

DITF

DEUTSCHE INSTITUTE FÜR
TEXTIL+FASERFORSCHUNG

An abstract graphic featuring a large, stylized white number '100' centered over a background of teal and green geometric patterns. The patterns consist of overlapping triangles and polygons, creating a sense of depth and movement. The colors transition from a light teal on the left to a darker green on the right.

100

ANNUAL REPORT ON THE ANNIVERSARY YEAR 2021

TEXTILE FUTURE

OPEN THE WINDOW INTO THE WORLD OF TEXTILE

TAKE A LOOK INTO THE DETAILS OF OUR RESEARCH, IN IDEAS
AND INNOVATIONS FROM THE GERMAN INSTITUTES OF TEXTILE
AND FIBER RESEARCH DENKENDORF



DITF

DEUTSCHE INSTITUTE FÜR
TEXTIL+FASERFORSCHUNG

ANNUAL REPORT 2021

FOREWORD

Dear Reader,

let's celebrate the textile future! Under this slogan we celebrated our 100th anniversary in 2021 and the development of the DITF into one of the world's leading textile research centers. Ten decades full of scientific curiosity, drive, inventive spirit, and enthusiasm for the future made this development possible. A look back shows particularly impressively what textile and fiber research can achieve.

The idea behind the foundation in 1921 was to support industry through independent research work – this claim of the founding fathers still characterizes Denkendorf textile and fiber research today. With product and technology-oriented innovations and testing services, the DITF support industry and thus make an important contribution to strengthening competitiveness and securing the location. With a clear focus on new key technologies and future fields, the DITF today are innovation drivers for many industries. They provide impetus in lightweight construction, in medical and environmental technology, in the fields of regenerative energies, resource efficiency and mobility, or in the classic areas of clothing and home textiles.

Strategy process 2021-2026

For good reason, DITF's bylaws require us to review our strategy every five years and adapt it to current developments. In 2021, the task was at hand: In a structured strategy process lasting several months, the extended Executive Board, together with many other DITF stakeholders, developed the Strategy 2021-2026. It defines what we stand for. Where we want to go. What long-term measures we need. And most importantly, how we can see whether we are achieving our goals and whether the strategy is successful. In 2022, we will start implementing the strategy – with an update of the research fields and a new strategy map including concrete targets.

Enabling technologies

Textiles have long since ceased to mean just "shirts and pants", but rather high-tech for many industries, often made in Baden-Württemberg. Fiber-based materials and textile components are increasingly becoming enabling technologies. In combination with other technologies, they create the basis for significant leaps in performance and capability. Thus, they are the initiator or catalyst of far-reaching innovations that go beyond the subject matter of the application itself. The Annual Report 2021 presents current research projects with different application focus. Digital technologies of the future and the concept of sustainability play a central role and are part of almost all projects.

Cooperations & Transfer

Close cooperation with partners from research and industry is an important element of technology and research transfer for us. In 2021, we were able to conclude two far-reaching cooperation agreements for this purpose. A close cooperation with the Technikum Laubholz was agreed with the aim of developing new and technical applications for hardwood and transforming them into marketable products. The industrial implementation of sustainable processes to produce technical regenerated cellulose fibers and carbon bonds based on lignin and cellulose is the main focus of the cooperation. Extensive patent families were sold by the DITF to the Technikum Laubholz GmbH as a basis for the technology transfer.



Peter Steiger

Prof. Dr. rer. nat. habil. Michael R. Buchmeiser

Prof. Dr.-Ing. Götz T. Gresser

A further cooperation agreement was concluded with the French Saint-Gobain Group after extensive negotiations. The aim is to jointly create the conditions for setting up a production facility for oxide ceramic fibers in Europe. As there is currently only one manufacturer of high-quality oxide ceramic fibers in the world, the planned production is intended to provide a "second source" which has been required for many years.

Digital & Hybrid – Events 2021

As in the previous year, the DITF event calendar was dominated by the Corona pandemic. As organizer of the Smart Textiles User Forum and the Aachen-Dresden-Denkendorf International Textile Conference, the DITF organized the two major textile conferences in hybrid format for the first time. Especially for the ADD International Textile Conference with 360 participants from 25 countries and 60 lectures in plenary sessions and three parallel sessions this was a challenging task, but thanks to good planning it was a success.

In this anniversary year, looking back on a hundred years of history, it becomes clear once again that innovation is a joint effort. Excellent research can only succeed if many clever minds – whether internal or external – pull together, get involved and show responsibility for the common goal. We would therefore like to thank all our partners, sponsors, supporters and, above all, our employees for their passionate and valuable commitment.

We wish all readers of the DITF Annual Report an interesting read!

Sincerely

Your DITF board of directors

Prof. Dr. rer. nat. habil.
Michael R. Buchmeiser

Prof. Dr.-Ing.
Götz T. Gresser

Peter Steiger

TABLE OF CONTENTS

Foreword	4
Table of contents	6
DITF	8
100 years DITF	10
What we offer	14
DITF Research fields	16
Areas of application	17
Figures – data – facts.	18
Networks and collaborations	19

Research projects, trends and highlights

Architecture and construction	20
Health and care	26
Mobility	32
Energy, environment and resource efficiency	38
Production technologies	44
Clothing and home textiles	50

DITF bodies	56
Association of DITF sponsors	58
Imprint	62

Documentation separate from the annual report provides an overview of

- > DITF points of contact
- > Publicly funded research projects
- > Published final reports, publications, lectures, press releases
- > Dissertations, awards
- > Events, trade shows, exhibitions
- > Patents
- > Bodies, scientific advisory councils

Orders: info@ditf.de



A woman with dark hair tied back, wearing a dark blue turtleneck sweater, is smiling and looking down at a spool of blue thread she is holding. The background is a bright, out-of-focus window with vertical blinds.

DITF

DEUTSCHE INSTITUTE FÜR
TEXTIL+FASERFORSCHUNG

GERMAN INSTITUTES OF TEXTILE AND FIBER RESEARCH DENKENDORF

FUTURE TEXTILES

The areas of textile chemistry and man-made fibers, textile and process engineering, and management research are united under the umbrella of the DITF. With their main research areas, they together cover the entire production and value chain of fiber-based materials – from the molecule to the product. Their potential lies in their close connection. Together, they are paving the way for the textile future.

GERMAN INSTITUTES OF TEXTILE AND FIBER RESEARCH DENKENDORF

We think in textile systems. They are the key to innovation in many important industries and high-tech sectors.

The DITF form the largest textile research center in Europe

With more than 250 scientists and technical employees, the German Institutes of Textile and Fiber Research Denkendorf cover the entire production and value creation chain in textiles as the only textile research institution in the world. The DITF have been covering all the important textile topic fields since 1921. In their fields of activity the DITF belong to the world-leading research institutions.

Application-oriented research from molecules to products

The DITF carry out application-specific research over the entire textile production chain. With product- and technology-oriented innovations as well as modern management concepts, the Denkendorf researchers contribute to the competitiveness and safeguarding of both the German and European economy.

Industry partners

The DITF are partners with numerous local and international enterprises. They take part in public research processes or issue direct research assignments to the DITF. The DITF support and advise companies in the most important industrialized nations worldwide.

R&D services

The DITF are an important R&D partner for industrial and service companies in fields ranging from ideas to material research, the development of prototypes and industrial processes, from pilot production to testing. The DITF are an important supplier of innovative expertise, especially for small and medium enterprises that do not have their own R&D departments.

Technology and knowledge transfer in practice

The DITF quickly transfer sustainable research results into economic utilization and application. Our most important goal is the conversion of scientific knowledge into market-ready processes, products and services.



Teaching and practical further training

As one of the leading European research institutions in the field of textile technology, the DITF have a special responsibility to encourage young scientists. Therefore, training and further education are among the DITF's central tasks.

Numerous lecturing and research collaborations have been formed with regional universities. A collaborative research and lecturing association with Reutlingen University exists through the Center for Interactive Materials (CIM). The DITF also have a close connection with the University of Stuttgart in the form of three professorships as well as courses in other study subjects.

Professorships at the University of Stuttgart

Professorship in Macromolecular Substances and Fiber Chemistry – Institute of Polymer Chemistry
Prof. Michael R. Buchmeiser

Professorship in Textile Technology, Fiber-Based Materials and Textile Machinery – Institute of Textile and Fiber Technologies
Prof. Götz T. Gresser

Institute for Diversity Studies in the Engineering Sciences
Prof. Meike Tilebein

DITF.100

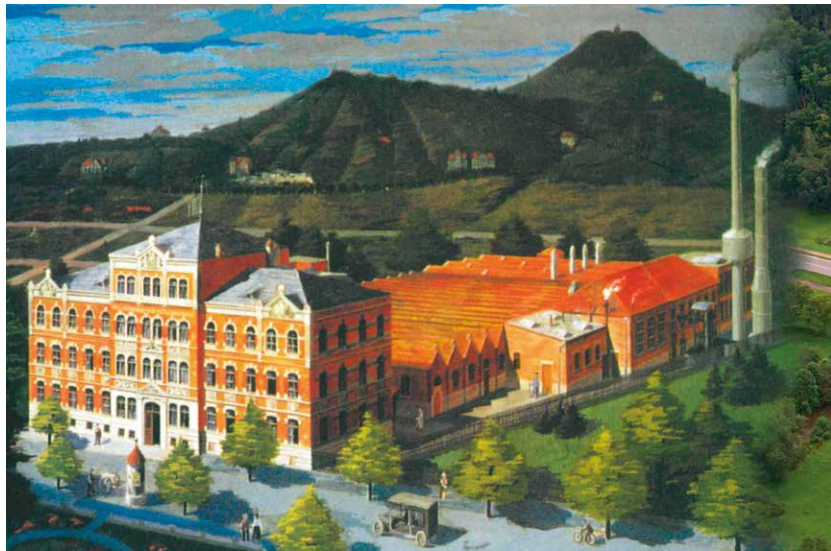
LET'S CELEBRATE THE TEXTILE FUTURE!

2021: The DITF celebrate their 100th anniversary and thus the development into one of the world's leading textile research institutions.

Then

In order to provide a basis for the upcoming textile industry in the rural Kingdom of Württemberg, a weaving school was founded in Reutlingen in 1855 on the initiative of the Central Office for Trade and Commerce. Within a few years, this developed into an educational institution covering all textile processes. Spinners, weavers, knitters, finishers as well

as laboratory and management staff for the textile industry throughout Europe are trained at the Reutlingen Technical School for the Textile Industry.



Prof. Dr.-Ing. E.h. Otto Johannsen (1864-1954), head of the Technical School from 1892 to 1932, also pushed ahead with research. In 1894, he habilitated at the Stuttgart Technical University and took on teaching responsibilities at the university as a professor. Before the First World War, a state testing office for textile fabrics was established at the Technical School. The founding of the long-planned research institute was delayed until 1921 due to the war.

Then, however, the Reutlingen Technical School with the testing office and the research institute became the pacemaker for the development of the prospering textile industry for a long time. The range of research tasks also grew, especially in the field of chemistry. In 1936, a separate department for textile chemistry was set up at the Research Institute. Its Head, Prof. Dr. Hermann Rath, was appointed to the newly established Chair of Textile Chemistry at the TH Stuttgart in 1962. The Institute of Textile Chemistry also moved to Stuttgart. There, Prof. Dr. Paul Schlack, inventor of the perlon fiber, took over the Department of Man-Made Fibers, which also became an independent Institute for Man-Made Fibers in 1968.

In keeping with economic developments, the Reutlingen Technical School, now a state engineering school, gradually loses its textile focus. At the end of the 1960s, general mechanical engineering and, shortly thereafter, business administration subjects were introduced as new departments. Finally, in 1971, the Technical School is absorbed into the newly founded University of Applied Sciences for Technology and Economics, now Reutlingen University.

Founded
from the crisis

Think tank for
the textile industry

Competence
in the center



Today

A new era also begins for textile research in the 1970s. Those responsible look for a location where the institutes from Reutlingen and Stuttgart are to be reunited. The choice falls on Denkendorf. Since 1937 a research institute, had already existed in the Körschtal, specializing initially in rayon spinning and, after the war, in man-made fiber research in general.

And there is room here for new buildings, for which the state parliament approves the funds in 1978. After completion in 1983, textile and fiber chemistry and textile technology are united again spatially under one roof as the German Institutes of Textile and Fiber Research.

What then begins can be called a success story, even if the general conditions are not easy: In the course of globalization, the European textile industry is undergoing a partially painful structural change. Traditional clothing production is migrating to low-wage countries. In order to survive the economic change, new products and innovative processes are required. The Denkendorf institutes are providing crucial support in this process.

Beyond classical textile chemistry and textile technology, new areas of research must be opened up. In particular, textiles for technical applications are coming into focus: fibers and textiles are now being designed as high-performance materials and developed specifically for key technologies such as architecture, mechanical engineering, vehicle construction, aerospace, medicine, environmental technology, etc. In order to cope with this range of tasks, the number of employees has also grown continuously: while about 100 people were employed at the time the research center was founded in Denkendorf, today more than 250 scientific and technical staff work on future textile topics in the overarching research areas of chemistry, process engineering and management research.

DITF.100

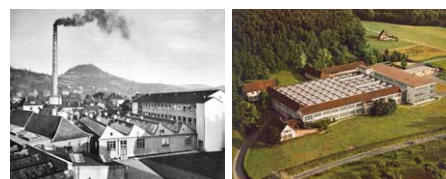
LET'S CELEBRATE THE TEXTILE FUTURE!



From this school, the Reutlingen *Technical School for the Textile Industry* grows until the First World War: a comprehensive textile training center, also for students of the nearby Technical University of Stuttgart. There are also plans for a research institute that is independent of teaching. However, this only became a reality after the war: On January 10, 1921, the *German Research Institute for the Textile Industry in Reutlingen-Stuttgart* was officially established as a foundation under public law by resolution of the State Ministry.



Almost at the same time, a research facility specifically for viscose fibers was established in Denkendorf in the form of *Zellwolle-Lehrspinnerei GmbH*. Here, scientists worked on establishing this new semi-synthetic fiber made from domestic raw materials in the textile industry. After World War II, activities are expanded to include all modern man-made fibers.



The Technical School for Textile Industry is integrated into the newly established Reutlingen University. The *Institute for Textile Technology and Process Engineering* expands its field of work: In addition to classical textile technology, environmental technology, medical textiles, data processing and management become important. At the same time, plans are developed for a comprehensive textile research center and Denkendorf is finally chosen as the new location.

1921

1936

1937

1962

1970

1983



The Research Institute and the Reutlingen Technical School lay the scientific and technical foundations for the burgeoning textile industry. Increasingly, chemical issues also play a role. Since 1936, there has been a separate research department for textile chemistry.

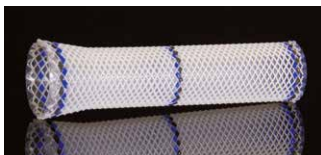


A chair for textile chemistry is established at the TH Stuttgart and filled by the head of the *Institute of Textile Chemistry* of the Reutlingen Research Institute. The *Institute for Textile Chemistry* moved to Stuttgart-Wangen. An Institute for Man-Made Fibers was also established here in 1968.



With the completion of the new buildings in the Körschtal, the largest state textile research center in Europe is created by merging the institutes from Reutlingen and Stuttgart: *The Institutes of Textile and Fiber Research Stuttgart* work on research projects along the entire value chain from raw material to product. In order to support the textile industry in its structural change, the focus is increasingly on technical textiles.

Image sources: Reutlingen City Archive, Stuttgart University Archive, Hubberten (Hundred Years of the Technical Center for the Textile Industry in Reutlingen), Eugen Wendler (original painting owned by Reutlingen University)



With the spin-off **ITV Denkendorf Produktservice GmbH** as a transfer center, the development of medical products became an important mainstay. One year later, the foundation of the **Center for Management Research** sets the course for digitalization and Industry 4.0.



With the **High Performance Fiber Center (HPFC)**, the first public research and development center for high-performance fibers in Germany is opened at the DITF. High-temperature-resistant ceramic fibers and carbon fibers made from natural raw materials are major research areas.



In **Strategy 2021**, the DITF are bringing the research areas of **chemistry**, **process engineering** and **management** even closer together: Six **competence centers** for areas with thematic overlaps, four **technology centers** for specialized areas and a **service center** for testing offers create new synergy effects internally and externally.

2001

2003

2014

2017

2020

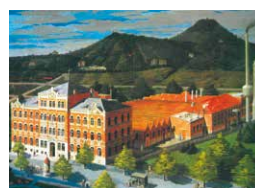


The chemical divisions are combined to form the **Institute of Textile Chemistry and Man-Made Fibers**. Together, they set new impulses in the field of high-performance materials. The technically complex production of carbon fibers becomes a focus of research.



The DITF present a new marketing concept: Three research institutes – one brand! The new DITF logo stands for the entire research center and represents all institutes to the outside world.

The DITF host the **ADD-ITC** for the first time: The **Aachen-Dresden-Denkendorf – International Textile Conference** takes place in the Liederhalle Stuttgart congress center. Over 600 participants from 28 countries discuss current topics of the textile world during two days.



100 years of DITF: From the first beginnings in Reutlingen, an internationally recognized research center has developed. More than 250 people are active in all areas of textile and fiber research. The DITF are linked to the University of Stuttgart via three chairs. Much has changed – but basically what was laid down in §1 of the statutes still applies: *"The Research Institute has the task of researching textile fiber and substitute raw materials, the manufacture of textiles and textile machinery in the laboratory as well as in factory operations in close cooperation with the industries involved and to bring the results of its research to the attention of the circles involved in an appropriate manner."*

FROM MOLECULE TO MARKET – WHAT WE OFFER



Molecule



Fiber



Tissue



Technology



Process



Prototype



Product



Market

The DITF support you – starting from brainstorming through material research, development of prototypes and production processes, pilot manufacture and testing to advice on new business models. We orient ourselves to the needs of the industry and create market-ready products, processes and services for it.

Denkendorf Future Workshop

Innovations are rarely created by coincidence or simply by intuition. A structured innovation process is essential for creating new, market-ready and implementable ideas. The Denkendorf Future Workshop can help with this. It offers companies targeted and systematic support for brainstorming.

Applied research and development

We invest in preliminary research, make the latest results from fundamental and application-oriented research available to the textile sector, operate joint research, contract research and development on commission. From the molecule to the finished product and its entry onto the market we research and develop along the entire textile value creation chain and in the process, also develop business processes and models.

Testing services

Since their foundation the DITF have had test laboratories and offer a comprehensive service catalog for testing fibers, yarns, surfaces and textiles. Hardly any other institution offers such comprehensive technology for the research and testing of fiber-based materials and textiles. State-of-the-art analysis and testing techniques are available for examining textile-technical, chemical, biological and sensory testing processes.

Pilot factory

The DITF operate a pilot factory in which all the important technologies along the process chain are implemented. With this pilot factory we offer the industry a unique opportunity in the textile market for zero and small series manufacturing. Experienced staff, combined with the existing machinery park and well-equipped technical facilities guarantee optimal framework conditions for contract manufacturing.

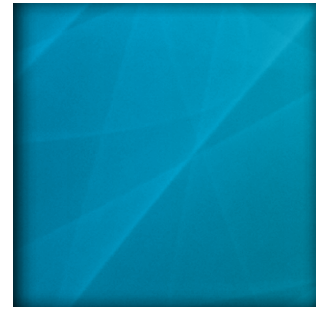
Prototype construction

We have in-house development and construction facilities for prototype construction. Well-trained personnel use the modern equipped workshop and the electronics laboratory to develop new ideas for testing and production processes for the textile industry. In this way we offer the textile industry the opportunity to test and optimize at specially built test stands.

Please ask us!



DITF RESEARCH FIELDS

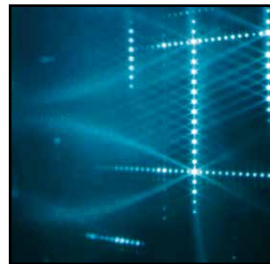


The six strategic research fields of the DITF use the unique feature of textile vertical integration for knowledge-based innovations. As the only textile research institution in the world the DITF cover the entire production and value creation chain of textiles.

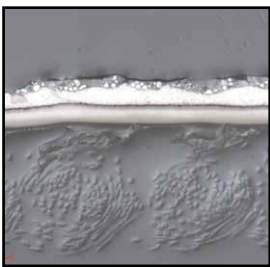
From the molecule to the finished product



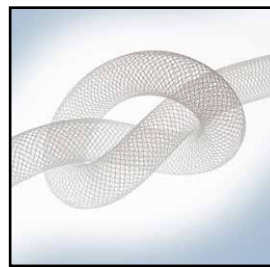
High-performance fibers and yarns
Development of high-performance fibers and yarns on the basis of synthetic polymers and sustainable raw materials



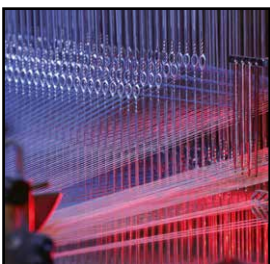
Smart textiles
Integration of existing technologies for the development of more active, more adaptable, more sensory and shinier textiles



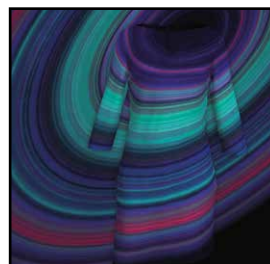
Textile finishing and coating
Development of functional technical textiles with new environmentally friendly technologies



Medical technology
Biologization of medical textiles and implants with active substance delivery systems and more active surfaces



Composite fiber and lightweight construction
Development of end-contour 3D-components with composite fiber technology



Textile 4.0
Digitization, process development, value creation and knowledge management in the textile and clothing industry

FIELDS OF APPLICATION

We encounter the textile world everywhere. Textile development and products are the key to innovation in many important industries and high-tech sectors. Fiber-based materials are among the most important materials of the 21st century. Multi-functional, cost-efficient and sustainable, they are recommended for

more and more fields of application. We have carried out diverse research projects for industrial as well as public clients in the following fields of application:



Architecture and construction

Construction materials with textile components, fiber-based materials



Energy, environment and resource efficiency

Energy technology, environmental technology (e.g. water treatment, geo- and landscape protection, recycling of high-performance fibers), intelligent energy management



Health and care

Textile implants and regeneration medicine, wound treatment products, diagnostic and monitoring systems, smart textiles, depot and therapy systems



Production technologies

Process engineering and technology for higher productivity, quality and energy efficiency, automation



Mobility

Fibers, structures and products e.g. for the automotive industry and for aviation and space travel technology

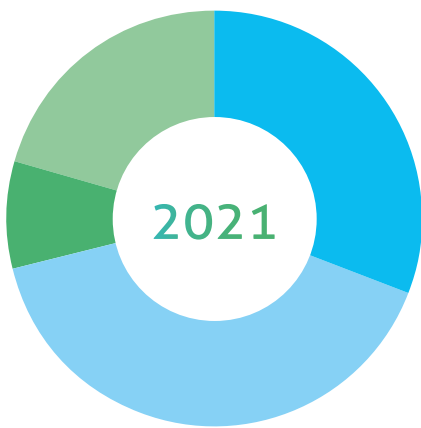


Clothing and home textiles

Functional clothing, climate-regulating textiles, light textiles, sound technological textiles, smart textiles

FIGURES – DATA – FACTS

27.741 Total revenue



■ Revenues Industry:	8.588 TEUR
■ Revenues from public contracts:	11.187 TEUR
■ Other revenues:	2.280 TEUR
■ Institutional funding:	5.686 TEUR

(Income excludes ITV Denkendorf Produktservice GmbH)

In terms of industrial revenues, small and medium-sized enterprises play a particularly important role for the DITF. The share of SMEs in industrial projects in 2021 was approx. 34 %.

159 Public research projects

Subsidies from state, federal and EU programs. 33.0 % of revenue from public contracts in the reporting period came from the ZIM funding program, which is open to all technologies and sectors and aims to sustainably strengthen the innovative strength of small and medium-sized enterprises.

Employees as of 31.12.2021



DITF

228	employees
106	scientists* and engineers*
122	non-scientific employees
12	doctoral students
41	students (Bachelor and Master students)
40 %	share of women

ITV Denkendorf Produktservice GmbH

42	employees
----	-----------



68 publications

52 of these in peer-reviewed journals

5 bachelor theses

11 master theses

3 dissertations

12 patents

Quality Management



Selected DITF laboratories and the testing laboratory of the ITV Denkendorf Produktservice GmbH are accredited according to DIN EN ISO/IEC 17025:2018.

The production areas filament yarns, needle felts, coated PP monofilament and the development areas of the DITF in the regulated area of medical devices as well as the ITV Denkendorf Produktservice GmbH are certified according to EN ISO 13485:2016. Scope: Design, manufacture and distribution of absorbable and non-absorbable polymers, fibers, films and membranes, surgical sutures, implants, wound dressings and anti-microbial meshes.

NETWORKS AND COLLABORATIONS

Networks help us to drive innovation faster and to operate more successfully in the market. For that reason, we actively promote networking and collaborations – across industries, nationally, and internationally.

Combined expertise

In addition to having close links to the business and science community, the DITF are intimately involved in the activities of a wide range of associations, organizations and thematic networks of excellence, which serve as a platform for cross-system, interdisciplinary research.

Applied research

One crucial task of the DITF is the support of SMEs through applied research together with the successful transfer of technologies. Networking and collaboration with other business-related research institutes help to reinforce the mid-tier research capacity in Germany. Accordingly, the DITF engage with the most significant research communities concentrating on industrial research at the state and federal level.

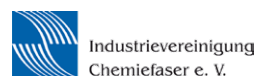


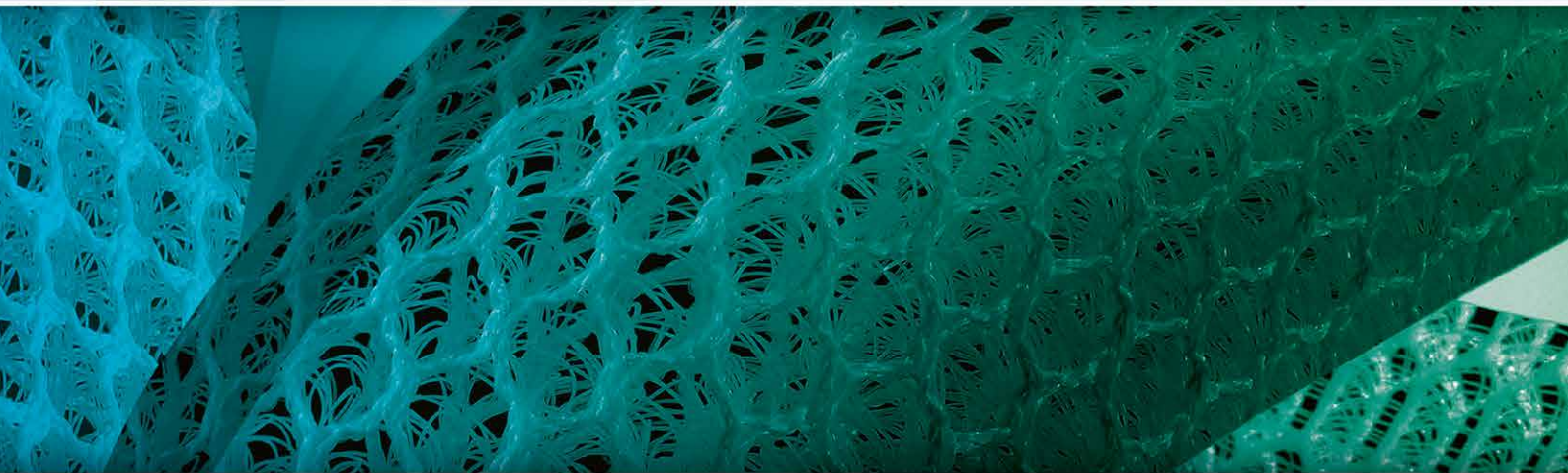
The DITF are part of the Innovation Alliance Baden-Württemberg (innBW), a group of 10 non-academic, business-related research institutions with a total of 1,500 employees. The institutes carry out result-oriented contract research in areas relevant for the future of the state. With around 4,700 industry projects per year, the innBW is an important partner, particularly for SMEs.




ZUSE-GEMEINSCHAFT

The DITF co-founded the German Industrial Research Foundation Konrad Zuse e.V. This association represents the public interests of non-profit industrial research institutions in Germany and is open to all technologies and sectors. Its members include independent research institutions from all over Germany. They promote innovations in all sectors, from agriculture to medicine to mechanical engineering and shipbuilding.







ARCHITECTURE AND CONSTRUCTION

Fiber-based materials and processes for tomorrow's construction. Improved aesthetics, greater sustainability, functionality and innovation. For temporary and permanent buildings.

- > Textile facade elements: intelligent, light building shading
- > Light-guiding textiles
- > Smart, textile construction elements
- > Pneumatic and hydraulic textile actuators
- > Autonomous living wall systems
- > Textile moss walls for particle reduction
- > Optically transparent fiber reinforced materials
- > Textile solutions for Smart Home and Smart Quarter
- > AI in construction
- > Soundproofing and sound absorbing textiles
- > Active sound-emitting acoustic textiles
- > Acoustically convertible textiles
- > New textile materials for construction

Architecture and construction

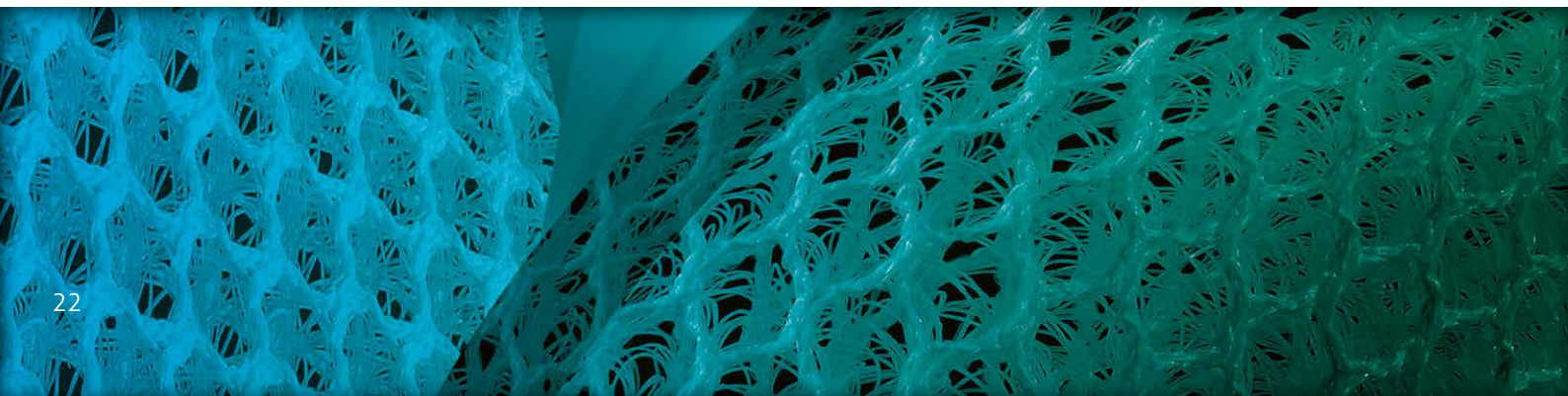
Sustainable, innovative, and attractive solutions for life in both urban and rural areas are the future tasks in construction. Qualitative and social redensification, smart neighborhoods, rain retention, improving air quality, avoiding urban heat islands, optimizing resource use, and recycling strategies are challenges in the construction industry for which the DITF are developing solutions. Housing situations changed by the COVID-19 pandemic also represent a new challenge. Ever shrinking homes in metropolitan areas require additional demand for innovative solutions in the context of home offices and homeschooling.

Functional, smart building textiles

To address these future challenges, the DITF are developing new textile solutions using new materials, structures and control systems to create new parts, components and products for the entire field of construction. The focus here is on integrated solutions. Accordingly, they protect from exposure to climatic influences as well as sound and light. The increase in weather extremes such as heavy rain also places new demands on construction. New materials and components must fulfill structural, energetic, and design functions in the context of sustainability. Fiber-based materials prove their worth especially in the context of such multiple demands. In combination with AI solutions this potential opens up for the user. The DITF develop feasible, efficient solutions for this purpose to enable qualitative and social densification.

Textile solutions for redensification

The Denkendorf ResearchCUBE allows us to develop ideas; moreover, test and demonstrate new approaches, which then results in the rapid introduction of new products. New shading textiles achieve optimum light distribution in the interior of a building because even though they reduce glare, they direct so much valuable daylight into a room that artificial lighting becomes unnecessary. Integrated textile sensors both measure the illuminance and control AI-supported textile-based actuators that adjust the shading depending on the position of the sun. Within the framework of the Mittelstand 4.0-Kompetenzzentrum *Textil vernetzt*, companies are supported in implementing such AI-based applications. In an AI Escape Room set up for this purpose, the possibilities can be experienced in a playful way. These textile AI solutions cannot only be used in the smart home, but also open up further possibilities in the area of smart districts. Here, tasks are no longer addressed in the individual object, but are solved in the intelligent networking of several buildings and with external knowledge. Research is focusing here on issues related to energy production and consumption as well as water supply and wastewater disposal in increasingly sealed areas.



Building facades also hold excellent potential for solving problems of redensification. Textile facade systems can be produced to be lightweight, flexible, and highly functional. Attached vertical greenery systems (living walls) not only improve the quality of the air and life in densely populated city centers, but can also be used in urban water management thanks to their controllable water retention capacity and, if used intelligently, reduce the heat island problem. Even textile roof constructions in the form of membrane structures have long become a part of permanent buildings. Accordingly, thanks to their low weight and flexibility, textile materials allow the roofs of stadiums, train stations, and airports to be versatile like no other material.

Fiber-reinforced composites in construction

Fiber-reinforced composites have industrially relevant properties as a result of their great specific strength and rigidity; subsequently, they are becoming increasingly important for use in construction. Moreover, the orientation of the fibers, adhesion at the fiber-matrix interface, as well as the many possible combinations of fibers and polymeric matrices, make it possible to adapt the material properties to various applications. The emerging digital transformation of everyday life and industry increasingly demands complex materials that, in addition to their usual intrinsic characteristics, have additional features such as artificial “sensory organs” to remain competitive in an ever more interconnected environment.

Textiles as acoustic design elements for living and working in the future

The modern world is characterized by increasing noise pollution. Urbanization, redensification, and high traffic volumes require sustainable and efficient acoustic design solutions both in the living environment and at work. The intrinsic properties of textiles, as well as the possibility of creating novel acoustic effects through textiles, make textile sound absorbers and attenuators essential in the building sector. Textiles themselves offer the potential of sustainable and resource-saving management of noise problems and are thus innovation drivers for many construction sustainability topics such as lightweight construction. In sum, textiles pave the way to a healthy, sustainable, and economical future for the human living space.



Sand curtains as temporary sound insulation for modern office spaces

Modern working environments are characterized by a departure from classic work structures. While the focus in the past was on work and the working person was the means to an end, today the focus lies on a healthy environment for employees. The strict allocation of work-space as office, meeting room, etc. exists less and less. Flexibility in the use of space is essential. Being a chill-out area at one moment, the room has to change into a meeting room for official events in the next moment.



Hand pattern of the assembled sand curtain with folding lines

This situation gives rise to the need for flexible, room-dividing elements that ensure effective sound insulation and acoustically decouple the room from its surroundings. Common curtain systems provide 16 dB of insulation with seven individually assembled layers. More is usually not economically justifiable.

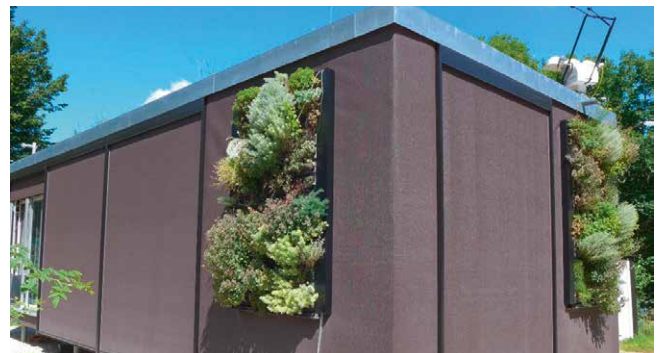
The sand curtain of the ZIM project "AbSchung" with Gerriets GmbH addresses this problem. A newly developed glass spacer fabric allows loose sand to be filled in between the textile layers. The cavity is prevented from expanding by the pile threads so that the sand does not sag. Thus, a highly efficient sand curtain could be developed, which, in addition to being incombustible, exhibits textile folding behavior. However, the acoustic properties are particularly outstanding: At 10 mm thickness, the single-layer system produces a sound insulation of 23 dB. The sand curtain offers a paradigm shift in sound insulation through curtains and will be commercially available soon.

Textile greening as a post-densification enabler

Scarce housing and the consequences of climate change pose major challenges for cities. To solve the need for housing and at the same time the infrastructure challenges, redensification is an essential tool. To do this in a socially and qualitatively responsible manner while using the existing stock as much as possible is the task of the time.

In urban areas, redensification measures can quickly exacerbate the problem of local heat islands. Here, greening in textile-based lightweight construction also help in existing buildings: Greened vertical building surfaces reduce the reflection of heat radiation and cool the immediate surroundings via evaporative cooling. Moreover, textile greening can be useful for another typical post-compaction problem: heavy rainfall in dense urban environments hits largely sealed surfaces, quickly pushing the existing sewer system to its capacity limit. The fiber-based plant substrates of textile greening, as well as integrated textile water storage systems, provide additional volume for water absorption during heavy rainfall if required, and thus replace missing infiltration options.

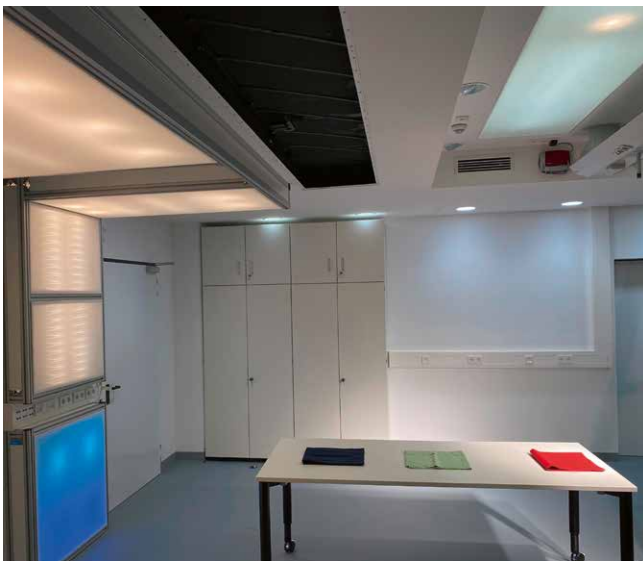
In this way, textile greening creates more living space in the context of redensification and, with more greenery in the city, also increases the quality of stay.



Building greening as living-wall systems at the ForschungsKUBUS at the DITF

Intelligent and energy-efficient production lighting using light-technical textiles as an example of the MICROFACTORY

Light is the most important factor for human work since people absorb 90 % of their information through optical perception. But light is not just light. Modern work profiles demand that a wide range of different and activity-specific luminance levels are provided in a room to improve production quality. The decisive factor here is energy-efficient lighting quality that enables glare-free and low-reflection workplaces with a high quality of stay. In their MICROFACTORY, the DITF show the application possibilities and potentials of textile lighting design.



Lighting scenario in the MICROFACTORY

The picture shows the performance of the MICROFACTORY. The optimum, pinpoint illumination at the active, red workstation can be seen. Intelligent lighting control that follows the production flow can increase the savings potential as well as support the workflow accordingly. The possible presence of different colored light sources can additionally adapt the workplace to different work scenarios and goods.

All requirements in the MICROFACTORY are opened up or intensified by textiles that are effective in terms of lighting technology. Large-area luminous ceilings allow homogeneous illumination of large work surfaces, while focusing elements bring in specific points of light. The MICROFACTORY is not fixed to one process. Depending on the requirements, the lighting situation can be re-evaluated, adapted, and adjusted to provide an optimally supportive lighting situation for flexible production.

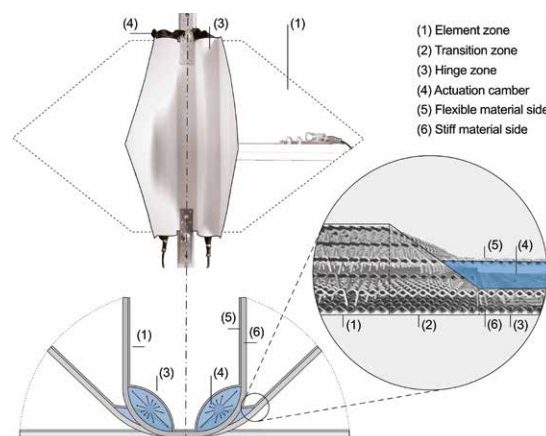
3D woven adaptive fiber-reinforced plastic composites

In a joint AiF project, the university institute of Prof. Dr.-Ing. Gresser, the Institute of Textile and Fiber Technologies (ITFT), and the DITF, together with the Institute of Building Structures and Structural Design (ITKE) of Prof. Dr.-Ing. Knippers are researching adaptive fiber-reinforced plastic (FRP) composites.

Recently developed multilayer material composites enable the integration of local hinge zones in stiff fiber-reinforced composite components, as shown for example by the Flectofold – demonstrator of a preliminary project of the ITFT and ITKE. However, the parameters for adjusting the mechanical properties and fatigue strength of the hinges have not yet been sufficiently determined.

In the project, material tests and calculations are being carried out so that FRP hinges can be sensibly designed and produced with a sufficient long term stability. 3D weaving technology offers optimum possibilities here. In addition to gradual material transitions, this type of production also allows interlaminar joints.

The integration of local hinges in FRP components opens up new fields of application for resource-saving lightweight construction in the building industry. The mechanical complexity of movable structures is significantly reduced. This allows adaptive low-maintenance shading systems for complex building geometries or short-term, temporary structures. Other industries can also benefit, e.g. designs for components in mechanical engineering or in the field of aircraft construction (e.g. aershutters, wing flaps) are possible.



Fiber-reinforced composite component with two integrated actuation chambers and schematic representation of the actuation principle as well as the corresponding 3D fabric





HEALTH AND CARE

*Textile materials, products, and processes
for innovative application fields related
to human medical care.*

- > Resorbable polymers and bio-materials
- > Implants
- > Cell scaffolds for regenerative medicine, biohybrid artificial organs
- > Additive manufacturing, micro injection molding
- > Sensory textiles
- > Personalized orthoses
- > Wound dressing materials
- > Bioactive coatings, e.g. for wound dressings
- > Drug delivery systems: capsules containing therapeutic agents and porous fibers
- > Antibacterial and antiviral textiles
- > Textile-based surgical instruments
- > Hospital and surgical textiles

Health and care

Another year of pandemics is behind us, and high infection rates have once again pushed our healthcare system to its breaking point. For medical device manufacturers, this presents a very mixed picture: While manufacturers are benefiting strongly, for example, in intensive care medicine and in vaccines, others are struggling with declining orders as a result of postponed operations and treatments. In addition, there is the massive burden of the new Medical Device Regulation, which requires a complete reauthorization of even established medical devices by 2024.

Nevertheless, the DITF continue to register great interest from companies that want to take advantage of its many years of experience in the field of medical device development and likewise its high level of expertise in the development and evaluation of products to defend against bacteria and viruses. In addition to new projects on protective equipment, the focus is often on sensory clothing in the broadest sense, which support patients in their therapies, but also on the functionalization of existing products to improve therapeutic success.

Biofeedback using smart textiles

Today, many therapy concepts increasingly involve the patients themselves in order to regain lost abilities of the body in specially developed training programs. For several years, the DITF have been working on how, on the one hand, textile constructions can be used e.g. to improve physical posture (by generating tension forces in the event of incorrect posture/position). On the other hand, it is possible to use "smart textiles" to record physiological parameters and/or muscle activities that signal back to the patient during training whether the exercise is being performed correctly. The system presented here for pelvic floor training is a good example for this.

Biofunctionalized wound covering

Functionalization is a key issue not only for classic textiles but also for all medical products. The integration of additional functions is intended to significantly improve healing times and success and thus save costs at the same time. Biological components that "communicate" with the cells and tissues of the patient are ideal for this purpose in the case of implants and in wound treatment. This is demonstrated here using the example of a wound dressing that stimulates the formation of new blood vessels by incorporating collagen, which is a key challenge, particularly in the case of chronic wounds.

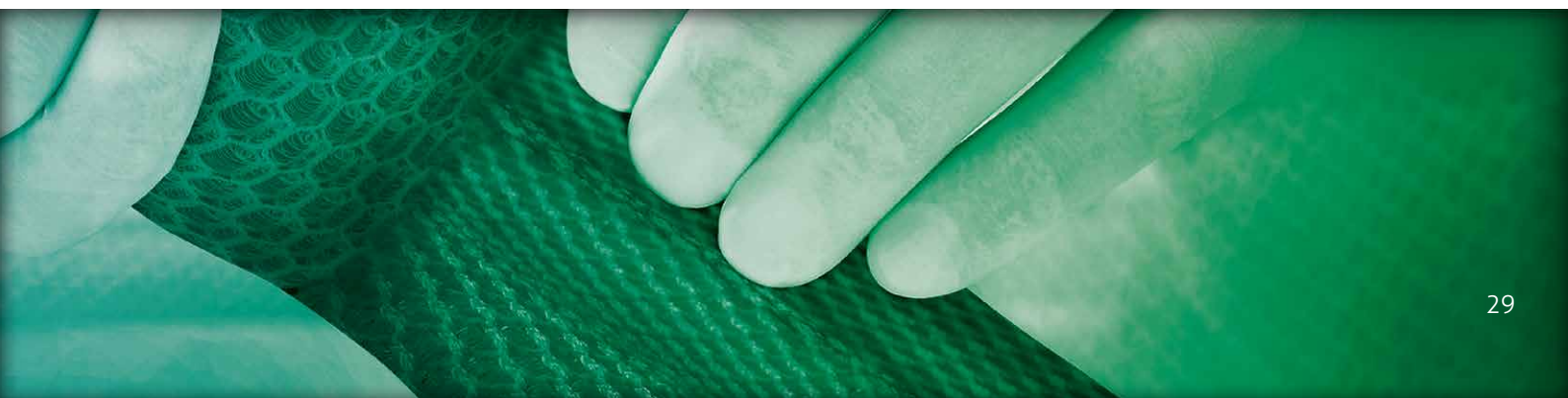
Safety of protective textiles

Textiles ensure protection against germs and can also significantly reduce the risk of injury at work or during many leisure activities. In order to distinguish high-quality goods with the highest possible protection factor from less safe products, suitable, very specific test methods are required. The DITF, together with the FIS, have defined requirements specifically for the protection of ski underwear against cuts from ski edges, and now offer a test method that checks and confirms compliance with these requirements.

Textile protection for a rare disease

One of the most serious consequences of the new Medical Device Regulation that is now becoming apparent is that manufacturers are massively streamlining their product portfolios due to the high costs of re-registration. This will primarily involve the elimination of products with low sales, which particularly affects the treatment of children and rare diseases. All the more interesting, therefore, is the project presented here on elastic orthoses and protective clothing for people with the rare brittle bone disease, which imposes considerable restrictions on children in particular in order to prevent bone fractures. Once again, the great potential of textile structures is demonstrated here, which enable both individual adaptation to the patient and force absorption or specific force transmission.

The DITF are excellently positioned in medical technology. For more than 40 years, fiber-based medical products have been researched and developed here in an interdisciplinary manner, from polymers to implants or hospital textiles. They offer the entire spectrum of innovative medical product development from polymer development to biomaterial processing and functionalization to prototype production. This also includes cell biological and microbiological testing for function in vitro. The DITF and their subsidiary, ITV Denckendorf Produktservice GmbH (ITVP), are certified according to ISO 13485:2016. This enables them to produce prototypes in the cleanrooms of the institutes and the ITVP that can be implanted directly into humans. Finally, if desired, the GmbH also makes its production capacities available. This means that the partners of the DITF and ITVP, who work together on new products, not only have access to the know-how and experience of the institutes, but also to research, development, and production that fulfills all current legal requirements and is documented in accordance with the approval.



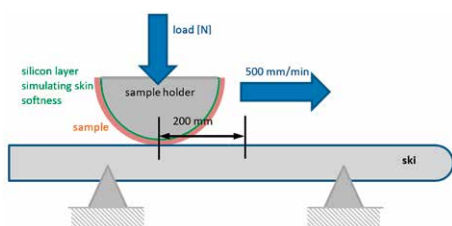
New procedure for testing the cut resistance of ski underwear

The DITF, together with the International Ski Federation (FIS) and textile manufacturers, have developed the FIS-DITF recommended minimum standard for the cut resistance of ski protection undergarment. The cut-resistant undergarment improves the protection of athletes from severe cut injuries. To determine whether the undergarment meets the test specifications, the cut resistance of the material is rated using a five-star scale.

Ski undergarment with the FIS-DITF label not only offers more safety for professional athletes on Olympic slopes, but also recreational skiers can benefit from the tested protection garment.

The scientists at the DITF check the compressive force at which the ski undergarment is cut through with a freshly and relevant grinded ski edge. The fabric must withstand a minimum 20 cm cutting length at an angle of 0, 45 and 90 degrees. The test simulates a cut on an arm or leg with a compressive force of up to 500 N.

The cutting speed is also precisely defined. For comparable data, the same type of ski is used for each test, the edges of which are always grinded in the exact same way. The development of the process for a reproducible sharpness of the ski edge was a challenge. Cut-resistant protection undergarment is awarded with a FIS label if the minimum recommended protection level is achieved. The star system is easy to explain: If the undergarment withstands 100 N of pressure, it reaches the minimum level of one star. For every additional 100 N an additional level and star is reached. Up to five stars are possible.



Principle of the cut test with underwear (sample) and the ski



FIS label for cut-resistant underwear with one star

Flexible textile structures for orthopedic care of OI patients

There is hardly a genetic defect that is described as metaphorically as Brittle Bone Disease. Every year, around 100 children are born in Germany with the very rare disease Osteogenesis Imperfecta (OI). It is estimated that there are about 5000 people affected in this country and approximately half a million worldwide. Characteristic of all forms of OI is a high bone fragility due to low bone mass, especially in childhood and adolescence, as well as bone deformities. Given the rarity and variety of manifestations of OI, there is no recommended treatment for the disease. Stiff and material-intensive devices are used, which are developed for other skeletal diseases. However, the risk of unfavourable force effects on the bones as well as the restriction of the natural movement necessary for OI patients is immense, even when used professionally.



Elastic OI-Orthosis with traction elements for deformation treatment

Together with the project partner Schlather GmbH, flexible textile devices are being developed in a ZiM project specifically for the needs of OI patients. On the one hand, elastic orthoses are being designed for the treatment of bone deformities. For this purpose, specific textile-mechanical structural properties are developed to support the bones to return to the natural growth pattern. On the other hand, a flexible protective clothing is being realized to significantly reduce the risk of bone fractures. The force -absorbing and -dissipating textile structures developed for this purpose are being integrated into garments that can be used in everyday life. The difficulty here is to maintain a high degree of flexibility and not to stiffen the overall structure in the long term.

Biofeedback-based pelvic floor training using smart textiles

About 14 percent of all women and nine percent of all men in Germany suffer from bladder incontinence. The likelihood of incontinence increases with age. To improve continence performance, those affected need to train their pelvic floor muscles. Together with the project partners Charité, Comazo GmbH & CoKG, IQE GmbH and GJB Datentechnik GmbH, the DITF are developing an intelligent and routine textile in the ZiM project "PelFit" that uses biofeedback to monitor pelvic floor training.



Smart Textiles with integrated, highly sensitive, embroidered electromyography sensors (EMG) for training the pelvic floor muscles

An essential component of the smart textile is the textile integration of highly sensitive embroidered electromyography (EMG) sensors, which measure electrical activity based on action currents of the relevant muscles. The embroidered EMG electrodes are made of conductive embroidery yarns and their size and geometry can be adapted to the shape of the muscle. Before each training session, the anatomical location of the EMG sensors is determined. The collected EMG signals during the training session should be analyzed for the visual guidance of the patient to be able to prevent the tension of the abdominal and gluteal muscles and overtraining of the external bladder muscle.

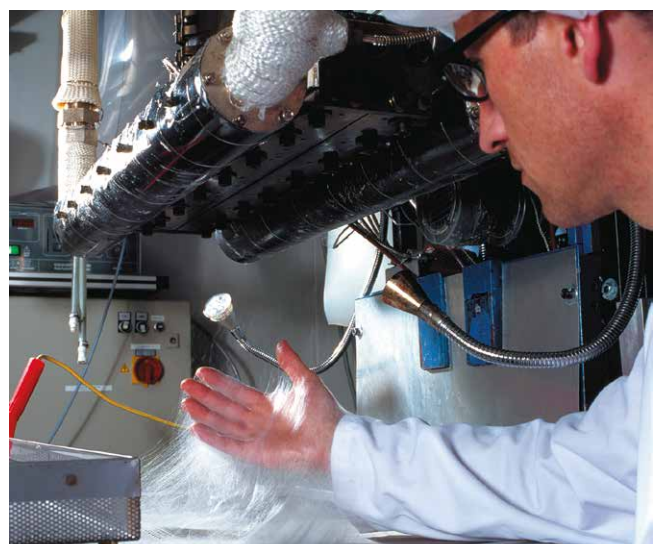
Technical challenges include distinction of muscle group activity, correct electrode positioning, and disinfectability and washability of the smart textile at high temperatures.

Biofunctionalized, resorbable wound cover

The aim of the research project "Development of a biofunctionalized, resorbable (degradable) wound covering for epidermal and (partially) dermal skin lesions of acute or chronic genesis" was – in collaboration with Polymedics Innovations GmbH – the development of a resorbable wound dressing system as a nonwoven based on synthetic, hydrolytically degradable polymers that can be biofunctionalized with biological, collagen-based components.

For this purpose, the meltblow and solution blow processes were used to produce a three-dimensional combination product that supports neovascularization, stimulates wound healing, and accelerates wound closure. Thus, virtually scar-free wound healing can be achieved.

A particular challenge was to process the amorphous material provided by the project partner into a fine fiber fleece using the meltblow process. A nozzle specially developed by the DITF for this requirement was used. The consolidation of the nonwoven could only be realized offline within the scope of the project but is also feasible online for a production process. The implementation of direct injection of collagen fibers in the meltblow process was not possible. The potential of nonwoven production of absorbable polymers from the melt as wound dressings was fully demonstrated. The functionality could be proven by the project partner in animal experiments.



Meltblow plant with connected clean room (ISO 8)





MOBILITY

The mobile world is in a state of upheaval. Textile innovations from DITF are helping to shape this process. We always keep an eye on the current requirements for comfort, functionality, energy and the environment.

- > Increasing use of natural fibers, bio-based fibers, bio-matrices and aggregates
- > Technologies for recycling bio-matrices as well as basalt, glass and carbon fibers
- > High-quality semi-finished products made from recycled carbon fibers for load-bearing components
- > Significant reduction of the carbon footprint through carbon fibers made of cellulose, lignin and chitin
- > Application of LCA methods down to the smallest screw
- > Manufacturing and component simulation to reduce costs and extend service life
- > Micro-computed tomography to detect and eliminate component defects
- > Smart textiles for vehicle interiors and exteriors
- > Weight savings of fiber composites by using sensors for life cycle health monitoring
- > Smart, resource-saving textile solutions for interior lighting, heating, operation
- > 3D space winding and tape laying for ultra-lightweight construction
- > Complex woven ceramic fiber preforms for ceramic matrix composites
- > Economic and ecological materials for fuel cells
- > Cellulose-based filter materials
- > Advancements of airbags and safety textiles for ultralight actuators
- > Use of microwaves or UV technology for low-energy production methods

Mobility

Weight reduction and material-saving processes

Fiber-reinforced composites (FRP) have found their way into almost all areas of technology. In addition to high stiffness and strength at low weight, these materials offer many other advantages, so that the higher price of the materials and manufacturing processes can be compensated. In addition to the classic textile techniques of multiaxial lapping, weaving, braiding and nonwovens, material- and cost-saving processes such as wet or tow-preg winding and tape lapping are increasingly being used, which generate very little waste and thus have an improved LCA. The textile techniques established at the DITF enable optimal advice to customers and provide the certainty of being offered the best textile solution in each case.

Hybrid construction: The right material in the right place

The materials are installed by means of the so-called hybrid construction method. Different materials are used at the optimum place in the overall component, for example metal, plastic, foam and FRP in a battery support module. It should be noted that the materials have different thermal expansions, so suitable joining processes are applied. In addition, direct contact between the carbon and metal components is prevented by an insulating intermediate layer of glass, so that no contact corrosion occurs.

Function integration

Textiles enable functional integration, for example embedding sensors, heating, lighting, gating of connectors/fasteners, and fabrication of textile hinges and actuators in the fiber composite. Thus, textiles with integrated

sensors can provide component monitoring without the need to screw on the sensor technology at great expense.

Bioeconomy/Sustainability

The establishment of a comprehensive life cycle assessment arises from the socially demanded bioeconomy with economic, ecological, and social aspects. LCA, or assessment of specific global warming potential, is performed down to the smallest material and energy stream and results in significant insights regarding current and future materials and production technologies. Since petroleum-based high-stiffness/high-strength carbon fibers have a high global warming potential, carbon fibers made of cellulose, lignin or chitin are used at the DITF. As a partial substitute for glass and basalt fibers, cellulose and natural fiber composites are being developed at the DITF and qualified for their use in mobility. With the appropriate use of resin systems and adhesion promoters, similar high strengths to glass fiber composites can be achieved.

In the ecological and also economic evaluation, the recyclability of the components and materials plays a decisive role. For improved economic efficiency and sustainability of FRP, residual fibers, textile offcuts, prepregs, and end-of-life components must be recycled in an environmentally friendly manner. Only with a high recycling credit can the materials realize their lightweight potential. Together with the fiber composite and recycling specialists at the DITF, proven experts from the DITF Management Research department are working with complex programs on the globally networked determination of sustainability key data (e.g. global warming potential (GWP)). With these key figures, materials and



products can be compared with each other in terms of their sustainability, from the extraction of raw materials through production and operation to the reuse of recycled materials.

Fire protection

At the DITF, improving the flame retardancy of matrix systems is an important research goal. Thermoplastic matrices such as PA6 with high flame retardancy (LOI of 34-36) could thus even penetrate areas previously reserved for much more expensive matrices such as PEEK and PSU.

The DITF and its partners are also conducting research on improving the fire protection properties of cellulose and natural fiber composites. First tests show that with a combination of internal and external additives even an excellent fire class B1 can be achieved. Furthermore, the DITF are investigating cold-curing ceramic matrix systems. The first concrete reinforcing bars (rebars) with matrix systems that remain stable up to 1,200°C have already been successfully produced by pultrusion.

Manufacturing and component simulation

Manufacturing and component simulation are used to reduce costs in development/design, shorten manufacturing times and extend service life. CAM programs for FRP are well established and enable cost savings in all phases of component life up to end of life – and beyond. The computer tomograph established at the DITF examines the component down to the smallest structural level and reveals weak points, such as microcracks, missing fibers or fiber misalignments.

Technology Transfer Program Lightweight Construction (TTP LB)

The Technology Transfer Program Lightweight Construction (TTP LB) of the German Federal Ministry for Economic Affairs and Energy (BMWK) continues to be an important innovation driver for lightweight construction in Germany. With increasing electromobility with heavy batteries – and thus increased tire wear – lightweight construction can reduce fuel consumption and microplastics from tire wear. The DITF have so far been able to win six projects in this call for proposals, which underlines the DITF's high level of expertise in lightweight construction.

Transfer of results

An even further exploitation of the positive properties with a very good environmental balance of fiber composites requires overarching research work in the areas of mobility, energy industry, construction, sports and other industries and the highly innovative, interdisciplinary German textile industry. The DITF bring together research and industry and organize workshops and symposia in key research fields and networks such as the Alliance of Fiber-Based Materials (AFBW e.V.), Leichtbau BW and Composite United.



Replacement of toxic chemicals in the production of tires and conveyor belts

In car tires, conveyor belts and V-belts, as well as in many applications in the production of technical products, rubber materials are reinforced by cords made of high-strength fibers such as polyester, aramid or polyamide. However, the adhesion of the fibers to the rubber matrix, without pretreatment, is usually low. Therefore, adhesion promoters made of resorcinol-formaldehyde-latex (RFL) are used in the established manufacturing process, which are applied and fixed to the fibers as so-called dips. However, RFL has a significant drawback: formaldehyde has been classified as a proven carcinogen and mutagen by the EU since 2014, and resorcinol has a human-toxic effect. That's why the industry is urgently searching for alternatives that are harmless to health.



Adhesion of polyamide 6.6 to rubber: without adhesion promoter (left), with RFL dip (center), with HMF dip (right)

A new, formaldehyde-free coating system based on hydroxymethylfurfural (HMF) has been developed at the DITF. HMF is derived from plants and, according to current scientific knowledge, is considered to pose no health problems. From a technical point of view, the HMF dips developed are promising: in the case of yarns made of polyamide 6.6, a simple impregnation is sufficient to achieve the desired adhesion improvement. Application of the HMF dip is possible under the same conditions and with the same technology used for the RFL dips. Thus, no additional investment is required to replace the adhesion promoter in production. In cooperation with industrial partners, the extent to which resorcinol can be replaced by lignin is currently being investigated.

New yarns expand possibilities in additive manufacturing

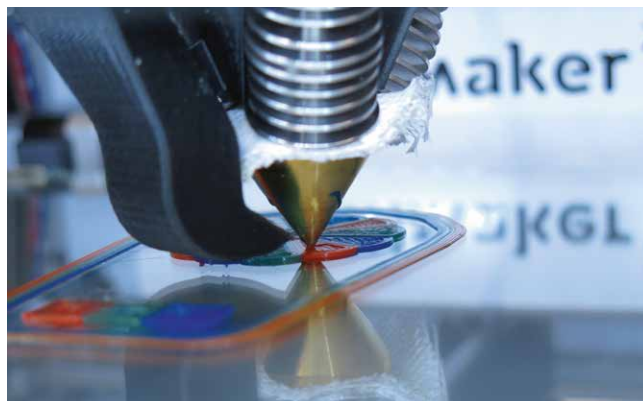
3D printing, also known as "additive manufacturing", has evolved in recent years from the simple production of low-cost plastic molded parts to sophisticated engineering manufacturing processes with high technical specificity, using a wide variety of plastics and metals. Accordingly, various printing processes have already been able to establish themselves. The Fused Deposition Modeling (FDM) process is the most common printing technique, which is also used in the consumer sector. However, the disadvantage of this process is the low molecular orientation of the polymers after curing, which means that only component strengths similar to injection molding can be achieved.

For this reason, specially prepared yarns are used as the sole printing material for fiber-reinforced 3D printing in the "FaserFab" research project.

Fiber as printing material

Core of the project are wrap-around yarns with a high-melting or non-melting fiber core and a wrap-around fiber that is melted in the print nozzle and pressed into the core fiber during 3D printing. In addition to the use of wrapping yarn, another approach is being pursued in which the prepared printing filament is to be a bicomponent fiber. This fiber consists of a high-melting core surrounded by a melting sheath polymer.

The laboratory samples are promising: the printed components with a high degree of fiber filling and fibers in the load direction show significantly increased strengths compared to additively manufactured components without fiber reinforcement.



Print head for processing fiber-reinforced polymers in 3D printing

Carbon filament yarns for sewing processes

Carbon filament yarns are an essential basis for light-weight structures. The low density combined with high tensile strength and stiffness makes carbon fiber composite components indispensable in many areas of industry. In textile processing, however, the stiffness of carbon fibers limits their usability to processes with low bending-specific stress (laying, weaving, braiding); loop-forming processes are out of the question due to considerable filament damage. To generate new products here, the bending stiffness must be reduced or the elongation at break of the carbon filaments increased. In addition, load-minimizing and -compensating coatings are required.



Carbon filament yarn from the DITF for lightweight structures

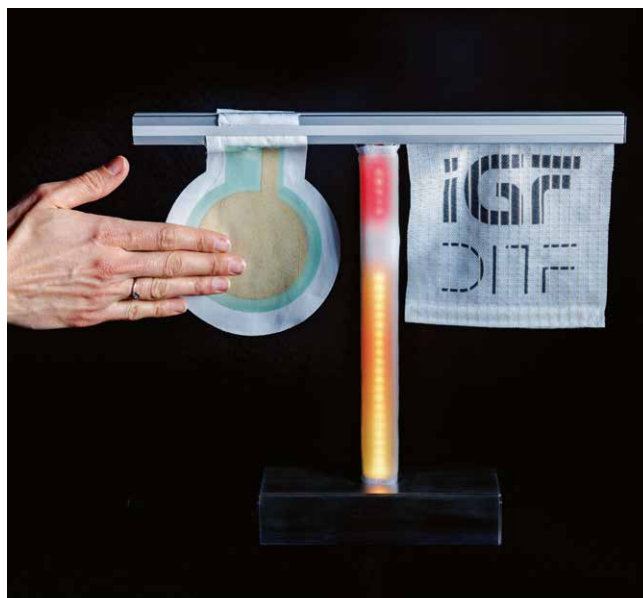
Carbon fibers with elongation

Therefore, at the pilot plants in the Fiber Technology Center HPFC of the DITF, polyacrylonitrile fibers as typical starting fibers are modified in their chemical structure by means of irradiation and a new low-pressure stabilization process in such a way that an increased elongation at break results. At the same time, the fibers are made more flexible by yarn formation and the novel yarn is made more resistant to the high transverse stresses, for example in sewing processes, by a protective coating. The carbon fiber yarns can then be processed without damage, e.g. as sewing yarn for conductive smart textiles or for sewing high-strength carbon fiber composites. This opens up new design possibilities – for example, when used in special weaving processes or in additive manufacturing.

Printed capacitive textile sensors for proximity switches

Textile products with integrated electronics offer a broad field of activity for SMEs and represent an above-average growth segment in textiles. In this research project, the basic knowledge to produce printed sensors and switches for smart textiles was created.

The sensors were manufactured by printing electrically conductive pastes and inks based on silver. The switching function could be realized with electrodes whose ohmic resistances are $< 1 \text{ k}\Omega/\text{sq}$. The structure of the proximity sensor was multilayer and fully insulated. Pastes and inks based on textile binders were formulated for the electrical insulation of the electrodes and crosslinked by adding a crosslinker. The topcoat survived $> 100,000$ Martindale abrasion cycles and is resistant to water. The electrical contacting of the electrodes resulted from mechanically anchored metallic push buttons, which were provided with a conductive PU adhesive towards the electrode. The development of versatile electronics, including an oscillating circuit and a micro-processor, made it possible to record and evaluate the sensor signal, which was successfully shielded by an impedance converter. The programming of the micro-processor caused the control of the electronic component. This made it possible to generate a light signal depending on the sensor approach as well as to trigger the heating of a textile without contact.



Use of a textile capacitive sensor for heating a textile and switching a light signal





ENERGY, ENVIRONMENT AND RESOURCE EFFICIENCY

The DITF institutes develop processes and systems for improved energy, environmental and resource efficiency – with and for their industrial partners. The results are sustainable products and services for a variety of applications.

- > High-performance fibers from biopolymers
- > Carbon fibers from cellulose and lignin precursors
- > Coatings and finishes from renewable raw materials (chitosan, lignin)
- > Environmentally friendly pulping processes for natural fibers
- > Cellulose-based nonwovens for CO₂ absorption from the air
- > Single-material, sustainable single-component composites
- > Sustainable polymer syntheses to replace petro-based monomers
- > Analysis of biodegradation in water and soils
- > Solvent-free, energy-saving processes for coatings and textile finishes
- > Minimal application technologies (foam, plasma, 100 % systems)
- > Use of artificial intelligence for good parameter setting of finishing machines
- > Textile-based thermal solar collectors
- > Energy generation through the use of technical textiles
- > Economical and environmentally sustainable materials for fuel cells
- > Textile materials for the extraction of drinking water from fog and industrial aerosol separation
- > Irrigation systems based on particularly high capillary forces and suction power
- > Filter materials for separating gases/solids/liquids
- > Recycling technologies for high-performance fibers and coated textiles

Energy, environment and resource efficiency

Fibers have always been crucial components of nature. Especially in the plant kingdom, nature utilizes the properties of fibers to build a wide variety of structures and functions. Thus, it is not surprising that fiber-based materials hold many compelling and sustainable solutions for the requirements of lightweight construction, energy efficiency and storage, resource efficiency, as well as environmental protection. Even though they are often invisible in the background and go unnoticed, fiber-based materials are indispensable to solving the problems in these fields of the future since they act as catalysts for increased efficiency, environmental protection, and reduced environmental impact.

Due to the increasing importance of the research field, the DITF are bundling the research capacities and know-how of different areas in two competence centers, the Competence Center for Biopolymer Materials and the Competence Center for Textile Chemistry, Environment & Energy. The development of processes and systems for improved energy, environmental and resource efficiency – with and for their industrial partners – make the DITF essential research partners in this area. The results are sustainable products and services for a variety of applications. Sustainable high-performance fibers, new biopolymer materials, filter and membrane materials for air and water purification, lightweight construction, insulators, sealants, as well as insulants for buildings and textile-based solar cells are just a few examples of the broad research portfolio at the DITF. Current research topics focus mainly on material substitution, material efficiency, use of artificial intelligence, biodegradation and recycling.

Renewable energy sources, energy systems

Technical textiles in Germany owe their success to the continuous development of new areas of application. Of particular interest in this context is the extraction of energy through the use of technical textiles, which is the subject of intensive research at the institutes in Denkendorf. Successes can be observed in solar thermal energy and thermal energy storage as well as in combinations thereof. Further developments include resource-saving and economical novel materials for hydrogen technologies, as well as new electrical energy storage systems. Recent work deals with safety and environmental aspects of solar cells using biopolymers. Another significant contribution of fiber-reinforced composites is in the development of wind turbine blades.

Textiles for environmental protection

In the meantime, technical textiles significantly contribute to the mastering of environmental protection-related tasks in many industries. Accordingly, our research efforts include new filter systems, such as filters to extract particulates and pollen from the air, as well as isolate aerosols in cold and hot flue gas streams. We also develop textile supporting materials for biological organisms in vertical greenery, sewage treatment plants, and algae production. Currently, we are working on new irrigation and water storage systems for greenhouses and plant growing systems. The advancement of acoustic absorption in the home and mobile sector continues to be a research topic.

The application of membranes in the wastewater treatment of the textile industry, as well as other manufacturing companies, has been a focus for years.



The direct absorption and desorption of carbon dioxide from ambient air is made possible by newly developed filter materials based on nonwovens made from functionalized cellulose fibers. Current research work is focusing on the industrial implementation of the new technology.

Sustainable fibers and composites

The sustainability of textile products is a central issue in our society and is currently undergoing a strong collective change. Given the discussion on microplastics in surface waters and oceans, our research on natural fibers and polymers from renewable resources, which are also readily biodegradable or recyclable, is of vital importance for the future. Natural fibers from wood, hemp, nettles, lavender or algae play an growing importance. Further work includes the processing of natural fibers into high-performance yarns using state-of-the-art technology as well as the development of new filter materials and composites made of cellulose and chitin. New cellulose-based reinforcing fiber types have been developed for these composites via HighPerCell® technology. These filament yarns are also suitable for the production of carbon fibers.

The production of cellulose composites creates lightweight, stable, aesthetic products that can be recycled or processed bioenergetically and lead to an overall reduced carbon footprint. Our research focuses not only on various modern manufacturing processes but also includes product cycle analyses and how these affect the properties of the materials.

Self-healing materials that regain their properties after damage constitute a relatively new branch of bionic developments. Initial approaches employing particular filled hollow glass fibers in composites have yielded promising results.

Often, these developments are accompanied by a life-cycle analysis to quantify both the consumption of our natural resources as well as the impact on the environment.

Energy consumption in textile manufacturing

Textile finishing and coating constitute the most energy-intensive processes in textile manufacturing. Thus, there is a need to review new technologies for their energy-saving potential. Such review includes the commissioning of cross-linking systems of solids without solvents and reactive hot melts, the use of minimal application technologies such as foam application and innovative pretreatment methods based on ultrasound and plasma.

Additionally, we are exploring the further development of dryer systems with more efficient heat-material transitions, heat recirculation, and heat recovery, as well as smart process control systems using artificial intelligence methods. New ways of interconnecting equipment and coatings result in energy savings in drying and achieve excellent properties. These include curing through the use of electron-beam technology and ultraviolet light based on LED.

We achieved notable success with atmospheric- and low-pressure plasmas, which find increasing application in textile manufacturing.

Hybrid yarn for eco-friendly and sustainable forest afforestation

Forests are a habitat for plants and animals, a recreational area for people, and important for both local and global climate. In this respect, afforestation is of vital importance because of weather and game damage, forest fires and forest dieback. The forest must be prepared for climate change. Growth covers are a crucial component of forest afforestation in the first few years.

Currently used growth covers are made of PP, PE, PVC or metal and are often not removed or only after years. Thus, the growth covers remain in forests until they rust or are mechanically shredded into environmentally harmful small and microplastics. For this reason, an environmentally friendly hybrid yarn made of natural fibres and bio-based thermoplastic (PLA) was developed at the DITF, which was then knitted by the company Buck GmbH & Co. KG to form a tube using a circular knitting machine and then consolidated into a stiff but at the same time flexible tube.

Cotton and PLA fibres were opened in processes of spinning preparation, mixed and processed into a sliver. Subsequently, a suitable yarn structure for the bio-based hybrid yarn was determined in spinning tests on a rotor spinning machine, on a roving frame, a process prior to ring spinning, and on a self-built filament wrap spinning machine.



Stephan Baz (Head of Staple Fiber Technologies) with the environmentally friendly growth cover in original size and as a demonstrator on a red maple

With the development of the hybrid semi-finished product from renewable raw materials and the sustainable growth covers made from it, the amount of plastic waste in the forest is reduced and the emission of greenhouse gases is reduced by replacing petroleum-based plastics.

DITF oxide ceramic fibers on the leap to industrial production

Oxide ceramic fibers are an essential component of fiber-reinforced ceramics (CMC: Ceramic Matrix Composites), a class of materials that is increasingly important for high-temperature applications. Fiber reinforcement produces a damage-tolerant ceramic material that is no longer brittle and is superior to monolithic ceramics, making it highly interesting both technically and economically. Potential applications include components in industrial furnaces and stationary gas turbines, charge carriers for temperature treatment, aircraft gas turbines with lower fuel consumption, or space applications. A significant increase in the industrial use of these CMCs is predicted for the coming years, and therefore a growing demand for ceramic fibers.



Meeting with Saint-Gobain Ceramic Materials to sign the contract at DITF in Denkendorf in December 2021

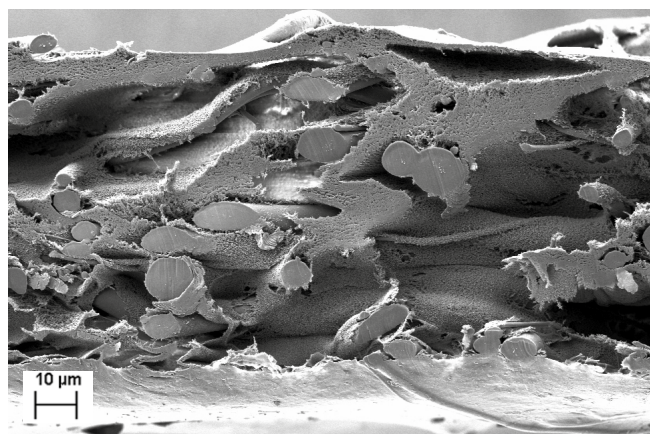
Research and development in the field of oxide ceramic fibers has been carried out continuously at the DITF since 1990, so that substantial and well-founded know-how exists. For several years, a pilot plant in Denkendorf has been operated in order to produce the so-called OxCeFi ceramic fibers, representing the complete manufacturing chain.

On this basis and after extensive negotiations, a cooperation agreement was concluded with the French Saint-Gobain Group in December 2021. The aim is to jointly create the conditions for establishing a production facility for oxide ceramic fibers in Europe. As there is currently only one manufacturer of high-quality oxide ceramic fibers in the world, the planned production is intended to provide a "second source" which has been required for many years.

Nonwoven-reinforced membranes for "Electrolysis made in Baden-Württemberg"

Solar energy and other types of regenerative energy are representative of the energy transition in Germany. A key technology for storing the energy generated is alkaline water electrolysis. The development of a highly efficient water electrolysis plant in a megawatt demonstrator is the goal of the joint research project "Electrolysis made in Baden-Württemberg" led by the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW). The task of the DITF is the development and production of membranes for the electrolysis cell.

Such membranes are already commercially available, but they usually have a high ohmic resistance due to their material thickness. Thinner and more efficient membranes with better electrochemical properties, on the other hand, have so far not been robust enough and are sensitive to mechanical stress. They are prone to stress cracking and material failure, especially when used in larger cells. Therefore, ultrathin membranes are mechanically reinforced at the DITF by using supporting nonwovens made of ultrafine fibers (fiber diameter 0.2-2 μm). The development of suitable ultrafine fiber nonwovens with tailored property profiles is just as great a challenge here as the production of the membranes themselves. The first promising membranes are available and are being tested and optimized with regard to their practical suitability. An additional reinforcing frame made of composite materials is also intended to absorb mechanical pressure loads during assembly in the demonstrator.



Scanning electron micrograph of a nonwoven reinforced electrolyte membrane

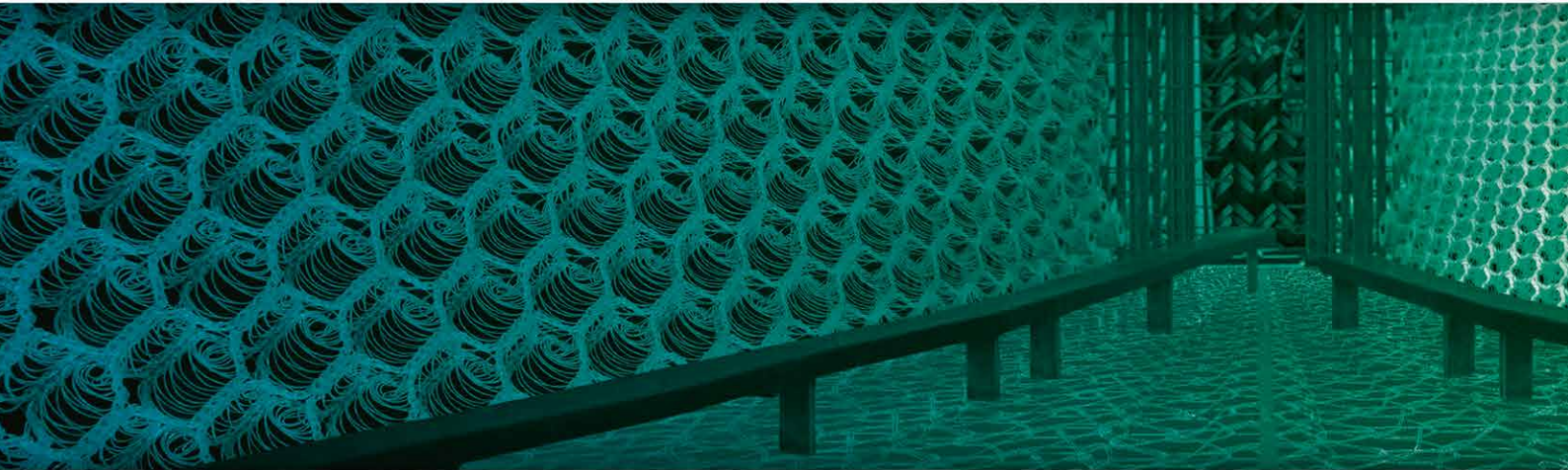
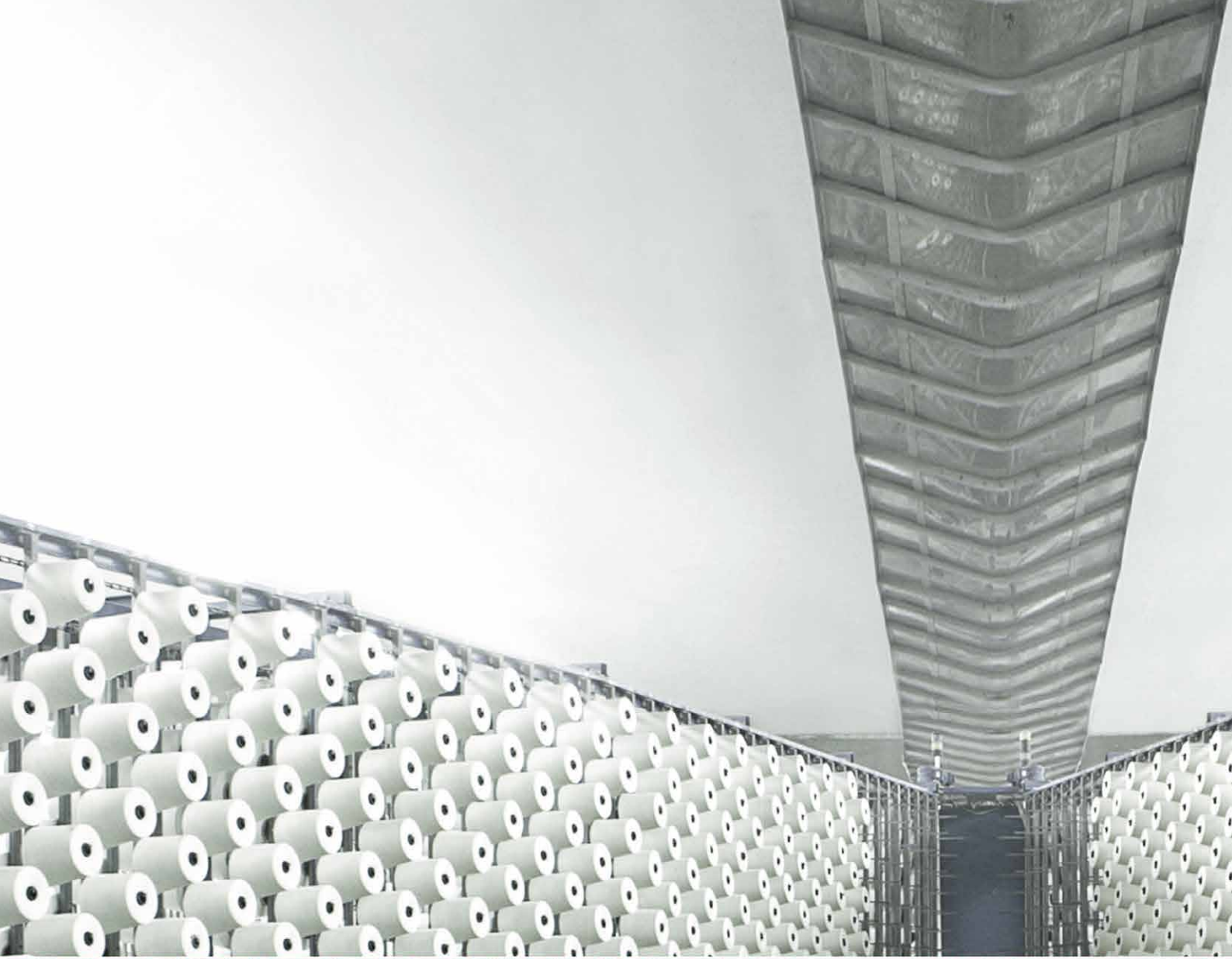
Nutrient recovery from liquid digestate

Digestate from biogas plants is a source of nutrients, but often contains pollutants and heavy metals such as copper. As part of a ZIM project, a new textile cleaning device for filtered, diluted digestate was developed with partners Westdeutsche Dochtfabrik GmbH & Co. KG and Weißenstephan-Triesdorf University of Applied Sciences. This cleaning device is compatible with existing under-glass fertilizer systems.



Filter cartridge with experimental plantings in the greenhouse at Weißenstephan University of Applied Sciences

Two purification stages are integrated in the filter cartridge. First, the micro-pollutants are removed by activated carbon and then the heavy metals are complexed by means of chitosan. Chitosan-coated braids also act as a heavy metal-specific color sensor at the end of the purification section. In the plant-tolerant range up to pH 6.0, up to 47 wt.% of copper could be removed from an aqueous model nutrient solution. The planting trials showed that the added indicator substance ibuprofen was not detectable either in the individual compartments head and root of the crop plants or in the planting substrate.





PRODUCTION TECHNOLOGIES

Digitization, modeling and simulation - important tools for the development of intelligent production technologies for the entire textile value chain.



- > Smart process control systems
- > Digital technologies for Industry 4.0
- > Microfactories for digitally networked production
- > Functionalization of textiles with modern technologies
- > Systems to bridge human-machine interaction
- > Modeling and simulation of processes as a basis for effective process optimization
- > New processes for the production of printed sensors and actuators on textile

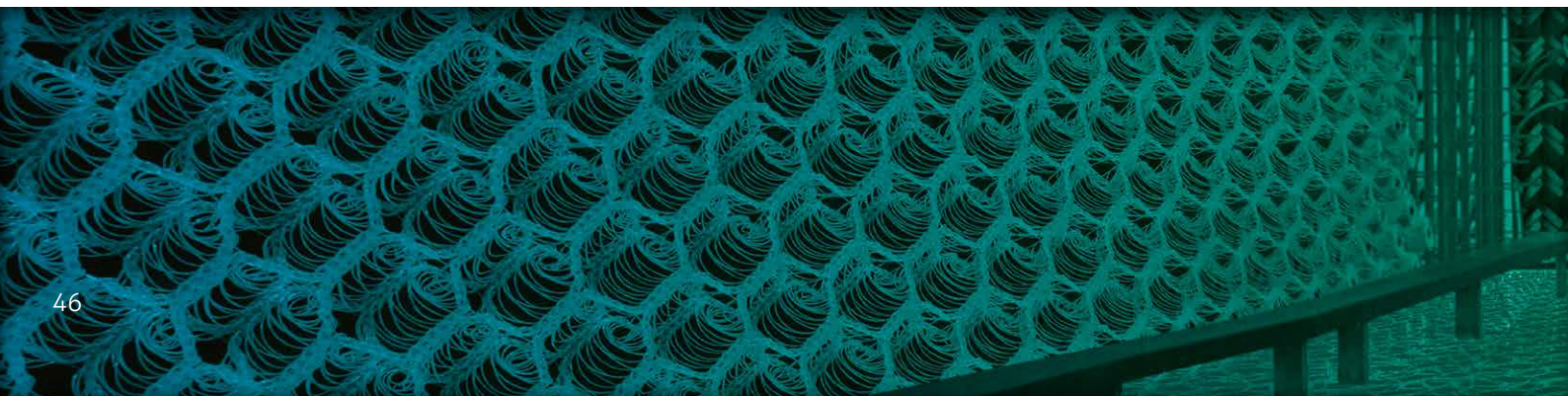
Production technologies

In the light of global competition, innovative approaches in the field of textile production technologies are needed more than ever. Under the aspects of sustainability, resource conservation and recyclability in the manufacture of textile products, the technologies for the production of such products must also be adapted and optimized.

Not only in the fields of textile process engineering and textile and fiber chemistry are the DITF the leading partner, but also the preferred development partner for non-textile companies that see the advantages of fiber-based materials in new fields of application. Whether in architecture and construction, in health and care, in mobility, in energy, environment and resource efficiency – these materials are used everywhere and are, for example, an important component of modern lightweight construction concepts. Production technologies are the largest research area in the DITF's application fields. In this context, digitization, modeling and simulation are becoming increasingly important for the development of intelligent production technologies across the entire textile value chain.

Interdisciplinary networking and collaboration as the key

The development of new process engineering and process technologies is effective when knowledge is available along the entire manufacturing chain. This is why the DITF have been conducting research along the entire textile manufacturing chain for decades. From the synthesis of fiber polymers to spinning processes and textile surface production to the manufacture of prototypes, the DITF can draw on the experience of longstanding employees. They use the know-how of experienced specialists in the individual process stages to achieve the optimum result for the customer. The focus is on the holistic approach that takes into account all areas such as technical, textile technological and economic aspects. The basis for this is the interdisciplinary cooperation of experts from various fields such as textile technology, mechanical engineering, process engineering, chemistry, physics, biology, cybernetics, computer science or economics.



Applied research on 25,000 m² of space

Applied research and development are only possible if appropriate industry-related equipment is available. With an area of 25,000 m², the DITF have the prerequisites to maintain, further develop and newly build production technologies in order to conduct research close to industrial reality. We can also cater for pilot or small productions. We develop and build prototypes in-house. Production processes for the manufacture of fiber-based composites, 3D textile structures, digitally printed textile structures, high-performance fibers, etc. are available under one roof and can be used and modified according to customer requirements.

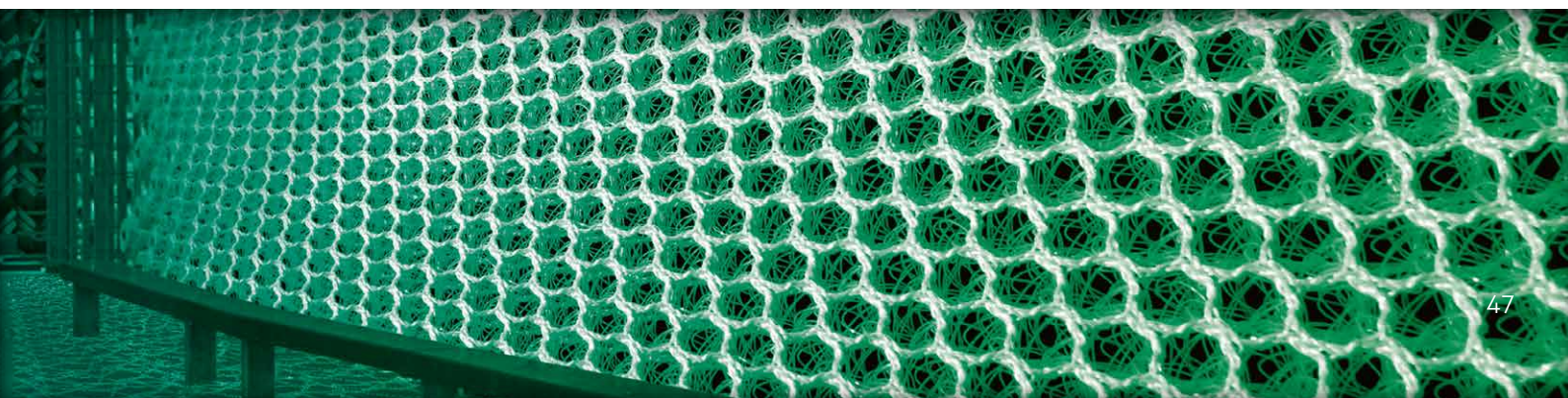
We also support partners in the area of electronics and control. A state-of-the-art workshop and electronics laboratory serve specialized technicians to implement new ideas into testing and production procedures of the textile industry.

What will the future bring?

The buzzword “digitization” will also determine the future of textile process engineering and production technologies. German and European textile machinery manufacturing certainly does not have to hide in this respect, as digitization is well advanced in modern machines. However, the requirements of Industry 4.0 do not only relate to individual machines, but to complete production processes, such as those implemented in the Microfactory of the DITF. Here, everything is digitally networked and documented, from the digital recording of body measurements, to computer-aided pattern making, to digital printing, to cutting for the manufacture of apparel textiles. For such production processes, the Textile 4.0 multifunctional laboratory of the DITF offers state-of-the-art process and IT infrastructure.

Not all processes have to be studied experimentally at great expense. Modern modeling and simulation tools allow pre-development on the computer, which limits the subsequent experimental effort and thus enables fast, targeted development.

For the process engineering developments of the future, considerations of sustainability, resource conservation, energy minimization and the recyclability of products are of decisive importance and must be seen as guard rails within which we must move.



Improvement of fiber orientation with high short fiber content

When processing inhomogeneous fiber blends consisting of different fiber finenesses and length distributions in the draw frame draft disturbances increasingly occur resulting in non-uniform slivers. In the project, investigations of fiber movement within the drafting zones were carried out using a high-speed camera and LDA. Furthermore, a new measuring system was used to determine the pressure distribution. The optimum pre-draft for the ring spinning process was determined using a pre-draft force measuring device.



Developed fiber guiding element with optimized position in the drafting system of a draw frame

New fiber guide elements were developed based on these findings. By using a fiber guide element positioned closer to the draw frame exit cylinder pair in the main field, we could reduce the average fiber speed locally. Thus, it was possible to parallelize the fiber mass significantly better and to improve the sliver non-uniformity value by up to 1.5 % points (CV%) compared to the installed standard guide element. Due to the sliver non-uniformity optimization, higher delivery speeds are achievable, resulting in up to 20% higher productivity at the same quality. In addition, fiber blends with large fiber length differences can be processed with consistent quality and higher productivity. The new fiber guiding element results in a higher flexibility regarding the processing of fiber blends as well as an increase of the efficiency and profitability due to a more stable running of the machines.

ExPerTex – Expert System for Energy Saving in Stenter Frame Treatments

Drying and fixing processes on the stenter frame are among the most energy-intensive processes in the textile industry. Energy price increases as well as political requirements for minimizing emissions of climate-damaging greenhouse gases inevitably require potential savings in stenter frame treatment in finishing plants.

Cost savings are possible in electricity consumption as well as in thermal management. To date, however, there is a lack of systems linked to the plant control system that combine process sensor technology and process data acquisition with quality control in order to flexibly adapt machine settings and production parameters to frequently varying processes for maximum energy efficiency.

The core innovation of the BMWK project “ExPerTex” consists of the development of a knowledge-based assistance system as a web application, by means of which the textile finisher can prepare a recipe and machine setting optimized for his specific application and machine.

By integrating adapted sensor technology in the stenter frame, essential characteristic data of a process are recorded in the form of drying curves (TVKs). In the project, the DITF analyze such TVKs depending on various characteristics such as type of textile substrate, finishing or coating agent. From this, suitable AI algorithms determine the best process parameters for new textiles. The plant engineering companies involved in the project plan to make the energy-optimized process control available to their customers as a service in the form of an assistance system.



Stenter frame of Brückner comp. in the textile technical center of the DITF

Enabling local, circular & bio-based textiles

The HereWear project aims to create a European circular economy for locally produced textiles and clothing from bio-based resources. This will be realized through a holistic approach: On the technical side, new sustainable technologies for wet and melt spinning of cellulose and bio-based polyesters, for yarn and fabric production as well as for coating and dyeing will be developed and tested on a semi-industrial scale. In addition, the sustainability and circularity of our clothing will be maximized through regional value-added structures using networked production resources in "microfactories" (small factories). The digital continuity and transparency for traceability, as well as the consistent orientation towards "production on demand", are elementary in this context.



From straw to sustainable textiles – filaments and knitted fabrics made from straw pulp

Production of cellulose filaments from bio-based waste streams and marine debris

In times of raw material shortages and energy bottlenecks, there is a strong focus on raw material diversity and novel, flexible technologies. Together with national and international partners in the HereWear EU project, DITF is investigating the use of second-generation raw materials to produce cellulose filaments. The HighPerCell® technology relies on the use of a new type of solvent called ionic liquids (IL). These are considered to be ecologically and safe, as they are neither toxic nor flammable. The filaments are processed into textiles and prototypes for project partners.

Virtual product development realizes peripheral milling cutters with extreme lightweight design

The milling cutter is one of the most important components in woodworking. In this context, the existing peripheral milling cutter, also known as planer head, made of aluminum have largely exhausted its lightweight potential. Lighter and more rigid tools enables better surface quality and productivity as a result of higher speeds and optimization of vibration behavior, while also saving energy.

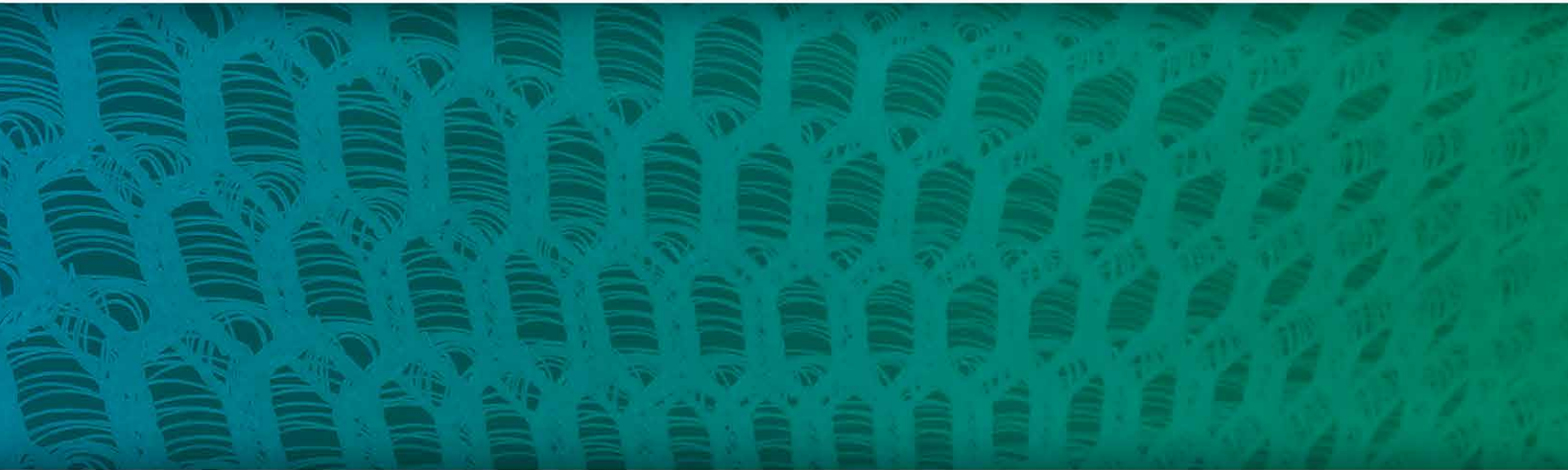
The extreme lightweight solution made of carbon fiber composite materials (CFRP) developed at the DITF by means of numerical simulation uses a completely new design principle of modular tool in which the different loads are distributed among individual structural parts and optimally designed for the respective loads and the fiber properties.

This extremely lightweight CFRP design was developed for the planer head for machining wood-based materials (circumferential face mill). With over 50 % reduction in the mass of a classic planer head, productivity increased by more than 1.5 times and the quality of the wood surface was maintained. This extreme lightweight design can be transferred to other tools.

However, the economical and reliable production of the CFRP individual components is still a major challenge for a feasible series production and requires further research. In addition, the design principle must be further optimized and specifically investigated in terms of maximum speed, damage tolerance, long-term and failure behavior, and functional integration.



New extrem-lightweight planer head – 50% lighter and 1.5 times faster than the reference aluminium peripheral milling cutter (ThinkIng Award May 2022)





CLOTHING AND HOME TEXTILES

*New and further development of textiles and processes.
For more comfort, functionality, and sustainability.*

- > New fibers and technologies to improve mechanical, haptic, optical, or acoustic properties
- > Antibacterial and antiviral finishes
- > Development of fluorine-free and formaldehyde-free finishing processes
- > Development of highly efficient halogen-free flame retardant finishes and coatings
- > Finishing via physical processes (UV, ESH, plasma)
- > Innovative carrier-free dyeing processes for high-performance fibers
- > New dyeing systems for NIR camouflage
- > Textiles with selective remission or reflection of thermal and IR radiation
- > Compressive sports textiles
- > Coated textiles, membranes, and laminates for comfort and security
- > Textiles for art and light applications
- > Sensor and actuator textiles through integration or printing on the respective circuitry, as well as fluorescent or electroluminescent colors and pigments
- > Digital coloring and functionalization of textile procedures
- > Textile lettering procedures for traceability and prevention of counterfeiting
- > Virtual product development and retailer feedback processes within the clothing industry

Clothing and home textiles

Sustainability and competitiveness

All environmental, economic, and social aspects of sustainability are gaining importance. Keywords such as “circular economy”, “sustainability” or “life cycle analysis” are now part of the daily vocabulary in the textile industry. Our expertise makes us part of the European initiative to create a broad network of companies in the textile industry with laboratories for innovation, service providers, and business consultancies and to provide alternatives to excess production and depreciation. This offers the opportunity – also due to Covid – to initiate a relocation of production capacities back to Europe and to improve resilience. These include new strategies for the reuse of often high-quality fiber products through appropriate fiber preparation or chemical recycling. At the same time, however, the use of fibers or coating materials from raw materials available from biogenic or renewable sources is also required. As renewable raw materials, cellulose, chitosan/chitin, alginate or, more recently, hyaluronate have been the focus of the DITF for several years. In the case of coatings, biogenic (partially) based polyurethane or polyurethane acrylate coatings are the focus of interest.

New finishes for antimicrobial properties

The development of textiles with antiviral function has taken on a completely new dimension with the Corona crisis. Since March 2020, the DITF have been working on the development of possible concepts for corresponding protective equipment, both for the clinical and private sectors. In several projects, methods are primarily being investigated here that achieve rejection and/or killing of germs by equipping them with physically based methods. In parallel, the reuse of protective clothing is an important topic. A large proportion of these textiles are made of synthetic fiber materials such as polypropylene or polyester. They end up in the trash or in the environment after mostly one-time use. Here, the DITF are developing new solutions for the appropriate finishing and use of natural fibers.

Chitosan-based finishing of textiles

Scientists at the DITF are working on replacing petrochemical-based substances in the finishing or coating of yarns and textiles with modified biooligomers or biopolymers in the future. Important aspects of this work are the appropriate preparation of potential natural substances, the formulation of an adequate, largely solvent-free chemistry for the respective modification, and finally – to achieve good wash resistance – the development of suitable cross-linkers based on compounds available from biogenic sources.

Depending on the preparation process of the biopolymers under consideration, different viscosities can be set. This makes it possible to use the modified natural substances either via common finishing processes or to apply them as coating pastes. In this context, research is

being carried out at the DITF, e. g. on modifying chitosan in such a way that wash-resistant hydrophobic finishes can be produced. Other goals that should be achievable with modified chitosans are antibacterial properties, high abrasion resistance and flame retardant properties.

Digital printing

Digital application processes have developed rapidly in recent years and thanks to their high flexibility and productivity, it is no longer possible to imagine the textile industry without them. They enable design changes at the touch of a button, no time for setting up the printing machine and allow continuous operation at printing speeds of more than 40 m/min while maintaining the highest level of quality. That is today's digital printing.

The DITF have been involved in this technology for many years and have made a significant contribution to the current state of the art through their wide-ranging research work in this field. The research work includes trend-setting developments in the field of fabric pre-treatment as well as UV-curable color inks, which can be fixed in a particularly energy-saving way. Increasingly, current research activities are focusing on the development of inks for the digital finishing and functionalization of textiles. The printing of invisible security markings (plagiarism protection) has also been realized, as well the digital printing of electrical switches and heating elements, as well as printed light.

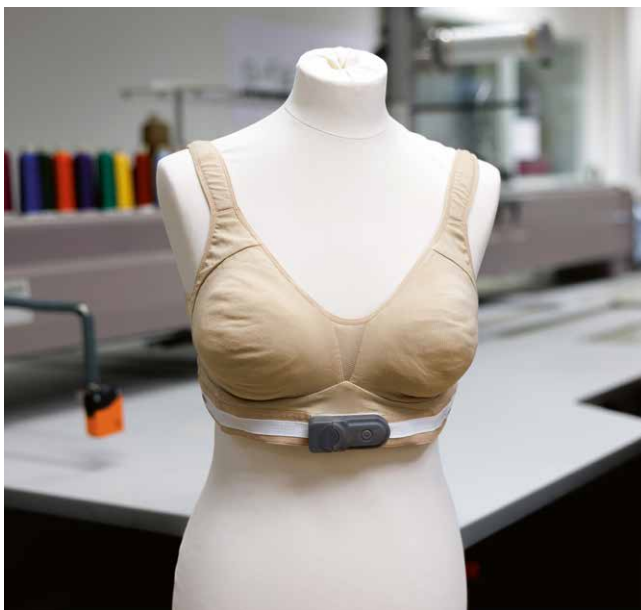
Continuous digital engineering and micro-factories

Digital technologies change the competitive environment and offer new chances to companies working in the apparel and household textiles industry. The DITF institutes have several laboratory and demonstration environments to show firsthand what digitization makes possible. The DITF showcase also presents "Digital engineering" at the Mittelstand 4.0-Kompetenzzentrum "*Textil vernetzt*", (competence center for mid-sized companies, "networked textiles"). It is a digital process chain in the area of clothing and home textiles. Continuous digital engineering from design to the final product is a milestone in digital transformation not only from a technical perspective. Fully integrated, automated digital process chains make even entirely new business models exciting and lucrative. They save material costs, development times and permit a swift but also flexible reaction to changes in the markets. It does not matter if they are micro-factories for regional or urban production of small batches or custom and unique individualized items – all of them address current market trends. Micro-factories also have substantial ecological advantages compared to conventional processes. The DITF with their Textile 4.0 multifunctional laboratory bring the newest technology for digitally networked development and production processes to customized enterprise solutions.



ECG measurement integrated into clothing for female heart failure patients

The DITF, together with the companies Nina von C. and Getemed have developed a bra that meets the demands of elderly women who have heart failure but who still want to live in their homes. The smart bra comprises textile electrodes and a device that records ECG signals. The bra transmits data to the doctor only when the bra's artificial intelligence has detected critical events in ECG signals.



The bra contains textile electrodes and a device for recording ECG signals

Using such AI algorithms can contribute to more personalized treatment and precision medicine and prevent serious heart problems by enabling early detection. Also, the use of the bra is suitable in the context of new remote monitoring services such as e-consultation, or as a new home-based follow-up to ensure seamless patient care after hospital or rehabilitation stays. This gives healthcare professionals better access to the patient's digital ECG data – regardless of where she lives – and allows the patient to feel more secure.

Chiengora® – Finest animal hair fibers for sustainable fashion

The textile and fashion industry must become more sustainable. The young brand "modus intarsia" shows how it can be done. From the undercoat of dogs, which is normally combed out and ends up in the trash, the two founders have created a high-quality yarn. The idea came from fashion designer Ann Cathrin Schönrock, whereupon textile engineer Franziska Uhl (Reutlingen University), together with scientists from the DITF, tested the developed yarn on industrial machines, optimized it, and produced it on a larger scale.

Chiengora® is the name they have given to the cashmere-like yarn – "Chien", French for "dog" and "gora" in reference to the fine angora obtained from hare hair. The yarn has the advantage over cashmere in that the raw material is not flown in from Mongolia and no animals are bred and kept specifically for wool production. The raw material for the yarn is produced incidentally during daily animal care, especially when the animals lose their winter coat in spring. Thus, the use of Chiengora® not only saves resources, but also serves animal welfare.



Finished yarn. Cap and scarf are made of Chiengora®

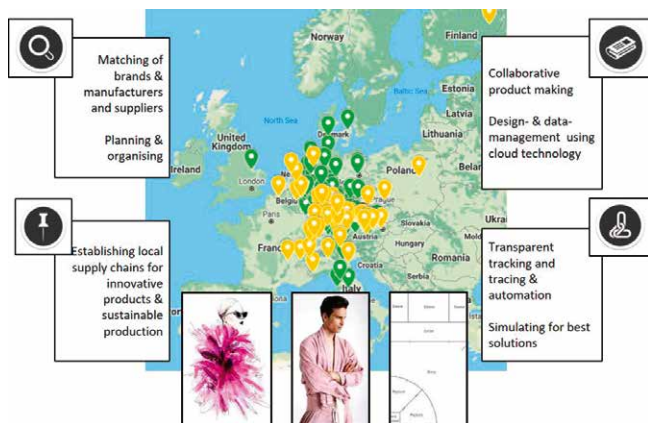
The potential is huge. In Germany alone, there are over 10.4 million dogs. Although not all dog breeds have suitable undercoats, over 1000 tons end up in the garbage every year throughout Europe. Schönrock and Uhl have set up a decentralized collection network. Anyone can participate, collect the undercoat of their four-legged friend and send it to Reutlingen. The project is supported by the state EXIST start-up grant and an investment from the textile industry.

KompakT – digital co-creation platform for sustainable fashion concepts

As part of the KompakT project, an intelligent service for the demand-oriented realization of creative fashion concepts is being developed, made available on a platform, and piloted on the German-speaking market. This digital service addresses the need of fashion makers to realize their concepts and designs in close cooperation with value creation partners along the textile value chain, in particular using sustainable materials, technologies and processes.

The aim is to organize the entire product life cycle from design to small-volume and series production to retail on a single platform: Both the search and mediation of suitable cooperation partners and the joint implementation of fashion concepts are supported. Focus areas are a taxonomy for apparel products, a matching algorithm, a provision of the carbon footprint, as well as the tracking of order processing at a glance. After implementation and extensive testing, these will be made available for use as a service on the existing "sqetch.co" platform.

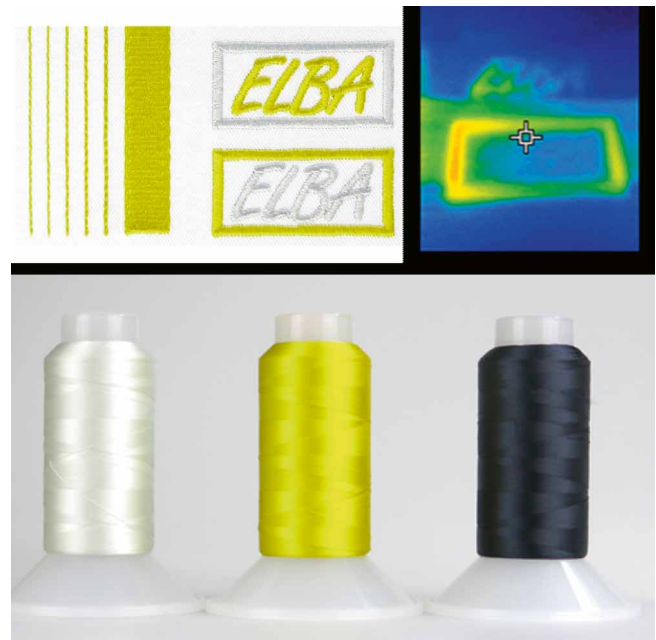
In the long term, manufacturers of other design-based products (interior design, toys, household, sports, and promotional items) should also be reached with this service. The two-year project is being carried out by the DITF together with the company Sourcebook from Berlin and is funded by the BMWK as part of the IGP program.



KompakT – Co-Creation Platform

Textile researchers put a stop to product piracy

Investigators, customs authorities, and textile companies have so far been unable to reliably detect counterfeit textiles. Time and again, they fail because of the criminals' skill and creativity. In a recently completed research project, scientists at the DITF and the DWI – Leibniz Institute for Interactive Materials e.V. have therefore developed security-marked sewing threads that provide a remedy. These contain small (approx. 100nm) infrared light-absorbing pigments that can be made visible with the aid of an IR camera (see figure).



Top: Embroidery "Emblem", yellow PET sewing thread with safety marking (left) and thermal image of the embroidered logo under irradiation with an NIR laser. Bottom: Undyed and yellow/black dyed PET sewing thread with safety marking.

In the project, various pigments (including LaB_6 , Cs_2WO_4) were investigated and compared. The sewing threads produced can be dyed well and adapted to the needs of textile manufacturers. It is thus possible to use them as discreet, unambiguous, and easily detectable security markings.

DITF BODIES

The DITF – founded in 1921 – are a non-profit research institution in the legal form of a foundation under public law. They fall under the jurisdiction of the Baden-Württemberg Ministry of Economic Affairs, Labor and Tourism.

The supervisory body of the DITF is the Board of Trustees. It advises the Management Board on questions of professional and structural orientation and includes representatives from science and business administration and representatives from the ministries of Economic Affairs, Labor and Tourism as well as Science, Research and Art of the state of Baden-Württemberg. The scientific advisory committees of the research institutes provide topic-specific advice directly to the specific fields.

Board of Directors

Prof. Dr.-Ing. Götz T. Gresser
(chairman of the board 2021),
Prof. Dr. rer. nat. habil. Michael R. Buchmeiser,
Peter Steiger

Trustees Committee

Oliver Dawid (since 18.05.2021)
Südwesttextil e.V., Stuttgart

Peter Haas (until 18.05.2021)
Südwesttextil e.V., Stuttgart

Andreas Georgii
Zweigart & Sawitzki GmbH & Co. KG, Sindelfingen

Ministerialdirigent Günther Leßnerkraus
Ministry of Economic Affairs, Labour and Tourism
Baden-Württemberg, Stuttgart

Dr.-Ing. Oliver Maetschke (chairman)
ETTLIN Spinnerei und Weberei Produktions GmbH & Co. KG,
Ettlingen

Dr. Oliver Staudenmayer
Freudenberg Filtration Technologies SE & Co. KG,
Weinheim

Board of Trustees

Carina Ammann (†)
ISCO-Textilwerk Gebr. Ammann GmbH & Co. KG, Stuttgart

Prof. Dr.-Ing. Christian Bonten
Institut für Kunststofftechnik, Universität Stuttgart

Oliver Dawid (since 18.05.2021)
Südwesttextil e.V., Stuttgart

Johannes Diebel (since 01.05.2021)
Forschungskuratorium Textil e.V.

Prof. Dr. Claus Eisenbach
Fakultät Chemie, Universität Stuttgart

Dr. Ronald Eiser
Lindenfarb Textilveredlung Julius Probst GmbH & Co. KG,
Aalen



Andreas Georgii
Zweigart & Sawitzki GmbH & Co. KG, Sindelfingen

Peter Haas (until 18.05.2021)
Südwesttextil e.V., Stuttgart

Dr.-Ing. Martin Hottner
W. L. Gore & Associates GmbH, Putzbrunn

Dr. Isabel Jandaisek
Ministerium für Wissenschaft, Forschung und Kunst
Baden-Württemberg

Eric Jürgens
Groz-Beckert KG, Albstadt

Dr. Grigorios Kolios (since 19.04.2021)
BASF SE, Ludwigshafen

Dr. Gert Kroner
Lenzing AG, Lenzing, Österreich

Joan-Dirk Kümpers
Kümpers Textil GmbH, Rheine

Ministerialdirigent Günther Leßnerkraus
Ministry of Economic Affairs, Labour and Tourism
Baden-Württemberg, Stuttgart

Dr. Harald Lutz
CHT Germany GmbH, Tübingen

Dr.-Ing. Oliver Maetschke (chairman)
ETTLIN Spinnerei und Weberei Produktions GmbH & Co. KG,
Ettlingen

Dr. Klemens Massonne (until 19.04.2021)
BASF SE, Ludwigshafen

Marcus Mayer
Mayer & Cie GmbH & Co. KG, Albstadt

Dr. Uwe Mazura (until 30.04.2021)
Gesamtverband der deutschen Textil- und Mode-
industrie e.V., Berlin

Christoph Mohr
AMOHHR Technische Textilien GmbH, Wuppertal

Walter Pritzkow
Walter E.C. Pritzkow Spezialkeramik,
Filderstadt-Sielmingen

Dr. Wilhelm Rauch
Industrievereinigung Chemiefaser e.V., Frankfurt/Main

Stefan Schmidt
Industrieverband Veredlung – Garne – Gewebe –
Technische Textilien (IVGT), Frankfurt/Main

Dr. Oliver Staudenmayer
Freudenberg Filtration Technologies SE & Co. KG,
Weinheim

Roland Stelzer
Gebr. Elmer & Zweifel GmbH & Co, Bempflingen

Dr.-Ing. habil. Katrin Sternberg
Aesculap AG, Tuttlingen

Dr. Rolf Stöhr
Textilchemie Dr. Petry GmbH, Reutlingen

Prof. Dr. Jochen Strähle
Hochschule Reutlingen

Wolfgang Warncke
Schill & Seilacher GmbH, Böblingen

Dr.-Ing. Stephan Weidner-Bohnenberger
Rieter Ingolstadt GmbH, Ingolstadt

ASSOCIATION OF THE SPONSORS OF THE GERMAN TEXTILE AND FIBER RESEARCH INSTITUTES DENKENDORF E.V.

Since its founding in 1961, the Association of the Sponsors of the German Institutes of Textile and Fiber Research Institutes has supported business-related research and development at the DITF. Currently, 35 members from industry and textile industry associations are involved in the association. The development of new technologies is supported and innovative preliminary research is financed through their membership fees and donations.

In the last few years, funding went mainly to individual projects, such as the expansion of the textile laboratory, investment in a vacuum hot press, a 3D flat knitting machine and in equipment and test equipment for the development of high-performance fibers. These investments in the infrastructure of the DITF directly benefit business, especially SMEs.

Chairman:
Andreas Georgii
71043 Sindelfingen

Gesamtverband der Deutschen Maschenindustrie,
Gesamtmasche e.V.
70182 Stuttgart

ADVANSIA Marketing GmbH
59071 Hamm

Global Safety Textiles GmbH
79689 Maulburg

Aesculap AG
78532 Tuttlingen

Groz-Beckert KG
72458 Albstadt

Archroma Management GmbH
4153 Reinach, Schweiz

Gütermann GmbH
79261 Gutach

BASF SE
67056 Ludwigshafen

Huntsman Textile Effects (Germany) GmbH
86462 Langweid am Lech

Campus Reutlingen e.V.
72762 Reutlingen

Industrieverband Veredlung – Garne – Gewebe –
Technische Textilien e. V. (IVGT)
60329 Frankfurt/Main

Cerdia Services GmbH
79123 Freiburg

Industrievereinigung Chemiefaser e.V.
60329 Frankfurt

CHT R. Beitlich GmbH & Co.
72072 Tübingen

ISCO Textilwerk
70190 Stuttgart

Dienes Apparatebau GmbH
63165 Mühlheim am Main

Joh. Jacob Rieter Stiftung
8406 Winterthur, Schweiz

Freudenberg Filtration Technologies SE & Co. KG
69465 Weinheim

KARL MAYER STOLL Textilmaschinenfabrik GmbH
63179 Obertshausen



Come in!

KOB GmbH
67752 Wolfstein

Kreissparkasse Esslingen-Nürtingen
73728 Esslingen

Lenzing AG
4860 Lenzing, Österreich

Mattes & Ammann GmbH & Co. KG
72469 Meßstetten-Tieringen

Mayer & Cie. GmbH & Co. KG
72438 Albstadt

Oerlikon Neumag
24531 Neumünster

Oskar Dilo Maschinenfabrik KG
69405 Eberbach

PHP Fibres GmbH
63784 Obernburg

PLEVA GmbH,
72186 Empfingen

Polymedics Innovations GmbH
73770 Denkendorf

Schill & Seilacher GmbH
71032 Böblingen

Südwesttextil e.V.
70182 Stuttgart

SV SparkassenVersicherung
71332 Waiblingen

Textechno Herbert Stein GmbH & Co. KG
41066 Mönchengladbach

Textilchemie Dr. Petry GmbH
72770 Reutlingen

Triumph International GmbH
80335 München

USTER Technologies AG
8610 Uster, Schweiz

Verein Deutscher Textilveredlungsfachleute e.V. (VDTF)
60329 Frankfurt

W. L. Gore & Associates GmbH
85639 Putzbrunn

Zschimmer & Schwarz GmbH & Co. KG
56108 Lahnstein

Dr. Zwissler Holding AG
89547 Gerstetten

DITF
VEREIN DER FÖRDERER

The association is open to new members.
Join us!

Promote application-oriented research and
development at the DITF and co-design the
textile future!

Contact: Peter Steiger, peter.steiger@ditf.de



Pneumatische Textilien

1. Energieeffizient
2. Hohe Kraft
3. Niederdruck
4. Extrem leicht
5. Formvariabel
6. Komplexe Bewegung

NOTES

IMPRINT

Deutsche Institute für Textil- und Faserforschung Denkendorf

Koerschtalstrasse 26 | 73770 Denkendorf

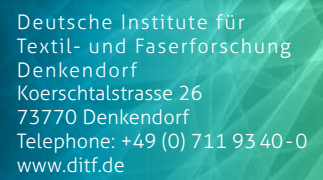
Telephone: +49 (0)7 11 / 93 40-0 | Fax: +49 (0)7 11 / 93 40-297

www.ditf.de | info@ditf.de

Copyright DITF | Peter Steiger (legally responsible for content), Director DITF

Do you receive our newsletter?

Register and be informed the whole year long: www.ditf.de/newsletter



Deutsche Institute für
Textil- und Faserforschung
Denkendorf
Koerschthalstrasse 26
73770 Denkendorf
Telephone: +49 (0) 711 93 40-0
www.ditf.de