

Members:

Business + Innovation Center Kaiserslautern GmbH
DDG - Digital Devotion Group GmbH
Deutsches Forschungszentrum für Künstliche Intelligenz GmbH, DFKI
Empolis Information Management GmbH
Fraunhofer-Institut für Experimentelles Software Engineering IESE
Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM
Hochschule Kaiserslautern
Human Solutions GmbH
Insiders Technologies GmbH
Leibniz-Institut für Verbundwerkstoffe GmbH
Landkreis Kaiserslautern
MP Beteiligungs GmbH
RECARO Group
Science and Innovation Allliance Kaiserslautern e.V.
Stadt Kaiserslautern
Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau
WFK Wirtschaftsförderungsgesellschaft Stadt und Landkreis Kaiserslautern mbH
Wipotec Wiege- und Positioniersysteme GmbH
Zetis GmbH

www.diemersteiner-kreis.de

Diemersteiner Kreis
Science goes Business

Dr. Stefan Weiler
Chairman Diemersteiner Kreis

CONTACT
kontakt@diemersteiner-kreis.de

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.

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) or the Chinese Scholarship Council. In this way, more than 100 exchanges have been enabled since 2010.

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*

Global Network

VolkswagenStiftung

International Cooperation

Through a grant from the Volkswagen Foundation, IVW was able to offer two Ukrainian scientists, who had to leave their country due to the war, an opportunity for further scientific development. Dr. Maryna Novitska and Prof. Nataliia Hudzenko (both from the National Academy of Sciences of Ukraine (Kiev), joined the IVW team in June 2022 and work in the two subprojects "Machine Learning for Flow Simulation - Crossing the Borders Between Civil and Materials Engineering" and "Bio-Based Non-Isocyanate and Phosgene-Free Polyurethanes" to significantly support ongoing work at IVW and to further advance interdisciplinary research.

Funded by Volkswagen Foundation

Dr. Maryna Novitska:
"I am deeply grateful to the Volkswagen Foundation and the Leibniz-Institut für Verbundwerkstoffe for the opportunity provided by the scholarship program. This scholarship has given me the opportunity for further scientific and personal development despite the war in Ukraine. I am deeply grateful for the support."

Prof. Nataliia Hudzenko:
"The Scholarship from the Volkswagen Foundation gives me the possibility to go on with research in the area of the development of bio-based non-isocyanate polyurethanes. Despite the war in Ukraine, this has enabled me to continue my scientific work. I want to thank the Volkswagen Foundation for supporting my research work at such a difficult time for us."

We would like to thank the Volkswagen Foundation for its support.

Automation Steeg & Hoffmeyer GmbH

www.automation-gmbh.com

Dr.-Ing. Markus Steeg
Chief Executive Officer

For more than 50 years the Automation und Steeg Hoffmeyer GmbH represents solutions in special engineering. A core task of the foundation in 1972 was to find efficient and automated technology solutions. Since this time Automation Steeg und Hoffmeyer GmbH has been a reliable and competent partner for the production of semi- and fully automated machinery for the glass and pharmaceutical industry. As quality proof we are proud to announce that much of our equipment is still in use and some machines have been operating for more than three decades. Since 2010, we have established the new business field for fiber reinforced composites. The old goals and core competencies will be retained in automation technology. We deliver customized system solutions, and we build special machines for the automated production of high-quality fiber reinforced composite structures.

CONTACT: Automation Steeg und Hoffmeyer GmbH | Mainzer Landstraße 155 | 55257 Budenheim | info@automation-gmbh.com

A+ Composites GmbH

A+ composites
light ■ stable ■ efficient

Dr.-Ing. Markus Brzeski
Chief Executive Officer

A+ Composites GmbH was founded on June 9, 2015, within the framework of the EXIST Research Transfer Program of the BMWK. The company is specialized in the production of customized fiber-reinforced tapes. These tapes are continuously developed and are used in more and more applications. Fiber-reinforced tapes can be used flexibly, which makes them interesting for many applications from different branches of the plastics processing industry. The main areas of application for A+ Composites are the logistics sector, orthopaedic technology and the automotive industry. In the logistics industry, for example, load carriers can be specifically reinforced with the tapes so that they are significantly more resilient and can hold many times their original loading capacity. In injection molded parts, the continuous fiber-reinforced plastics are used as inserts to improve the mechanical properties of the components. In addition to the production and development of its products, A+ Composites is also active in research projects. For example, the aim of the All-Polymer project, which is funded by the BMBF (Federal Ministry of Education and Research), is to contribute to the recycling of recycled plastics by compensating the lower performance of recycled plastics with tapes. Besides A+ Composites, two universities and three companies are involved in this project.

www.aplus-composites.de

exist Existenzgründungen aus der Wissenschaft

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

ESF Europäischer Sozialfonds für Deutschland

EUROPÄISCHE UNION

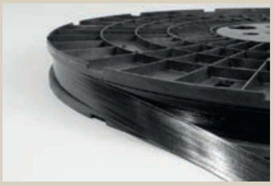
CONTACT: A+ Composites GmbH | Rudolf-Diesel-Straße 7 | 66919 Weselberg | info@aplus-composites.de

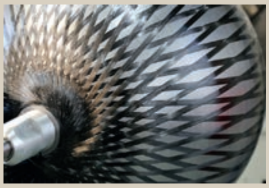
CirComp GmbH

Dr. Ralph Funck
Senior Director R & T

CirComp GmbH is specialized in the manufacturing of components from composite materials in filament winding technology. Furthermore, processing of continuous fiber reinforced thermoplastic tapes is developed and used for cost-efficient production with short cycle times like injection molding or pressforming. By specific combination of different fibers and matrix materials and the use of special reinforcement architectures, the products become tailor-made components of composite materials for different applications and requirements. CirComp GmbH is a guarantor for the reliable supply of high quality products and is leading manufacturer for advanced lightweight and cost-efficient components. CirComp GmbH is a subsidiary of Albany Engineered Composites (AEC) since November 2019. AEC acts at the leading edge of 3D-Weaving Technology followed by high rate RTM and closed molding for Aerospace Application.

www.circomp.de





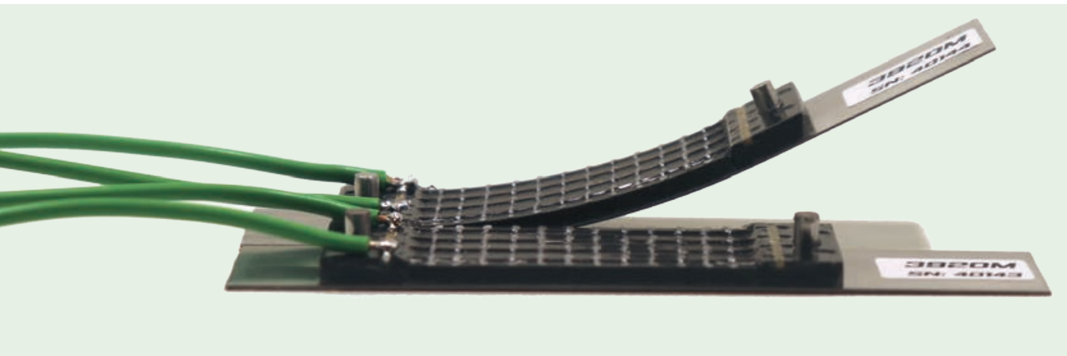
CONTACT: CirComp GmbH | Marie-Curie-Straße 11 | 67661 Kaiserslautern | ksn.sales@albint.com

CompActive GmbH

Dr.-Ing. Moritz Hübler
Chief Executive Officer

CompActive is a young technology company focusing on the development and production of actuators - more specifically novel bending actuators. The patented technology allows the special performance profile of shape memory alloy to be used economically while keeping system complexity low. This means that conventionally required components such as mechanics, motor and gearbox are no longer needed. By integrating the active modules into products, desired adjustment functions are possible in the most compact installation space with minimal additional mass. Whether it's an innovative functional enhancement or a new version of an established adjustment function, CompActive offers everything from feasibility studies and the construction of functional prototypes to detailed design and manufacturing, all the way from the idea to the new series product. The recently established manufacturing facility in Neustadt an der Weinstraße ensures quality and availability "Made in Germany".

www.compactive.de



CONTACT: CompActive GmbH | Erfurterstraße 9-11 | 67433 Neustadt an der Weinstraße | info@compactive.de

Easicomp GmbH

Easicomp GmbH was founded in 2011 and is a leading service provider in the field of LFRT (long fiber-reinforced thermoplastics). Easicomp´s services include, amongst others, counseling, production, development and distribution of thermoplastic composites. The Easicomp team, consisting of qualified and experienced experts in LFRT, can therefore offer its clients "the whole package" around the subject "thermoplastic composites". Current projects address the topics of re- and upcycling as well as antimicrobial functionality in LFT compounds.

Dr.-Ing. Tapio Harmia
Chief Executive Officer

Success made „easi"!

www.easicomp.de

CONTACT: Easicomp GmbH | Junkers-Straße 10 | 67681 Sembach | info@easicomp.de

Evolime GmbH

The current processes for manufacturing wheel structures from fiber-reinforced polymer composites (FRPC) are often not very flexible or require a high degree of manual working steps, making their use uneconomical for many areas of application. The founders of Evolime GmbH have brought an alternative manufacturing technology to market stage. The publicly funded technology development "CompoSpoke" is based on a wet winding process in which fibers are automatically wound onto small molded parts and simultaneously formed into wheel structures. The process is currently the only fully variable process for the production of monolithic composite wheel structures from a single continuous fiber. It is virtually free of waste and therefore has a very good environmental balance. Combined with mold construction using 3D printing, it enables efficient and flexible production of spoked wheels made of carbon and other fiber polymer composites alike. The use of the technology aims primarily at markets in mechanical and plant engineering as well as mobility applications.

Dr.-Ing. Marcel Bücker
Chief Executive Officer

www.evolime.de

CONTACT: Evolime GmbH | Gewerbestraße 4D | 67251 Freinsheim | kontakt@evolime.de

The "CompoSpoke" project is funded by the German Federal Ministry for Economic Affairs and Climate Action and the European Social Fund as part of the EXIST program.

Dr.-Ing. Markus Steffens
Owner & CEO

INTELLIGHT

INTELLIGHT stands for unique competence and more than 20 years of experience in the analysis of potentials, the development and implementation of intelligent plastic, composite and hybrid lightweight construction solutions in almost all industrial sectors.

INTELLIGHT is completely independent in terms of materials and processes: We offer objective expert advice to identify the potentials of lightweight construction solutions in the respective field of application. Based on state-of-the-art engineering methods with computer-aided design and state-of-the-art simulation techniques, we implement lightweight construction solutions tailored to our customers' needs, from the first functional prototype and component testing right up to series production.

www.intellight.de

CONTACT: Intelligent Lightweight Solutions | Am Potzbacher Pfad 7 | 67722 Winnweiler | info@intellight.de

Gründungsbüro RPTU & HS Kaiserslautern

Dr. Bernhard Schu
Manager Gründungsbüro

The „Gründungsbüro" (start-up office) started in 2008 as a competent contact point for all those members of the University of Kaiserslautern and the University of Applied Sciences Kaiserslautern-Landau interested in establishing their own company. Our mission is to embed entrepreneurial spirit and leadership competence in the everyday academic and research practice. The objective of our measures is to increase the number of spin-offs, particularly in the technology sector.

It all starts with raising awareness and qualification for entrepreneurial thinking and acting. Individual consultancy and a broad supply of workshops teach important entrepreneurial core competencies. This helps to develop young leadership personalities, create a supportive environment and strengthen the entrepreneurial spirit.

Students, alumni, scientists and all other staff members of the two universities and research institutes receive professional support tailored to their particular needs and topics. We want to encourage all people to realize their ideas by starting their own business.

The IVW spin-off "Evolime"
received the transfer award 2021
"Founder of the Year"

www.gruendungsbuero.info

CONTACT: Gründungsbüro der RPTU & HS Kaiserslautern | Postfach 3049 | 67653 Kaiserslautern | info@gruendungsbuero.info

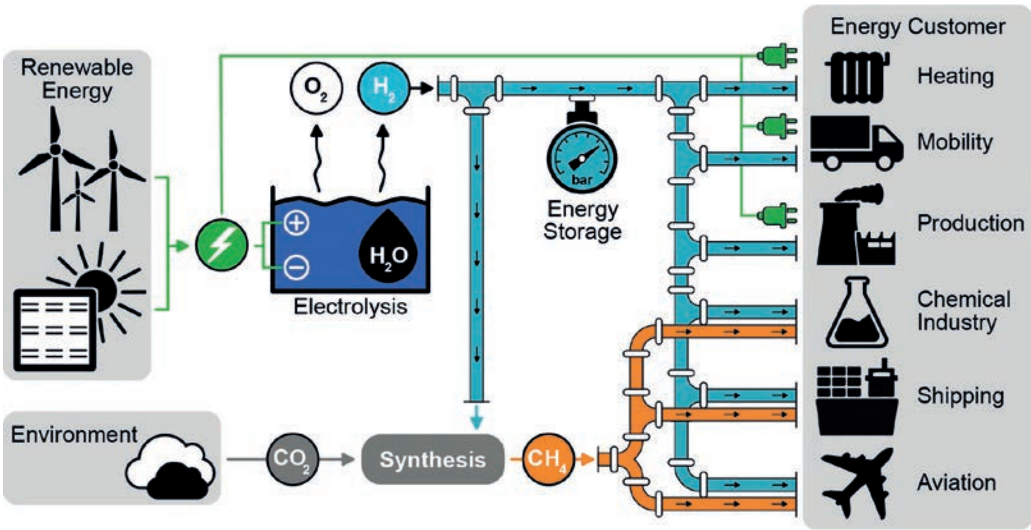
NEW

Isitec-Composites

The development of a sustainable, global energy system based on renewable energies requires a system for coupling all sectors of energy consumption. Green hydrogen, which is generated in a climate-neutral manner from renewable electricity, is a versatile energy carrier and is ideally suited for this. For the practical implementation of a functioning energy economy based on green hydrogen, storage and pipeline transport systems are necessary. Such pipelines are nowadays exclusively made of steel materials. Depending on the operating mode and pressure, they have to be oversized at a high cost, since steel tends to change its mechanical properties when it comes into contact with hydrogen (hydrogen embrittlement). Alternatively, pipelines can be made from fiber-thermoplastic composites. Although these are resistant to hydrogen, they are expensive to manufacture due to the manufacturing methods currently available. Thus, a significant cost advantage compared to steel pipelines is currently not possible. The goal of isitec-composites is to change this. With the help of a new manufacturing process, high-performance pipelines for transporting hydrogen can be manufactured inexpensively from fiber-thermoplastic composites. The basis is a direct impregnation process that enables the processing of raw materials, consisting of fibers and thermoplastic polymer, directly into the finished hydrogen pipe. As a result, intermediate steps of conventional manufacturing methods are avoided, which can lead to a significant cost advantage. The new technology thus offers the opportunity to accelerate the establishment of a climate-neutral, hydrogen-based energy industry by reducing investment costs.

isitec composites

Dr.-Ing. Tobias Donhauser
Project Manager



Climate-neutral energy management based on renewable energies with hydrogen as a key element for coupling different industrial sectors

eXIST Existenzgründungen aus der Wissenschaft
Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag
ESF Europäischer Sozialfonds für Deutschland
EUROPÄISCHE UNION
Zusammen. Zukunft. Gestalten.

CONTACT: Leibniz-Institut für Verbundwerkstoffe | isitec composites | 67663 Kaiserslautern | tobias.donhauser@ivw.uni-kl.de

IVW Student Competition: Congenial Composite Carrier

8 teams of students from the TU Kaiserslautern were extremely inventive and tested their self-built vehicles in good spirits in a competition on the university's sports field on February 11, 2022.

1st Place for team "CarbonTrio"

With a set of various materials and semi-finished products, including carbon and glass fiber fabric as well as synthetic resin, which was made available to all teams at the beginning of the winter semester, and a maximum of 50 euros for additional materials of their own choice, they had to create the smartest possible means of transport. The aim was to transport 3 full milk cartons undamaged and as quickly as possible over a distance of 100 m or as far as possible on the day of the competition. The concept for the drive energy was freely selectable, but fossil and electrochemical drives were "penalized" with a time or distance factor. All students enrolled at TUK or University of Applied Sciences Kaiserslautern were eligible to participate, but doctoral students were excluded. The concepts ranged from the impulse-driven fiber composite pressure vessel "Flitschi 3.0" to rubber- and wind-driven vehicles (team "Fischel"), radio-controlled electric cars with carbon fiber chassis (team "TillRiThen") and sandwich constructions with 3D printed components with winch drive (team "Carbon Trio"). Speeds of over 80 km/h were achieved.

The participants were rewarded - in addition to plenty of fun and audience applause for 3 attempts each - with a book prize and certificates, and the winning teams also received nice cash prizes.

2nd Places for the teams "TillRiThen" and "Flitschi Engineering"

3rd Place for team "Creative Cargo Concept"

Teaching

In 2022, the institute was able to offer 46 semester hours of lectures and laboratories at the University of Kaiserslautern-Landau and the University of Applied Sciences Kaiserslautern with its 3 professors as well as 9 internal and external lecturers. In addition, students gained insights into modern research operations and current, promising research topics by working on student theses. 12 project and student research projects, 10 bachelor theses, 19 master and diploma theses as well as 6 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 Kaiserslautern Landau

Winter Term

	SWh
Introduction to Composite Materials May / Breuer / Hausmann / Wetzel	3
Design and Analysis of Composite Materials Hausmann	2
Commercial Aircraft Composite Technology Breuer	2
Joining Technologies for Composites Geiß / Mitschang	2
Designing with Plastics Endemann	2
Laboratory „Technology of Materials“ Eifler / Geiß / Breuer / Mitschang / Seewig	4
Integrated Product Development with Composites May	2
Biomimetics in Materials Science Wetzel	2
Laboratory „CAE with Composite Materials“ Hausmann / Schmeer / Duhovic	3

Summer Term

	SWh
Processing of Composite Materials Mitschang	2
Design of Composites Schmeer	2
Fatigue and Life Cycles Magin	2
Light Weight Stuctures Hausmann	4
Laboratory „Machine Design“ Beck / Eigner / Geiß / Mitschang / Müller / Sauer / Stephan	4
Physics of Multifunctional Materials Gurka	2

Hochschule Kaiserslautern University of Applied Sciences

Winter Term

Tribologie Gebhard	2
Allgemeine Chemie Gryshchuk	4

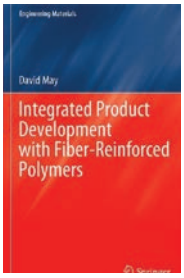
Summer Term

Materialien aus nachwachsenden Rohstoffen und Stoffkreisläufe Gryshchuk	2

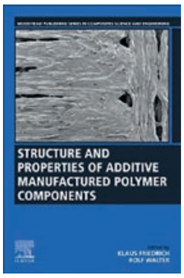
Excerpt from our Intellectual Property Rights

- DE102013102486B3
  Verfahren zur kontinuierlichen Messung des hydrodynamischen 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 Herstellungsvorrichtung 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 Deorbitierung eines künstlichen Satelliten aus der Erdumlaufbahn
  Esha
- DE102021109854.8
  Verfahren zur Auslegung und Betriebsvorhersage 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
- DE10354723B4
  Stoßfängerquerträger für ein Fahrzeug
  Pfaff, Thomas; Schmitt, Uwe
- 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
- DE502013001471.1
  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
- DE102008009540B3
  Vorrichtung zum Umformen eines Werkstückes aus einem thermoplastischen Werkstoff
  Velthuis, Rudi
- DE102005018478B4
  Vorrichtung zum Induktionsschweißen von Kunststoffteilen
  Velthuis, Rudi; Collet, Christoph

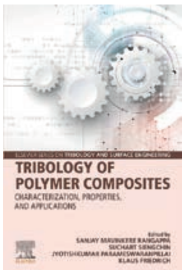
Books by IVW Authors (selection)



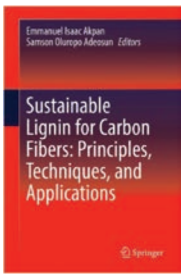
Integrated Product Development with Fiber-Reinforced Polymers
David May
Springer Vieweg, 2021
ISBN: 978-3-030-73406-0
https://www.springer.com/de/book/978030734060



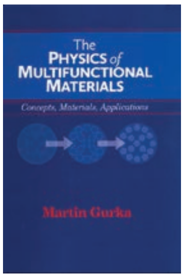
Structure and Properties of Additive Manufactured Polymer Components
Klaus Friedrich, Rolf Walter
Woodhead Publishing, 2020
ISBN: 978-0-12-819535-2
https://www.elsevier.com/books/structure-and-properties-of-additive-manufactured-polymer-components/friedrich/978-0-12-819535-2



Tribology of Polymer Composites: Characterization, Properties and Applications
Sanjay Mavinkere Rangappa, Suchart Siengchin, Jyotishkumar Parameswaranpillai, Klaus Friedrich (Editors)
Elsevier, 2020
ISBN: 978-0-12-819767-7
https://www.elsevier.com/books/tribology-of-polymer-composites/mavinkere-ragapa/978-0-12-819767-7



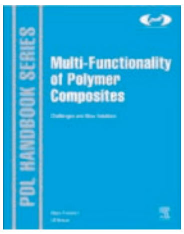
Sustainable Lignin for Carbon Fibers: Principles, Techniques, and Applications
Emmanuel Akpan, Samson Oluropo Adeosun (Editors)
Springer, 2019
ISBN: 978-3-030-18792-7
https://www.springer.com/de/book/9783030187910



The Physics of Multifunctional Materials:
Concepts, Materials, Applications
Martin Gurka
DEStech Publications, 2019
ISBN: 978-1-60595-260-4
https://www.destechpub.com/product/physics-multifunctional-materials/

Commercial Aircraft Composite Technology
Ulf Paul Breuer
Springer, 2016
ISBN: 978-3-319-31917-9
https://www.springer.com/de/book/9783319319179

Materials Chemistry: A Multidisciplinary Approach to Innovative Methods
Klaus Friedrich, Gennady E. Zaikov, A. K. Haghi (Editors)
Apple Academic Press, 2015
ISBN: 978-1-77188-2
https://www.appleacademicpress.com/title.php?id=9781771882514



Multifunctionality of Polymer Composites: Challenges and New Solutions
Klaus Friedrich, Ulf Breuer
Elsevier, 2015
ISBN: 978-0-323-26434-1
https://www.elsevier.com/books/multifunctionality-of-polymer-composites/friedrich/978-0-323-26434-1

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
https://www.hanser-fachbuch.de/buch/Handbuch+Verbundwerkstoffe/9783446436961

JANUARY Prof. Dr.-Ing. Manfred Neitzel Passed Away

On January 24, 2022, the founder and long-time director of our institute, our dear Prof. Dr.-Ing. Manfred Neitzel, passed away.

Professor Neitzel, born in 1934, studied mechanical engineering and received his doctorate from the Technical University of Hanover in 1965. In 1968, he completed his habilitation on the subject of "Composite materials in pressure vessel construction". From 1969 on he worked for BASF, where he was extremely successful in setting up a research group in the field of composite materials. In 1990 he was appointed managing director of the newly founded Institut für Verbundwerkstoffe GmbH. Step by step, with great success, he developed our institute into an important partner for industry and science. At the end of 2002 he left the institute to take his well-deserved retirement.

Professor Neitzel was the author and editor of several textbooks (including "Die Verarbeitungstechnik der Faser-Kunststoff-Verbunde" and "Handbuch Verbundwerkstoffe") and numerous international scientific publications in the field of fiber composites. He contributed to teaching at the Technische Universität Kaiserslautern in the Department of Mechanical and Process Engineering with his own lectures on plastics and composites. At IVW, he successfully built up the area of Manufacturing Science and placed particular emphasis on the promising field of thermoplastic fiber composites as well as on corresponding industrial cooperations for technology transfer. He guided numerous scientific employees, who today work in leading positions in industry and science, to their doctorates.

Professor Neitzel received the highest award of the state, the Order of Merit of the State of Rhineland-Palatinate, for his services to the establishment and further development of IVW. This was presented to him on November 20, 2002 in Mainz by the then Prime Minister of Rhineland-Palatinate Kurt Beck.

Through his creative energy, his positive basic attitude, his great skill in shaping national and international networks, his desire for friendship and cooperation, his leadership and, above all, his special talent for motivating people who were entrusted to his care, he shaped our company from the very beginning and laid the foundations of our success. We remember him with great appreciation and gratitude.

JANUARY Development of Hydrogen Technology through Fiber Composites

Hydrogen technology is one of the greatest hopes in the fight against climate change, for example on the way to sustainable mobility. The Leibniz-Institut für Verbundwerkstoffe (IVW) in Kaiserslautern, which is one of Germany's leading research institutes in the field of innovative materials, is making essential contributions to the success of thicy with its research work. As part of its latest research project in this field, the institute is receiving funding from the state of Rhineland-Palatinate and the European Regional Development Fund (ERDF) totaling €2.9 million for the future development of novel pressure vessels made of innovative thermoplastic fiber composites for the storage and transport of hydrogen.

State Secretary Dr. Denis Alt from the Ministry of Science and Health in Rhineland-Palatinate, said at the presentation of the grant: "The state government promotes hydrogen technology out of conviction. It is a key technology for reducing CO2 emissions: The further development of hydrogen storage technology through the use of fiber composites as part of IVW project represents an important step on the road to climate neutrality in the areas of transport and industry. At the same time, this project will provide important impetus for science and industry in Rhineland-Palatinate and nationwide. This shows once again how important and powerful IVW's research is not only for the region, but for our society."

State Secretary Dr. Denis Alt (right) and Prof. Dr.-Ing. Ulf Breuer (left), Scientific Director of IVW

Professor Ulf Breuer, Scientific Director of the Leibniz-Institut für Verbundwerkstoffe added: “With the funds from this grant project, we will not only be able to develop advanced structures for hydrogen storage and transport, but consequently also invest in the necessary equipment and testing facilities that will enable efficient design and manufacturing. This will take us, our partners and our industrial customers quite decisive steps forward.”

Current hydrogen storage systems made of metal are too heavy for future mobile applications, and the lightweight solutions available to date are not sufficiently capable of large-scale production. For this reason, the basic knowledge and suitable infrastructure for efficient, large-scale production of hydrogen storage and transport systems based on particularly environmentally friendly and recyclable thermoplastic fiber composites will be developed in the future at IVW as part of the project “Infrastructure development for thermoplastic fiber composite pressure vessels for hydrogen storage and transport (TPC-H2-Storage)”.

FEBRUARY *IVW Student Competition 2021/2022*

8 teams of students of the TU Kaiserslautern were extremely inventive and tested their self-made vehicles in a competition on the sports field of the university on February 11, 2022.

The 1st place went to the team “CarbonTrio”, the almost euqal teams “TillRiThen” as well as “Flitschi Engineering” landed on the 2nd place each and the team “Creative Cargo Concept” on the 3rd place.

Further information and pictures of the competition please read the full article on page 78.

APRIL — *MdB Matthias Mieves visits IVW*

On April 14, 2022, Matthias Mieves, Member of the Bundestag, was a guest in Kaiserslautern. He is a full member of the Bundestag's Committee on Digital Affairs as well as the Committee on Health, and he is also a deputy member of the Committee on Climate Protection and Energy. During his visit to TUK, SIAK, DFKI, ITWM, IESE, and IVW, he learned in particular about the competencies of the Kaiserslautern location in the field of health. At the Leibniz-Institut für Verbundwerkstoffe, Janna Krummenacker explained to him the latest developments in the field of implants and orthoses based on fiber composites.

APRIL — *JEC*

JEC World 2022, held in Paris from May 3-5, 2022, is the largest and most important trade show for the composites industry. It provides an overview of the value chain from raw material production and composites production to the final product and downstream services. After a three-year break due to the Covid pandemic, the composites industry met again for international exchange. The event was very well attended with more than 33,000 visitors and more than 1,200 exhibitors from 112 countries. IVW was represented at the joint booth of Composites United e.V. and presented, among other things, new implants for spine and sternum made of carbon fiber-reinforced plastic and developments on thermoplastic fuselage structures for aviation.

MAY — *David May wins BMBF Science Slam*

On May 19, VDI Technologiezentrum GmbH organized the Future Talk on Materials Research in Ingolstadt on behalf of the German Federal Ministry of Education and Research (BMBF), this time under the title "Materials innovations for sustainability and climate protection - focus on electromobility".
Citizens were offered an informative and entertaining insight into new developments as well as the opportunity to discuss with researchers. This also included a science slam on new research areas. Researchers had seven minutes each to present their field of research as entertainingly and comprehensibly as possible.

David May presented his junior research group "Topology-optimized and resource-efficient composites for mobility and transport", which is funded by BMBF at IVW. He won first place with his presentation, which discussed, among other things, the similarities between algorithms for topology optimization, the game Jenga, and the weather map on the evening news. Congratulations!

MAY 2500 tons Press for Research

Science Minister Clemens Hoch (right) and
Prof. Dr.-Ing. Ulf Breuer (left), Scientific Director of IVW

On May 31, 2022, the new Technology Center Thermoplastic Composites "TTC" was ceremonially put into operation at the Leibniz-Institut für Verbundwerkstoffe GmbH (IVW) by Science Minister Clemens Hoch. The centerpiece of the technology center is a new large forming press.

Minister Hoch was impressed by the new technical equipment at IVW: "Excellent research requires excellent research infrastructure. I am pleased that the state of Rhineland-Palatinate, together with the European Union, has been able to help realize the Thermoplastic Composites Technology Center here at IVW. It is a further step towards strengthening the science location Kaiserslautern and materials science in Rhineland-Palatinate. In the development of new materials, construction methods and manufacturing processes lies great potential for engineering sciences and a key to solving numerous societal challenges."

On the occasion of the ceremony, the scientific director of IVW, Professor Breuer, said, "With the commissioning of the 2500 t press from Langzauner, which was specially tailored to research needs, component developments can now also be carried out on a 1:1 scale. This will enable us to produce ultralight and multifunctional structures, which are important for combating climate change and for hydrogen technology, among other things."

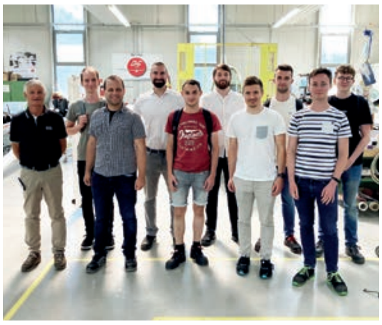
With around 160 employees, IVW Kaiserslautern has already been successful in research and technology transfer for more than 30 years. The fiber composite market is growing at double-digit rates, as this class of materials contributes to greater environmental compatibility, weight and energy savings, increased passenger safety in means of transport and the avoidance of harmful CO_2 emissions for many applications. For this reason, fiber composite technologies from the aerospace industry, e.g. from Ariane or Airbus, are also increasingly being used in automotive engineering, mechanical engineering, the energy sector and also in medical technology.

However, the fiber composites used today are mostly produced with plastics that cannot be remelted, cannot be welded and can only be recycled with very high energy input. In addition, the materials used to date are hardly suitable for the production of very large quantities due to long cycle times. For future applications, therefore, better environmentally compatible thermoplastic fiber composites must be developed that can be economically processed into complex components in very short cycle times. They must also be formable and weldable, and at the end of their service life it must be possible to reuse them as materials for their original purpose.

The concept developed by IVW for the expansion of scientific competencies and the provision of innovative technologies for science and industry in the form of new, cost-effective starting materials, improved component designs and innovative manufacturing technology has been supported over the past 4 years with funding from the European Regional Development Fund "ERDF" and with funding from the state of Rhineland-Palatinate totaling € 10 million. Numerous spin-offs have already emerged from IVW. The latest spin-off project deals with advanced fiber composite technology for the storage and transport of hydrogen.

JUNE *Excursion Days "Industrial Production of Composite Materials"*

As part of the excursion series "Industrial Production of Composite Materials", IVW was invited to DG Flugzeugbau GmbH in Bruchsal and A+ Composites GmbH in Weselberg on June 06. While the participants were able to gain extensive insights into the production of sailplanes at DG Flugzeugbau, the production and testing of thermoplastic tapes was on the agenda at A+ Composites. The excursion series continued on July 07 with a visit to Röchling Automotive in Worms and CirComp in Kaiserslautern. At Röchling, the participants were introduced to several manufacturing processes for fiber-plastic composites in large-scale production, including injection molding and the LFT process. The afternoon program was dedicated to CirComp in Kaiserslautern, a specialist in the field of fiber winding technology.



Visit of DG Flugzeugbau GmbH

In addition to the lectures given by IVW, the excursion days gave the participants the opportunity to expand their specialized knowledge with practical impressions of the industrial production of fiber-plastic composites. We would like to take this opportunity to express our special thanks to the participating industrial companies and long-standing partners of IVW for the insights into their daily business, which contributed significantly to the success of this event.

JUNE *SPOTEC 2022 – 25 Years of Sport and Technology Colloquium*

On June 23 and 24, SPOTEC 2022 took place in Magdeburg with a broad exchange in the field of sports equipment and medical technology. The 25th anniversary of the study

program Sport and Technology was accompanied by an industry colloquium and lecture program.

SEPTEMBER *IVW at BMBF's Virtual Lab Day*

On September 6, 2022, IVW, together with other research institutes, presented a cross-section of the field of materials research at the Virtual Lab Day of the VDI Technology Center. There was a virtual institute tour with videos from the laboratories as well as an overview lecture on the research areas of materials. Around 20 young people from upper secondary schools across Germany took part in the virtual excursion. They were informed about possible applications of innovative materials using concrete examples and were able to ask the scientists questions afterwards.

SEPTEMBER *Technology Day at IVW*

A large number of innovations, e.g. in transportation, medical technology as well as energy technology, are made possible by the use of thermoplastic fiber composites. They are characterized in particular by high lightweight construction potential, durability, particularly low-emission processing, cost-effective semi-finished products, simple shaping options, weldability and the possibility of material recycling.

Particularly high-quality and advanced plant technology has been installed at IVW for this purpose, which is being used to work together with research partners on the applications of tomorrow and the foundations for innovations of the future. In addition to ultra-lightweight solutions for next-generation aircraft or automotive structures, work is also being done, for example, on advanced storage technologies for hydrogen. For medical technology, particularly patient-friendly implants and orthoses made of thermoplastic fiber composites are being developed. New recycling technologies are being researched in order to recover the high-quality carbon fibers at the end of the component's life for new applications.

With over 100 engineers and the latest infrastructure, the Thermoplastic Composites Technology Center "TTC" at Leibniz-Institut für Verbundwerkstoffe is a development catalyst for regional and supraregional medium-sized companies and large enterprises along the entire process chain, from the white sheet of paper to the tested component.

On September 14, 2022, IVW, together with renowned equipment manufacturers, presented the technologies installed in recent years for the design, production and characterization of thermoplastic fiber composites to the professional public. Around 60 participants from industry and research were able to see for themselves the performance of the installed plant technology for ultrafast tape laying, press technology, hybrid component production, advanced X-ray processes and quasi-static and short-term dynamic mechanical material characterization during technical presentations and in the on-site laboratories.

SEPTEMBER *"Space Sustainability Award"*

The European Interparliamentary Space Conference (EISC) and the European Space Agency (ESA) have awarded the "Space Sustainability Award 2021" in the category "Special Jury Mention" to our scientific employee Esha's concept of the self-cremating satellite as a next generation satellite. It was presented at the fall plenary meeting of the EISC on September 16, 2022. This award recognizes young researchers for their ideas that promote sustainable use of space. It provides a platform for these scientists to present their ideas at the European Interparliamentary Space Conference.

The idea addresses the drawbacks and challenges of current sailing devices. For this purpose, a highly efficient sailing device with a consistently high decay rate was developed. The most important aspect of the self-cremating satellite is the solution to the tumbling of the satellite while de-orbiting: the satellite rotates itself while remaining in orbit. Thereby, the conventional sail device cannot provide a constant and consistent high drag force to push the satellite down to earth due its single sail membrane. The self-cremating satellite will eject multiple small sail membranes in each direction instead of one large sail membrane. This will insure that at least one sail membrane contributes to the drag forces. Hence, extremely large sail areas are not needed to de-orbit a satellite into orbit, nor an attitude stabilising system to control the rotation of the sail membrane.

Aside from this, material degradation due to harsh space environment is also used to increase the surface-to-mass ratio. The MLI (multi-layer insulation) will be used as the sail membrane after the operational period of the satellite. Therefore, the process of mass degradation will increase during deorbiting, contributing to a high area-to-mass ratio. This opens the possibility to use sails in large numbers without the risk of high probability of collision. This idea has already been filed for patent by Leibniz-Institut für Verbundwerkstoffe.

SEPTEMBER *Further State Funding for IVW*

The Leibniz-Institut für Verbundwerkstoffe GmbH (IVW) in Kaiserslautern will receive a state grant of 500,000 euros to implement measures that will lead to improvements in energy efficiency as well as additional gains in security against hacker attacks.

State Sceretary Dr. Denis Alt (right) with Pascal Sadaune (left)

Dr. Denis Alt, State Secretary in the Ministry of Science and Health, presented the grant to the IVW management. "The project funding helps ensure that IVW, which works on cutting-edge technologies and materials and makes important contributions to addressing challenges facing society as a whole, can continue to conduct its work under secure and economical conditions in the future," said State Secretary Alt. Pascal Sadaune, administrative director of IVW, said, "The recent state funding contributes twofold to securing our research, through even better protection of our data and through greater self-sufficiency in our energy supply," and Professor Ulf Breuer added, "This is of great importance because we are conducting cutting-edge research for important future fields. These include, for example, the use of fiber composites for storing and transporting hydrogen for the energy transition, new lightweight structures for next-generation vehicles and aircraft, and also applications in medical technology, such as particularly well-tolerated implants or customized orthoses."

OCTOBER *K Plastics Fair*

The world's most important trade fair for the plastics and rubber industry took place in Düsseldorf from October 8-15. The nearly 176,000 visitors from was offered a wide range of the plastics industry. IVW showed its activities in the field of medical technology (implant developments) at the joint stand of the Composites United.

NOVEMBER *Excursion to Airbus Production Site*

On November 3, 2022, students of the lecture "Composites in Aircraft Construction" of Prof. Ulf Breuer (lecture supervising assistant Dipl.-Ing. Julia Jungbluth) were again on an excursion to the aircraft manufacturer Airbus. The program included wing, fuselage and vertical stabilizer production in Stade, from semi-finished fiber products to single part production and component assembly. The tour then continued to the "Final Assembly Line" at the Hamburg plant, where the path from components to the finished aircraft could be followed.

DECEMBER *"JAZZ IM TREPPENHAUS"*

At the 24th edition of "Jazz im Treppenhaus", the Volker-Klimmer-Band presented well-arranged international classics from pop and jazz in the familiar urban atmosphere. Popular jazz standards sung by Lisa Mosinski and accompanied by the Klimmer band on piano, trumpet, saxophone, bass or drums entertained the numerous guests. People met over coffee, cake, appetizers and sparkling wine and refreshed old acquaintances. This success story began in 1997 and since then has complemented the cultural landscape of the TU and the city of Kaiserslautern. During this time, Rolf Walter, Michael Schnoor, and Rolf Jäger have spared no effort to realize this high-quality event, which is open to all interested parties. Thanks to the loyal support of sponsors, it is still possible to offer a relaxed atmosphere with top-class musicians at free admission.

Peer-Reviewed Journal Articles

C. Andriß, A. Kenf, T. Donhauser, and S. Schmeer, “Characterization and modeling of continuous carbon fiber-reinforced polycarbonate under multiaxial loads,” *Composites Part B: Engineering*, vol. 235, p. 109740, 2022, doi: 10.1016/j.compositesb.2022.109740.

P. Bauer, N. Motsch-Eichmann, S. Schmeer, K. Mehl, I. Müller, and J. Hausmann, “Hybrid Thermoset-Thermoplastic Structures: An in-depth study on plasma pretreated continuous fiber-reinforced epoxy specimens,” *Composites Part C: Open Access,* vol. 8, p. 100281, 2022, doi: 10.1016/j.jcomc.2022.100281.

A. Baumann, D. May, and J. Hausmann, “Characterization of metallic bushings in RTM-made composites by in-situ leak detection under mechanical loading,” *Composites Part C: Open Access,* vol. 7, p. 100226, 2022, doi: 10.1016/j.jcomc.2021.100226.

S. Becker and P. Mitschang, “Process Improvement of Continuous Induction Welding of Carbon Fiber-Reinforced Polymer Composites,” *Journal of Materials Engineering and Performance,* vol. 31, p. 7049–7060, 2022, doi: 10.1007/s11665-022-06842-0.

S. Becker, M. Michel, P. Mitschang and M. Duhovic, „Influence of polymer matrix on the induction heating behavior of CFRPC laminates,” *Composites Part B: Engineering,* Volume 231, 2022, doi: 10.1016/j.compositesb.2021.109561

S. Cassola, M. Duhovic, T. Schmidt, and D. May, “Machine learning for polymer composites process simulation – a review,” *Composites Part B: Engineering,* vol. 246, p. 110208, 2022, doi: 10.1016/j.compositesb.2022.110208.

M. Chijiiwa, N. Berger, M. Schäfer, R. Merz, M. Kopnarski, P. Mitschang, and J. A. L’huillier, “Multiple regression analysis of the chemical components effect on wettability at ps laser micro-structured surfaces on stainless steel 304,” *Applied Surface Science*, vol. 607, p. 154852, 2022, doi: 10.1016/j.apsusc.2022.154852.

M. Eckrich, P. A. Arrabiyeh, A. M. Dlugaj, and D. May, “Structural topology optimization and path planning for composites manufactured by fiber placement technologies,” *Composite Structures*, vol. 289, p. 115488, 2022, doi: 10.1016/j.compstruct.2022.115488.

Esha and J. Hausmann, “Development of an Analytical Model to Predict Stress–Strain Curves of Short Fiber-Reinforced Polymers with Six Independent Parameters,” *Journal of Composites Science,* vol. 6, no. 5, p. 140, 2022, doi: 10.3390/jcs6050140.

A. Gebhard and B. C. Jim, “Formation, stability and degradation of transfer films formed by polyphenylene sulfide (PPS) and its composites in dry sliding against steel,” *Wear,* vol. 500-501, p. 204343, 2022. doi: 10.1016/j.wear.2022.204343.

F. Gortner, A. Schüffler, J. Fischer-Schuch, P. Mitschang, and P. Bachmann, “Influence of fungal decay on mechanical properties of bio-based sheet molding compounds (SMC),” *Polymers and Polymer Composites,* vol. 30, p. 1-11, 2022, doi: 10.1177/09673911221145050.

F. Gortner, A. Schüffler, J. Fischer-Schuch, P. Mitschang, and P. Bachmann, “Use of bio-based and renewable materials for sheet molding compounds (SMC) – Mechanical properties and susceptibility to fungal decay,” *Composites Part C: Open Access,* vol. 7, p. 100242, 2022, doi: 10.1016/j.jcomc.2022.100242.

S. Grzesiak, M. Pahn, A. Klingler, E. I. Akpan, M. Schultz-Cornelius, and B. Wetzel, “Mechanical and Thermal Properties of Basalt Fibre Reinforced Polymer Lamellas for Renovation of Concrete Structures,” *Polymers,* vol. 14, no. 4, p. 790, Feb. 2022, doi: 10.3390/polym14040790.

J. Hausmann, Esha, S. Schmidt, and J. Krummenacker, “Mean Value-Amplitude Method for the Determination of Anisotropic Mechanical Properties of Short Fiber Reinforced Thermoplastics,” *Journal of Composites Science,* vol. 6, no. 6, p. 179, 2022, doi: 10.3390/jcs6060179.

B. Khatri, J. Rehra, S. Schmeer, U. Breuer, and F. Balle, “Metal/Carbon-Fiber Hybrid Composites - Damage Evolution and Monitoring of Isothermal Fatigue at Low and Elevated Temperatures,” *Journal of Composites Science,* vol. 6, no. 3, p. 67, 2022, doi: 10.3390/jcs6030067.

A. Klingler, M. Gilberg, B. Wetzel, U. Breuer, and J.-K. Krüger, “Temperature-rate induced polymerization and phase separation of block copolymer toughened polymer composites,” *Composites Science and Technology,* p. 109329, 2022, doi: 10.1016/j.compscitech.2022.109329.

A. Klingler, M. Gilberg, B. Wetzel, and J.-K. Krüger, “Simultaneous access to different types of volume changes and the degree of cure during isothermal polymerization of polymer networks,” *Express Polymer Letters,* vol. 16, no. 11, pp. 1193–1207, 2022, doi: 10.3144/expresspolymlett.2022.87.

A. Klingler, M. Gilberg, J.-K. Krüger, and B. Wetzel, "On volume changes during homopolymerization of polymer networks accessed via "Temperature modulated optical refractometry", *Thermochimica Acta*, vol. 711, p. 179185, 2022, doi: 10.1016/j.tca.2022.179185.

A. Klingler, Q. He, B. Wetzel, T. Allen, L. Ye, and U. Breuer, "Low velocity impact resistance of thin and toughened carbon fibre reinforced epoxy," *Composites Science and Technology,* p. 109362, 2022, doi: 10.1016/j.compscitech.2022.109362.

M. Kosarli, G. Foteinidis, K. Tsirka, N. Markaide, A. Ruiz de Luzuriaga, D. Calderón Zapatería, S. Weidmann and A. S. Paipetis, "3R Composites: Knockdown Effect Assessment and Repair Efficiency via Mechanical and NDE Testing," *Applied Sciences,* vol. 12, no. 14, p. 7269, 2022, doi: 10.3390/app12147269.

J. Lee, M. Duhovic, T. Allen & P. Kelly, "Transverse liquid composite moulding processes for advanced composites material manufacturing," *Plastics, Rubber and Composites*, 51:8, 373-382, https://doi.org/10.1080/14658011.2022.2108983

V. Popow, J. Vogtmann, and M. Gurka, "In-situ characterization of impact damage in carbon fibre reinforced polymers using infrared thermography," *Infrared Physics & Technology,* vol. 122, p. 104074, 2022, doi: 10.1016/j.infrared.2022.104074.

T. Rief, N. Motsch-Eichmann, D. May, and J. Hausmann, "Development of a new method for manufacturing hollow fibre-reinforced plastic structures for aeronautical applications using structural CFRP cores," *Plastics, Rubber and Composites*, vol. 51, no. 8, pp. 407–417, 2022, doi: 10.1080/14658011.2022.2117120.

V. Romanenko, M. Duhovic, D. Schommer, J. Hausmann, and J. Eschl, "Advanced process simulation of compression molded carbon fiber sheet molding compound (C-SMC) parts in automotive series applications," *Composites Part A: Applied Science and Manufacturing,* vol. 157, p. 106924, 2022. doi: 10.1016/j.compositesa.2022.106924.

M. Salmins and P. Mitschang, "Bending properties of structural foams manufactured in a hot press process," *Advanced Manufacturing: Polymer & Composites Science*, vol. 8, issue 3 p. 117 - 133, 2022, doi: 10.1080/20550340.2022.2077277.

J. E. Semar, D. May, and P. Mitschang, "Evaluation of different bonding strategies for glass fibre-reinforced epoxy resin with embedded elastomer layers," *Plastics, Rubber and Composites,* Volume 51, Issue 8, p. 454-461, doi: 10.1080/14658011.2022.2111512.

J. Rehra, C. Andriß, S. Schmeer, and U. P. Breuer, "Describing the Material Behavior of Steel and Carbon Fiber Reinforced Composites Using a Combined Damage-Plasticity Approach," *Journal of Composites Science,* vol. 6, no. 8, p. 235, 2022, doi: 10.3390/jcs6080235.

S. Weidmann, P. Volk, P. Mitschang, and N. Markaide "Investigations on thermoforming of carbon fiber reinforced epoxy vitrimer composites," *Composites Part A: Applied Science and Manufacturing*, vol. 154, 2022, doi: 10.1016/j.compositesa.2021.106791

B. Willenbacher, D. May, and P. Mitschang, "Saturated out-of-plane permeability and deformation metrology of textiles at high levels of injection pressure," *Advanced Manufacturing: Polymer & Composites Science,* Volume 8, Issue 2, p. 97-101, 2022, doi: 10.1080/20550340.2022.2064070.

Specialized Conferences

P. Arrabiyeh, M. Eckrich, A. M. Dlugaj and D. May, "Wet Fiber Placement - Additive manufacturing with fiber bundles impregnated with thermoset resin", presented at the *ACME 5- 5th International Symposium on Automated Composites Manufacturing,* Bristol, UK, 2022.

Baumann and J. Hausmann, "Irradiation induced crosslinking in thermoplastic polyurethanes for structural applications" presented at the *23. Symposium Verbundwerkstoffe und Werkstoffverbunde,* Leoben, Austria, 2022.

P. Bauer, K. Mehl, N. Motsch-Eichmann, S. Schmeer, I. Mueller and J. Hausmann, "A novel hybrid thermoset-thermoplastic robot-based production concept for lightweight structural parts: A special view on the hybrid interface," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

C. Becker, N. Motsch-Eichmann and J. Hausmann, "In-Situ X-Ray Microscopy on CFRP to validate a meso-level based material model for simulative damage prediction," presented at the E*SMC 2022, European Solid Mechanics Conference,* Galway, Ireland, 2022.

C. Becker, N. Motsch-Eichmann and J. Hausmann, "Analysis of the mechanical and fracture behavior of recycled carbon staple fiber yarn under static load," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

B. Bergmann and J. Schlimbach, "Novel process for the filament winding," presented at the 23. Symposium Verbundwerkstoffe und Werkstoffverbunde, Leoben, Austria, 2022.

M. Duhovic, T. Hoffmann, D. Schommer, J. Ernst, K. Schladitz, A. Moghiseh, F. Gortner, J. Hausmann, P. Mitschang, K. Steiner, "Digitizing the production of carbon fiber sheet molding compounds," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

M. Duhovic, S. Cassola, T. Hoffmann, P. Mitschang, "Towards Faster 3D Simulations of CFRTP Induction Welding", presented at the *16th LS-DYNA Forum 2022,* Bamberg, 2022

M. Eckrich, P. Arrabiyeh, A. Dlugaj and D. May, "Topology-Optimized Design to Manufacture for Wet Fiber Placement," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

M. Fickert and A. Gebhard, "Improved Design Process of Dry-Running Plastic Radial Plain Bearings," presented at the *23rd International Colloquium Tribology,* Stuttgart/Ostfildern, 2022.

G. Foteinidis, M. Kosarli, K. Tsirka, A. Ruiz De Luzuriaga, A. Leroy, T. De Lumley Woodyear, S. Weidmann, A. S. Paipetis, "Mechanical characterization of 3R-Repairable composites and 3R bonding techniques produced b different processes and their repair efficiency," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

G. Foteinidis, M. Kosarli, K. Tsirka, A. Ruiz De Luzuriaga, A. Leroy, T. De Lumley Woodyear, S. Weidmann and A. S. Paipetis, "Structural Health Monitoring (SHM) on fibre reinforced composite T-joint geometry manufactured by a novel 3R resin," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

A. Gebhard, B.C. Jim, E. Kuksa, "In-Situ Detection and Quantification of Transfer Films," presented at the *4th International Conference on Polymer Tribololgy,* Stockholm, Sweden, 2022.

A. Gebhard, W. Kassem, and M. Oehler, "Cylinder-on-ring model wear tests as an input data source for the simulation of the friction and wear of plastic gears," presented at the *4th International Conference on High Performance Plastic Gears 2022,* Garching b. München, 2022.

M. Gilberg, B. Wetzel, and J.-K. Krüger, "Determination of Polymerization-Induced Volume Changes of UV-Curable Resins via TMOR," presented at the *Poly-Char 2022,* Halle, 2022.

M. Gilberg, J. K. Krüger and B. Wetzel, „Investigation and optimization of UV curable resins via TMOR for the production of low-shrinkage glass fiber composites," presented at the *23. Symposium Verbundwerkstoffe und Werkstoffverbunde,* Leoben, Austria, 2022.

L. Gryshchuk, S. Unik. "Influence of recycled polyurethane-polyols on the properties of rigid polyurethane foams for pre-insulated pipes" presented at the *International Conference Polymers 2022 – New trends in Polymer Science: Health of the Planet, Health of the People,* Turin, Italy, 2022.

L. Gryshchuk, S. Grishchuk, M. Gilberg. "Novel bio-based indirect polyurea resins" presented at the *International Conference Polymers 2022 – New trends in Polymer Science: Health of the Planet, Health of the People,* Turin, Italy, 2022.

B. E. Güttler, „Bio-based Composites & Circular Economy“, presented at the *Composites Lounge Conference CLC 3.0,* online, 2022.

B. E. Güttler, „Biocomposites: the Past, Present and Future“, presented at the *Sustainable Composites Conference*, online, 2022.

T. Hoffmann, S. Becker, M. Duhovic and P. Mitschang, “Influence of Polymer Matrix on the Induction Heating Behavior of CFRPC Laminate,” presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

J. Hausmann, Esha, S. Schmidt, J. Krummenacker, “Layerwise extraction of anisotropic mechanical properties of short fiber reinforced thermoplastics,” presented at the *ITHC 2022, 6th International Conference and Exhibition of Thermoplastic Composites,* Bremen, 2022.

J. P. Hüppauff, “Influence of the Boundary conditions on the low-velocity-impact behavior of curved composites plates,” presented at the *SAMPE Europe Conference 2022,* Hamburg, 2022.

J. P. Hüppauff, T. Pfaff, N. Motsch-Eichmann and J. Hausmann, “Optimized design of leightweight hydrogen pressure vessels,” presented at the *23. Symposium Verbundwerkstoffe und Werkstoffverbunde*, Leoben, Austria, 2022.

J. P. Hüppauff, N. Motsch-Eichmann and J. Hausmann, “Einfluss der Einspannung auf das Low-velocity-Impakt-Verhalten von gekrümmten Strukturen,“ presented at the *DLRK 2022, Deutscher Luft- u. Raumfahrtkongress,* Dresden, 2022.

J. P. Hüppauff, J. Hausmann, N. Motsch-Eichmann and T. Pfaff, “Optimized design for lightweight hydrogen pressure vessels”, presented at the *5th International Conference Hybrid 2022 - Materials and Structures,* Leoben, 2022.

M. Kaiser, M. Gurka, and M. Kunzler, “Airfoil trailing edge morphing based on modified SMAHC concept: design, implementation, and experimental studies,” presented at the *SPIE Smart Structures + Nondestructive Evaluation,* Long Beach, United States, 2022.

R. Köhler, F. Gortner, P. Mitschang, H. Lengsfeld and J. Schneider, “Developement of a carbon fiber reinforced sheet molding compound for high temperature applications,” presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

M. Kunzler, M. Kaiser, S. Fischer and M. Gurka, “Design, construction and simulation of a shape memory alloy based morphing airfoil demonstrator based on the agonist-antagonist principle,” presented at the *SPIE Smart Structures + Nondestructive Evaluation,* Long Beach, United States, 2022.

J. Lee, M. Duhovic, T. Allen and P. Kelly, “Transverse Liquid Composite Molding Processes and Lubrication Effects in Advanced Composites Material Manufacturing”, presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

F. Mischo, A. Kenf, M. Kammler and S. Schmeer, “Influence of Manufacturing Procedure on Mechanical Properties of Continous Fiber Reinforced Thermoplastics,” presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

N. Motsch-Eichmann, J. Hüppauf, T. Pfaff, and J. Hausmann, “Novel Structure integrated hydrogen storage systems for aerospace applications,” presented at the *SAMPE Europe Conference 2022,* Hamburg, 2022.

N. Motsch-Eichmann and S. Fischer, “Hybrid lightweight Front Loader Bucket in Metal/ Fiber Composite Construction”, presented at the *7. Internationales Commercial Vehicle Technology Symposium,* Kaiserslautern, 2022.

V. Nagaraj, “A comparative study on using BESO and SIMP to optimize the design of laminated carbon fiber reinforced plastics using topology optimization,” presented at the *SAMPE Europe Conference 2022,* Hamburg, 2022.

V. Nagaraj, N. Motsch Eichmann und J. Hausmann, “Anisotropic topologa optmization of carbon fiber reinforced composite materials engineered with novel manufacturing technologies,” presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

V. Nagaraj, J. P. Hüppauff, T. Pfaff, N. Motsch-Eichmann and J. Hausmann, “Neuartige strukturintegrierte Wasserstoffspeicher für Luftfahrtanwendungen,“ presented at the *DLRK 2022, Deutscher Luft- u. Raumfahrtkongress,* Dresden, 2022.

M. Novitska, M. Duhovic and D. May, “Microscale domain permeability calculations of fiber reinforcement structures based on the lattice Boltzmann method”, presented at the *VI International Scientific-Technical Conference, Actual Problems of Renewable Power Engineering, Construction and Environmental Engineering,* Kielce, Poland, 2022.

Specialized Conferences

A. Nuhn, Esha, N. Motsch-Eichmann and J. Schlimbach, "Hybrid Processing of Coupling Rod", presented at the *VI International Scientific-Technical Conference, Actual Problems of Renewable Power Engineering, Construction and Environmental Engineering,* Kielce, Poland, 2022.

M. Salmins and P. Mitschang, "Influence of process parameters on properties of thermoplastic structural foams manufactured through hot press process," presented at the *ITHEC 2022, 6th International Conference and Exhibition of Thermoplastic Composites,* Bremen, 2022.

M. Salmins and P. Mitschang "Influence of compression behavior on skin formation in thermoplastic structural foams manufactured in a hot press process," presented at the *SAMPE Europe Conference 2022,* Hamburg, 2022.

S. Schmeer, F. Mischo and D. Scheliga, "Tapered geometry for testing continuous fiber reinforced thermoplastics under tension," presented at the *ECCM20, 20th European Conference on Composite Materials,*Lausanne, Switzerland, 2022.

T. Schmidt, E. Syerko, D. May, C. Binetruy, L. Silva, S.V. Lomov, S.G. Advani, "First insights from the virtual permeability benmark on a fibrous microstructure," presented at the *ECCM20, 20th European Conference on Composite Materials, Lausanne,* Switzerland, 2022.

J. Schlimbach, A. Nuhn, T. Rief, and N. Motsch-Eichmann, "Structural optimization and process for a hybrid coupling rod", presented at the *Materials Science and Engineering MSE Congress,* Darmstadt, 2022.

D. Schommer, T. Hoffmann, M. Duhovic and D. May, "Prozess Digitalization of Carbon Fiber Sheet Molding Compounds (C-SMC)," presented at the *9. Fachkongress Composite Simulation,* Kaiserslautern, 2022.

D. Schommer, N. Sindhe Narayana, T. Rief, M. Duhovic, N. Motsch Eichmann and J. Hausmann, "Digital process chain for thermoplastic structural components with local unidirectional reinforcements for aerospace applications," presented at the *ICMAC 2022, International Conference on Manufacturing of Advanced Composites,* Sheffield, UK, 2022.

J. E. Semar, D. May and P. Mitschang, "Entwicklung einer modularen, forschungstauglichen RTM-Injektionsanlage für in-situ polymerisierende Thermoplaste", presented at the *23. Symposium Verbundwerkstoffe und Werkstoffverbunde,* Leoben, Austria, 2022.

M. Szcesny, P. Middendorf, M. Päßler and B. Bergmann, "Development and validation of a gravity independent inline impregnation method for multi-tow robotic coreless fiber winding," presented at the S*AMPE Europe Conference 2022,* Hamburg, 2022.

M. O. Voltz, O. Zöllner and P. Mitschang, "Effects of thermoforming parameters on surface quality of unidirectional reinforced amorphous thermoplastic composites," presented at the *ITHC 2022, 6th International Conference and Exhibition of Thermoplastic Composites,* Bremen, 2022.

J. Weber and J. Schlimbach, "Co-Consolidation of Tape-Preforms to realize local reinforcements presented at the stamp-forming," presented at the *SAMPE Europe Conference 2022,* Hamburg, 2022.

J. Weber and J. Schlimbach, "Herstellung von rCF-Tapes aus co-mingled Stapelfasergarnen", presented at the *15th Colloquium re4tex – recycling for textiles,* Chemnitz, 2022.

J. Weber and J. Schlimbach, "Co-consolidation and stamp-forming as an one-shot process to manufacture complex CF/PEEK parts," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

S. Weidmann and P. Mitschang, "In-line-quality assurance and process control fully automated welding process," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

S. Weidmann and P. Mitschang, "In-line-quality assurance and process control fully automated welding process," presented at the *23. Symposium Verbundwerkstoffe und Werkstoffverbunde,* Leoben, Austria, 2022.

S. Weidmann and P. Mitschang, "Induction joining for thermoplastic fiber reinforced polymer composites and metals for automotive applications," presented at the *Automotive Circle: 25th Global Car Body Benchmarking Conference in Car Body Engineering*, Bad Nauheim, 2022.

B. Wetzel, E.I. Akpan, A. Gebhard, "Properties of delignified compacted wood," presented at the *4th International Conference on Polymer Tribology,* Stockholm, Sweden, 2022.

H. Yagdjian, J. Vogtmann and M. Gurka, "Development of a new Methodology for Automated Quantification of Impact Induced Damage Pattern in CFRP Measured by IRT and X-ray Radiography," presented at the *ECCM20, 20th European Conference on Composite Materials,* Lausanne, Switzerland, 2022.

Doctorates

February 14, 2022
Dipl.-Wirtsch.-Ing. Bai-Cheng Jim
"Transferfilm-Luminance-Analysis: A comprehensive transfer film detection and evaluation method"
Chairperson:
Prof.-Dr.-Ing. J. Hausmann, IVW
Report:
Prof. Dr.-Ing. Jürgen Molter, HS Mannheim
Prof. Dr.-Ing. Karsten Stahl, TUM
Prof. Dr.-Ing. U. Breuer, IVW

February 17, 2022
Stephan Becker, M.Sc.
"Untersuchung und Optimierung des induktiven Aufheizverhaltens von textilverstärkten CFK-Organoblechen"
Chairperson:
Prof. Dr.-Ing. Ulf Breuer, IVW
Report:
Prof. Dr.-Ing. Michael Kupke, Institut für Materials Resource Management, Universität Augsburg
Prof. Dr.-Ing. Peter Mitschang, IVW

June 2, 2022
Dipl.-Ing. Janna Krummenacker.
"Investigations on the high cycle fatigue strength of short glass fiber reinforced polyamide 66"
Chairperson:
Prof. Dr.-Ing. Ulf Breuer, IVW
Report:
Prof. Valter Carvelli, Politecnico Mailand
Prof. Dr.-Ing. Joachim Hausmann, IVW

June 13, 2022
Florian Schimmer, M.Sc.
"Einfluss des Matrixsystems und der Strukturverkrümmung auf die Schlagbelastbarkeit von Faser Kunststoff-Verbunden"
Chairperson:
Prof. Dr.-Ing. Ulf Breuer, IVW
Report:
Prof. Dr.-Ing. habil. Bodo Fiedler, TU Hamburg
Prof. Dr.-Ing. Joachim Hausmann, IVW

September 6, 2022
Jan Rehra, M.Sc.
"Beitrag zur Beschreibung des mechanischen Materialverhaltens von Metall-Faser-Hybrid-Verbund-Werkstoffen am Beispiel von stahl- und kohlenstofffaserverstärktem Epoxidharz"
Chairperson:
Prof. Dr.-Ing. Joachim Hausmann, IVW
Report:
Prof. Dr.-Ing. Frank Balle, INATECH, Albert-Ludwigs-Universität Freiburg
Prof. Dr.-Ing. U. Breuer, IVW

October 24, 2022
Dipl.-Chem. Andreas Gebhard
"Creation of an Information Management System for Tribology Laboratories and its Application to Transfer Film Luminance Analysis"
Chairperson:
Prof. Dr.-Ing. J. Hausmann, IVW
Report:
Prof. Dr.-Ing. Stefan Deßloch, TU Kaiserslautern
Prof. Dr.-Ing. U. Breuer, IVW

Guest Scientists

Prof. Dr. Dr. h.c. Jan Kristian Krüger
Universität des Saarlandes, Germany
since October 1, 2019
(sponsored by Saarland University)

Seyedshahabaldin Amirabadi
University of Toronto
May 20, 2022 until August 15, 2022
(DAAD Rise Professional)

Helena Pérez Martín
University of Edinburgh
May 26, 2022 until August 05, 2022
(DAAD Rise Professional)

Prof. Nataliia V. Hudzenko
Institute of Macromolecular Chemistry,
National Academy of Sciences of Ukraine
since June 1, 2022
(Volkswagen Foundation -
Guest program for escaped Ukrainian guest scientists)

Dr. Maryna Novitska
Institute of Macromolecular Chemistry,
National Academy of Sciences of Ukraine
(Volkswagen Foundation -
Guest program for escaped Ukrainian guest scientists)

Anja Schmidt
Universidade da Coruña
August 31, 2022 until November 30, 2022
(sponsored by IVW)

Internal Colloquia

January 10, 2022

D. May, M. Duhovic

Initial insights into the Leibniz Collaborative Excellence Project ML4ProcessSimulation: Machine learning for simulation intelligence in composite process design

M. Chijiiwa

Photonik-Zentrum Kaiserslautern e.V. (PZKL)

Multiple regression analysis for the effect of chemical components on wettability at ps laser micromachined surface on stainless steel 304

February 7, 2022

J. Jungbluth

Interface characterization in functional hybrid composites

A. Nuhn

Pro-TP-Struktur: Holistic development of a hybrid coupling rod

April 4, 2022

B. Güttler

Sustainable composites

M. Kaiser

Development of a design method for efficient shape control of SMAHC under external influences

May 2, 2022

T. Donhauser

New possibilities in the field of optical measurement technology by using a self-developed sample printer

M. Fickert

Improved design process of dry-running radial plastic plain bearings by coupling laboratory testing and component simulation

June 13, 2022

B. Bergmann

MaTaInH2: Material-efficient and cycle-time optimized industrialization of H2 pressure vessels

A. Gebhard

Object-oriented modeling and relational persistence of test and meta data by the example of tribological laboratory tests

July 4, 2022

A. Dlugaj

Resin modification for wet fiber placement

September 5, 2022

V. Nagaraj

Hytraleicht – Leveraging structural optimization to maximize the performance of Tailored Fiber Placement (TFP) designs

October 10, 2022

D. Schommer, M. Duhovic

Characterization and simulation of thermoset molding compounds at IVW

M. Salmins

Production of thermoplastic structural foams in a hot press process

November 7, 2022

A. Klingler

Vitrimers – an investigation of the topology freezing phenomenon with regard to technological challenges

December 5, 2022

U. Blass

Development of a tubular pressure vessel to store compressed gaseous hydrogen

C. Pirro

Scanning force microscopic characterization of composites and nanocomposites

International Cooperations

- *Montanuniversität Leoben, Austria*
- *University of Auckland, Australia*
- *University of Sydney, Center of Advanced Materials Technology, Australia*
- *Katholieke Universiteit Leuven, Belgium*
- *Royal Military Academy, Brüssel, Belgium*
- *Technisch en Wetenschappelijk Centrum voor de Belgische Textielnijverheid, Zwijnaarde, Belgium*
- *UCL, Université Catholique de Louvain, Ottignies-Louvain-la-Neuve, Belgium*
- *FAPESP, Sao Paulo, Brazil*
- *Universidade de São Paulo, Brazil*
- *Aerospace Manufacturing Technology Center, Montreal, Canada*
- *Ecole Polytechnique at University of Montreal, Canada*
- *McGill University, Montreal, Canada*
- *Chinese University of Hong Kong, China*
- *Donghua University, Shanghai, China*
- *Hong Kong University of Science and Technology, China*
- *Lanzhou Institute of Chemical Physics (LICP), Chinese Academy of Sciences, China*
- *Materials Science Institute, Sun Yat-sen University, Guangzhou, China*
- *National Center for Nanoscience and Technology, Beijing, China*
- *Zhongshan University, Guangzhou, China*
- *University of Split, Croatia*
- *Technical University of Denmark, RISO DTU, Roskilde, Denmark*
- *Teknologian tutkimuskeskus VTT Oy, Espoo, Finland*
- *University of Technology, Helsinki, Finland*
- *Centre National de la Recherche Scientifique, Paris, France*
- *CPPM – Centre de Physique des Particules de Marseille, France*
- *École Centrale de Nantes, France*
- *Ecole Nationale Superieure des Arts et Industries Textiles, Roubaix, France*
- *Institut Nationale des Sciences Appliquées de Lyon (INSA), France*
- *Institut Nationale des Sciences Appliquées de Rouen (INSA), France*
- *LAPP – Laboratoire d'Annecy-le-Vieux de Physique des Particules, France*
- *SLCA – Société Lorraine de Construction Aeronautique, Florange, France*
- *Université Montpellier 2, France*
- *Université de Technologie de Troyes, France*
- *National Technical University of Athens, Greece*
- *University of the Aegean, Chios, Greece*
- *University of Patras, Rio Achaia, Greece*
- *CAM – The Chancellor, Masters and Scholars of the University Cambridge, Great Britain*
- *College of Science Technology and Medicine, London, Great Britain*
- *National Physical Laboratory, Teddington,Great Britain*
- *QMUL – Queen Mary and Westfield College, University of London, Great Britain*
- *University of Bristol, Great Britain*
- *University of Glasgow, Great Britain*
- *University of Sheffield, Great Britain*
- *Central Leather Research Institute, Chennai, India*
- *Indian Institute of Technology, Centre for Industrial Tribology, Delhi, India*
- *Indian Institute of Technology Madras, Chennai, India*
- *Vel Tech Technical University, Chennai, India*
- *CTL, Composite Testing Lab Ltd., Galway, Ireland*
- *NUI, National University of Ireland, Galway, Ireland*
- *Technion-Israel Institute of Technology, Haifa, Israel*
- *Centro Ricerche Fiat S.c.p.A., Turin, Italy*
- *Consiglio Nazionale Delle Ricerche, Rom, Italy*
- *INFN – Istituto Nazionale di Fisica Nucleare, Rom, Italy*
- *Polytechnic of Milano, Italy*
- *University of Naples Federico II, Neapel, Italy*
- *University of Padova, Department of Management and Engineering, Vicenza, Italy*
- *University of Salento, Lecce, Italy*
- *Kyoto Institute of Technology, Japan*
- *Kyoto University, Department of Mechanical Engineering and Science, Japan*
- *Shonan Institute of Technology, Fujisawa, Japan*
- *Korea Dyeing & Finishing Technology Institute, Seo-gu, Daegu, Korea*
- *Seoul National University, Korea*
- *Ulsan National Institute of Science and Technology (UNIST), Korea*

- Latvijas Valsts Koksnes Kimijas Instituts, Riga, Latvia
- Universität Luxembourg, Luxembourg
- School of Materials and Mineral Resources Engineering, Penang, Malaysia
- Delft University of Technology, Netherlands
- The University of Auckland, New Zealand
- CENTI – Centro De Nanotecnologia e Materiais Tecnicos Funcionaise e Inteligentes, Vila Nova de Famalicao, Portugal
- Citeve, Vila Nova de Famalicão, Portugal
- INEGI, Instituto de Engenharia Mecanica e Gestao Industrial, Matosinhos, Portugal
- Universidade do Minho, Portugal
- Institute of Strength Physics and Materials Science (ISPMS), Russian Academy of Sciences, Tomsk, Russia
- University of Edinburgh, Scotland
- Lulea University of Technology (LTU), Department of Engineering Sciences and Mathematics, Sweden
- SWEREA SICOMP AB (Swedish Institute of Composites), Pitea, Sweden
- CERN, Genf, Switzerland
- Ècole Polytechnique Federal de Lausanne, Switzerland
- ETH Zürich, Switzerland
- Fachhochschule Aargau, Switzerland
- University of Applied Sciences and Arts Northwestern Switzerland, Windisch, Switzerland
- Nanyang Technological University (NTU), Singapur
- University of Ljubljana, Faculty of Mechanical Engineering, Slovenia
- AIMPLAS Instituto Technologico del Plastico, Valencia, Spain
- Centro tecnológico LUREDERRA, Los Arcos, Spain
- Cidetec (Research Alliance), San Sebastian, Spain
- Escuela Politécnica Superior, Universidad de Jaén, Spain
- FIDAMC – Fundacion para la Investigacion, Desarrollo y Aplicacion de Materiales Compuestos, Madrid, Spain
- Fundació Ascamm Technology Centre, Cerdanyola del Vallès, Spain
- Fundación CIDAUT, Valladolid, Spain
- Fundación IMDEA Materials, Madrid, Spain
- TECNALIA Research and Innovation, Derio-Bizkaia, Spain
- Universidad de Alicante, Sant Vicent del Raspeig, Spain
- Universidad de Barcelona, Spain
- Universidade da Coruña, Spain
- Universidad de Jaén, Spain
- Universidad de Murcia, Spain
- Universidad de Oviedo, Spain
- Universidad de Sevilla, Spain
- Universidad de Valencia, Spain
- Universidad de Valladolid, Spain
- Universitat Politècnica de Catalunya (UPC), Terrassa, Spain
- KMUTNB – King Mongkut´s University of Technology North Bangkok, Thailand
- The Sirindhorn International Thai German Graduate School of Engineering (TGGS), Bangkok, Thailand
- KhAI – National Aerospace University "Kharkiv Aviation Institute", Ukraine
- Ukrainian Academy of Sciences, Kiev, Ukraine
- Center for Composite Materials, University of Delaware, Newark, USA
- Pennsylvania State University, State College, USA
- University of Delaware (USA)
- University of Washington (USA)
- USC University of Southern California, Los Angeles, USA

Expert Panels / Reviews

- *Advanced Materials Engineering (AME) Landesforschungsschwerpunkt*
- *AiF – Arbeitsgemeinschaft industrieller Forschungsvereinigungen*
- *Alexander von Humboldt-Stiftung*
- *Arbeitskreis „endlosfaserverstärkte Thermoplaste" der AVK e.V.*
- *Bayerische Forschungsstiftung*
- *Beirat des DIN Normenausschusses „Kunststoffe"*
- *BMWK Expertengruppe Elektropower*
- *Bundesministerium für Bildung und Forschung, Projektträger Jülich*
- *Composites United e.V. – Arbeitsgruppen*
  - Biocomposites
  - Smart Structures
  - Thermoplastische Composites
  - Bearbeitung
- *CU West, Vorstand*
- *CVC Rheinland-Pfalz*
- *DAAD Deutscher Akademischer Austauschdienst*
- *DGLR – Deutsche Gesellschaft für Luft- und Raumfahrt e.V.*
- *DGM e.V. – Fachausschuss „Hybride Werkstoffe und Strukturen"*
- *Deutsche Gesellschaft für zerstörungsfreie Prüfung e.V.*
  – Fachausschuss „Faserkunststoffverbunde"
  – Fachausschuss „Zustandsüberwachung"
  – Fachausschuss „Structural Health Monitoring"
  – Fachausschuss „Akustische Emission"
- *DIN-Fachbereich 2 „Duroplast- und Thermoplast-Formmassen"*
- *DLR – Deutsches Zentrum für Luft- und Raumfahrt*
- *DLRK – Deutscher Luft- und Raumfahrtkongress*
- *DFG Normalverfahren*
- *DFG Sonderforschungsbereich Begutachtung*
- *DIN Normenausschuss, NA 054-02-02 AA „Verstärkte Kunststoffe und härtbare Harze"*
- *DIN Normenausschuss, NA131-02-01 AA „Verbundwerkstoffe – Luft und Raumfahrt"*
- *Dutch Research Council NWO*
- *European Society for Composite Materials*
- *European Structural Integrity Society (ESIS)*
  – Technical Committee 4 (TC4)
  Polymers, Polymer Composites and Adhesives
- *Fraunhofer Leistungszentrum Simulations- und Software-basierte Innovation, Kaiserslautern, Executive Board*
- *FVA – Forschungsvereinigung Antriebstechnik e.V. PA Kunststoffe*
- *Gemeinschaftsausschuss Verbundwerkstoffe (GAV)*
- *Industrieausschuss Strukturberechnungsunterlagen (IASB) des Luftfahrttechnischen Handbuchs (LTH)*
- *Innovationscampus Mobilität der Zukunft des Landes Baden-Württemberg*
- *ISO – Mitglied der deutschen Delegation zu ISO Technical Committee „Plastics" TC61/SC13 „Composites and reinforced fibers"*
- *ISO Standardization Project – Working Group 5 Leader: Process Simulation*
- *Kompetenznetz Adaptronik e.V.*
- *Kunststoffe in der Pfalz*
- *Netherlands Organisation for Scientific Research (NWO)*
- *Östereichische Forschungsförderungsgesellschaft FFG*
- *Stiftung Industrieforschung*
- *Rat für Technologie des Landes Rheinland-Pfalz*
- *RCI – The renewable carbon initiative*
- *VDI Richtlinienausschuss 2014*
- *VDMA Arbeitsgemeinschaft Hybride Leichtbau Technologien*
- *VDI/VDE-GMA Fachausschuss „Smart Materials and Systems"*

Leibniz-Institut für Verbundwerkstoffe GmbH
Erwin-Schrödinger-Straße 58
67663 Kaiserslautern
Germany
Phone: +49 631 2017-0
www.ivw.uni-kl.de

2022