

FIBER COMPOSITES

From matrix resins to the assembly of large structures



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FRAUNHOFER IFAM – ALL EXPERTISE UNDER ONE ROOF

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COMPETENCE NETWORK

ADHESIVE BONDING TECHNOLOGY AND SURFACES

8	<i>Image on cover page: Bonded beam made of glass fiber reinforced plastic for deter- mining the fatigue strength of rotor blade materials.</i>
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The Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 67 institutes and research units. The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of € 2 billion. Of this sum, more than € 1.7 billion is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe.

Fraunhofer IFAM – Adhesive Bonding Technology and Surfaces

The Adhesive Bonding Technology and Surfaces division at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has more than 300 employees and is the largest independent research institution in Europe working in the area of industrial adhesive bonding technology. The R&D activities focus on adhesive bonding technology, surface technology, and fiber composite technology. The objective is to supply industry with application-oriented system solutions.

Multifunctional products, lightweight design, and miniaturization – achieved via the intelligent combination of materials and joining techniques – are opening up new opportunities which are being exploited by the Adhesive Bonding Technology and Surfaces division. The activities range from fundamental research through to production right up to the market introduction of new products with partners. Industrial applications are mainly found in the transport sector – manufacturers of aircraft, cars, rail vehicles, ships – and their suppliers, energy technology, the construction industry, the packaging sector, textile industry, electronics industry, microsystem engineering, and medical technology.

“Adhesive bonding technology”, a core competence, involves the development and characterization of adhesives, the design and simulation of bonded and hybrid joints, as well as the characterization, testing, and qualification of such

joints. The planning and automation of industrial production as well as process reviews and certifying training courses in adhesive bonding technology and fiber composite technology are additional provided services.

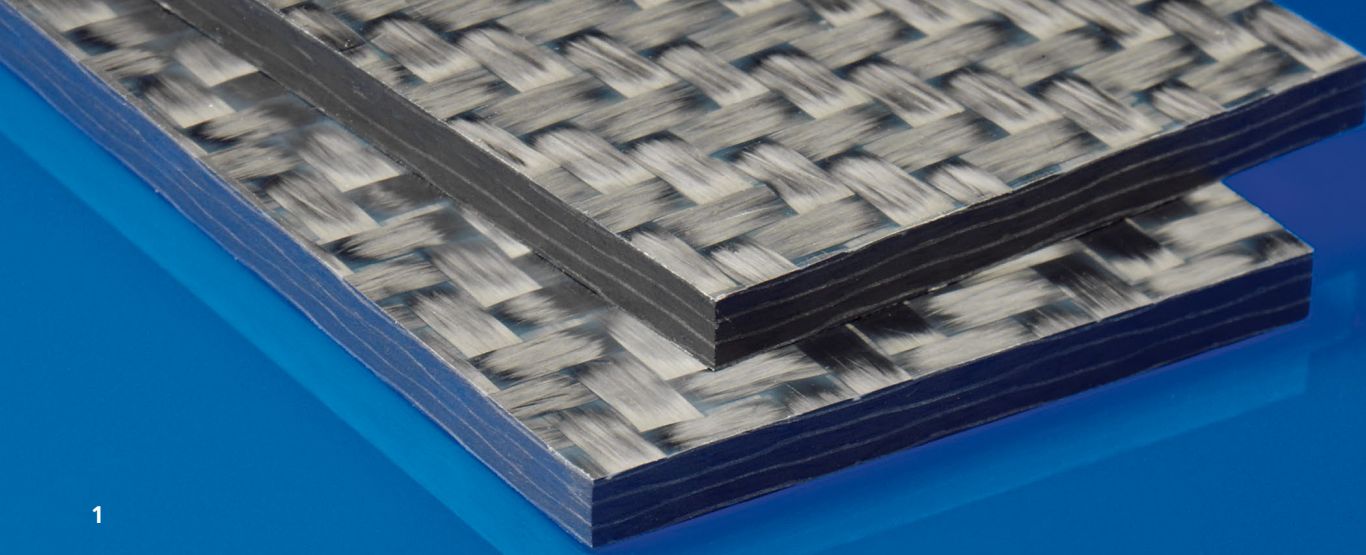
The core competence “surface technology” covers plasma technology, paint/lacquer technology, as well as adhesion and interface research. Customized surface modification – for example surface pre-treatment and functional coatings – considerably expand the industrial uses of many materials and in some cases are vital for the use of those materials. The focus here is on the optimization of the long-term stability of bonded joints and coatings, including early detection of degradation and corrosion phenomena, the validation of aging tests, and inline surface monitoring. The research results in the area of aging and surface pre-treatment provide important fundamental knowledge for both adhesive bonding and coating technology, thus contributing to the safety and reliability of bonded joints and coatings.

The department Automatisation and Production Technology at Forschungszentrum CFK NORD (Research Center CFRP NORTH) in Stade, which is a part of Fraunhofer IFAM, is carrying out forward-looking work on large fiber reinforced plastic structures. The scientists in Stade are to join, assemble, process, repair, and carry out non-destructive tests on large 1:1 scale structures. The “fiber composite technology” core competence thus closes the gap between the laboratory/small pilot-plant scale and industrial scale FRP applications. The aspects mentioned above concerning adhesive bonding technology, plasma technology, paint/lacquer technology, as well as adhesion and interface research are also key aspects of this core competence. This is complemented by further know-how about matrix resin development, fiber-matrix adhesion, up to the sizing of joints.

The entire Adhesive Bonding Technology and Surfaces division is certified according to DIN EN ISO 9001. The laboratories for material testing, corrosion testing, and paint/lacquer technology are further accredited in accordance with DIN EN ISO/ IEC 17025. The Center for Adhesive Bonding Technology has an international reputation for its training courses in adhesive bonding technology and is accredited via DVS-PersZert® in accordance with DIN EN ISO/IEC 17024. It is accredited in accordance with the German regulation for employment promotion, AZAV. The Plastics Competence Center is also accredited in accordance with AZAV and meets the quality requirements of DIN EN ISO/IEC 17024. The “Certification Body” for the Manufacture of Adhesive Bonds on Rail Vehicles and Parts of Rail Vehicles is accredited by the Federal Railway Authority (FRA, Eisenbahn-Bundesamt) in accordance with DIN 6701-2 and following DIN EN ISO/IEC 17021.

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and Advanced Materials IFAM
– Adhesive Bonding Technology and Surfaces –



FRAUNHOFER IFAM – ALL EXPERTISE UNDER ONE ROOF

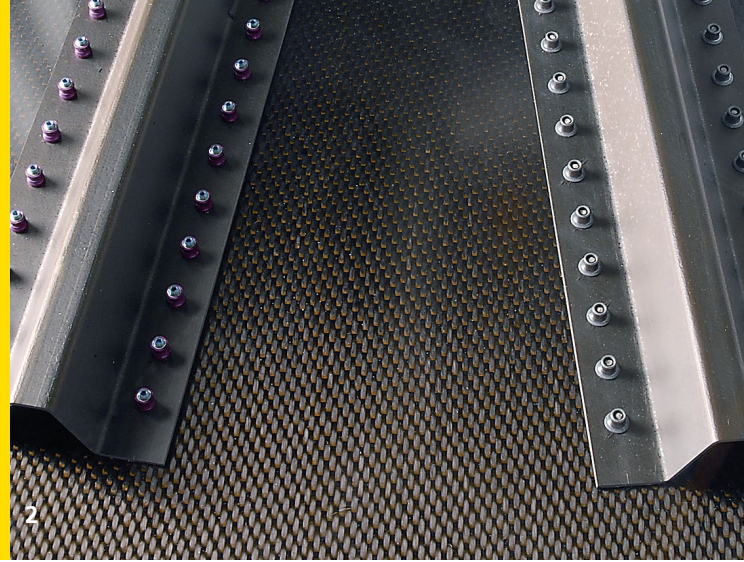
Industry favors these unique materials: Fiber composites. In general, fibers of carbon, glass, or other materials are embedded in a resin matrix. The advantage: Depending on the requirements, several layers of the fibers can be positioned on top of one another in different orientations. After curing, the resulting laminate or component has low weight but enormous tensile strength. Light, very stable, and customizable for the relevant application: Fiber reinforced plastics (FRPs) are very popular, despite their comparatively complex manufacturing processes – diverse advantages justify the effort.

It is important to realize at the outset that fiber composites would not be possible without adhesive bonding technology. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has built up outstanding knowledge over many decades, ranging from the understanding of processes at the molecular level to the joining of fiber reinforced plastics on an industrial scale. The institute has actively supervised many development projects.

Both carbon fiber reinforced plastics (CFRPs; Fig. 1) and glass fiber reinforced plastics (GFRPs) have become established in industry. The applications for these materials vary tremendously and range from canoes, molded from resin-soaked glass fiber mats, to the wings of the latest Airbus wide-bodied aircraft. Other applications include those in high-performance sports and in high-tech areas: CFRPs are used to make tennis racquets, the frames of racing cycles, and skis, while GFRPs are used in shipbuilding and wind turbines. In the aviation industry, glass fiber reinforced aluminum – GLARE – plays an important role: Alternating layers of aluminum and glass fibers laminated together.

The branches of the division of Adhesive Bonding Technology and Surfaces at the Fraunhofer IFAM are involved in questions relating to the manufacture and application of fiber composites. More often than not, the transitions are seamless: Close collaboration between the individual work groups guarantees comprehensive and effective project work and appraisal from different points of view.

1 Carbon fiber reinforced plastic (CFRP).



Dimensioning, design, manufacturing, testing and joining of FRP

The field of Material Science and Mechanical Engineering is involved with the dimensioning and design of fiber composites, as well as with their manufacture, mechanical testing, and issues regarding bonding and bolting of these materials. Resin infusion and prepreg methods are preferred for the manufacture of fiber composite laminate sheeting up to a size of two square meters. Here, either dry fiber mats are placed in a mold and soaked with resin during the further processing, or – as in the prepreg method – pre-soaked mats are placed on molds and then cured in a special container under pressure and heat. The latter method requires extensive know-how, but gives particularly high-quality products, as required, for example, by the aviation industry.

Also important is the institute's long-time experience in testing fiber composites. Whether the operational areas are the aircraft and wind energy industries or yacht construction: The experts at the Fraunhofer IFAM are able to determine the load limit and fatigue strength of fiber composite materials under static or alternating loads, right through to crash tests. Empirical knowledge is also important for dimensioning and designing components. This is because fiber composites can be manufactured with completely different mechanical properties, namely the layer structure and the properties of the resin can be tailored for the subsequent application.

The specialists of Material Science and Mechanical Engineering work also on the further processing of fiber composite components. These can be bonded, so giving thin-walled, light structures and a planar load transfer – ideal for the growing area of lightweight construction.

Hybrid structures using fiber composites and other materials are also possible. In the aircraft manufacturing sector, where CFRPs are widely used, these materials are still often bolted in

structural areas. The bolting of CFRPs and hybrid joining – namely the integration of adhesive bonding technology and bolting – are R&D areas in which Fraunhofer IFAM has built up extensive knowledge and experience (Fig. 2).

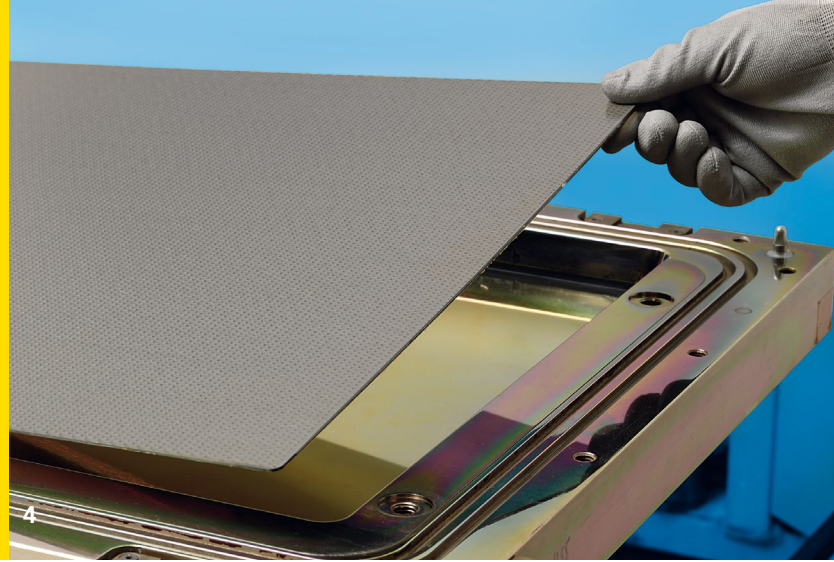
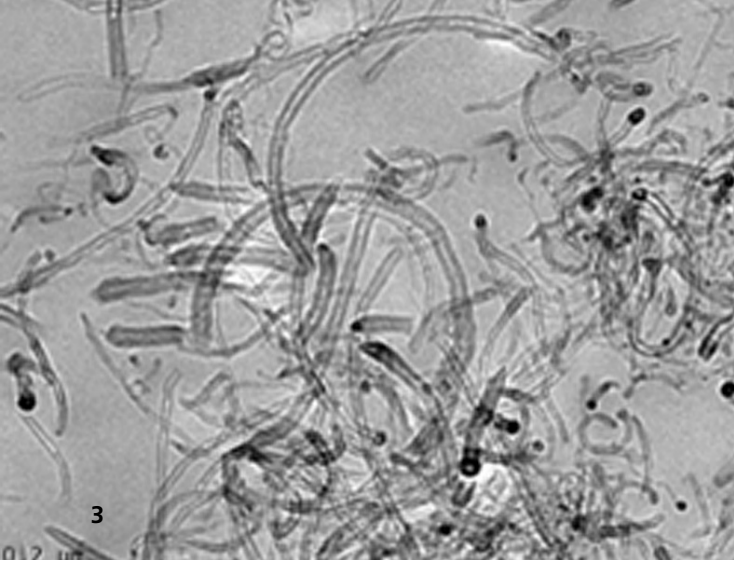
Fibers and resins: The chemistry must be right

A prerequisite for optimum production and the successful use of fiber composites is precise knowledge of the relationships between the fibers and resins, including all their individual features. For example, the weight and strength depend on the composition and structure of the composed CFRP or GFRP material. The field of Adhesives and Polymer Chemistry is involved with matrix resins, the optimal attachment of the fibers to the matrix, and the modification of the resins in order to optimize the property profile.

Thermosets or thermoplastics are used as the matrix resins, with the focus at Fraunhofer IFAM being on thermosets. After curing they often have a certain brittleness which is one of the main causes of damage to fiber composite materials. Although the toughness of the materials can be improved with various additives, however, these often reduce the strength. Intensive work is being carried out to find ways of overcoming the current limitations. Other important points for optimization regarding the production of fiber composites are the rheological properties of the resins and the curing conditions.

Amongst the additives which are used, special attention is put on modified nanoparticles. These particles have already been proven to have positive effects in adhesive formulations. The main material being used here is silicon dioxide pre-treated in various ways, but also elastic nanoparticles, aluminum oxide, and carbon nanotubes (CNTs; Fig. 3) are being employed.

2 Hybrid joined CFRP component.



Pre-treatment of FRP-surfaces essential

Surface pre-treatment is highly important for fiber composites. The experts of Plasma Technology and Surfaces – PLATO – devote themselves to this task. The pre-treatment starts with the individual carbon fibers, which may already be affected by the oxidation processes used for their industrial manufacture. The surfaces of the fibers can subsequently be further modified, depending on the particular application, for example via plasma pre-treatment or wet-chemical processes. Together with the aforementioned optimization of the matrix resins, Fraunhofer IFAM hence creates the preconditions for manufacturing fiber composite products having the best possible properties.

During the manufacture of fiber composite components or laminates in molds, the matrix resin generally acts as an adhesive. This is why thin release layers are necessary, consisting for example of wax or silicone, to enable easy removal of the finished fiber composite parts from the molds. The residues of the release agents which remain behind on the parts are, however, a problem. They prevent safe bonding and/or coating and hence must be removed. PLATO has developed innovative surface pre-treatment methods for cleaning. These include techniques involving the removal of material such as the CO₂ snow jet or vacuum suction blasting. In addition, the surfaces are activated by plasma treatment or with high energy radiation in the vacuum ultraviolet spectral region (VUV). At a molecular level these techniques allow improved attachment of adhesives or paints/coatings.

An alternative method for removing fiber composite components from molds is the coating of the molds with a permanently active release layer. In contrast to conventional release agents, the molding tool is coated with a release layer developed by PLATO. Even after many molding cycles this still has very good release properties. After being removed from the molds, the CFRP components show no presence of contami-

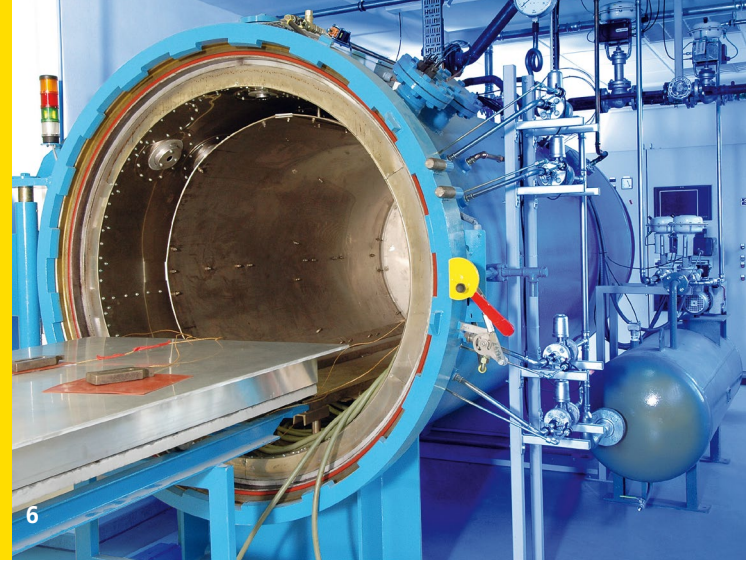
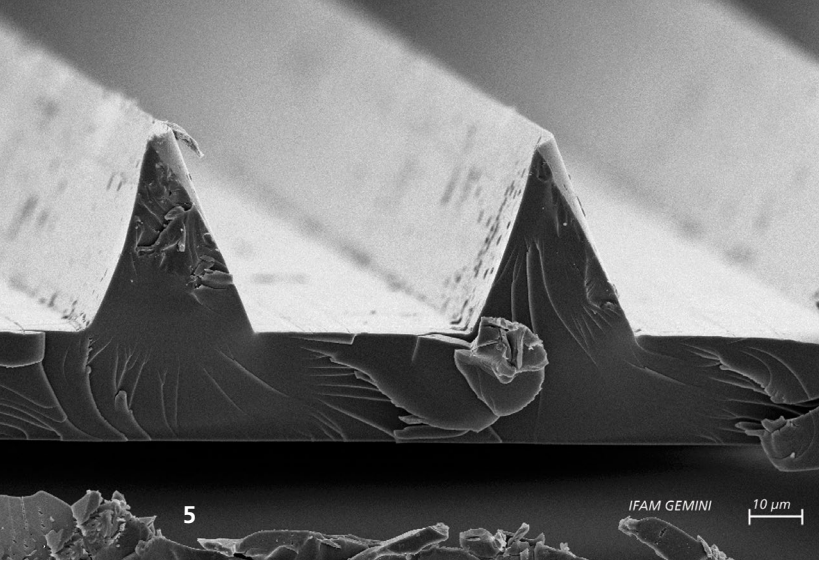
nants, meaning they are “ready-to-paint” or “ready-to-bond”. Figure 4 shows a plasma-polymer coated molding tool on removal of a CFRP component.

The expertise of Plasma Technology and Surfaces is also relevant for other aspects of the manufacture and processing of fiber composite materials. This is particularly so regarding plasma-etching: In order to be able to monitor the intactness of carbon fiber materials during their everyday use, for example as aircraft components, glass fibers will in the future be incorporated into CFRP components as sensors to indicate the state of the component during usage (structural health monitoring; SHM). When joining such CFRP components, the individual glass fibers must be connected to each other. It is therefore necessary to expose them using a process as gentle as possible, and atmospheric plasma treatment is able to achieve this.

A further research topic of PLATO is corrosion protection when joining fiber composites with other lightweight construction materials, for example aluminum. As damage often occurs due to so-called contact corrosion, corrosion-suppressing plasma-polymer layers are applied in the joint regions.

3 Adhesive with dispersed carbon nanotubes (CNTs).

4 Permanent release layer to allow molded CFRP components to be easily removed from molds.



Coating and functionalizing of FRP

Surfaces are also of vital importance in the work of the specialists of Paint/Lacquer Technology. They are investigating ways of measuring and eliminating undesired surface defects. This work concerns a variety of defects. High-quality CFRP components in particular require defect-free surfaces. A component can, however, only be as good as the mold in which it is made. If the mold as a “negative” has defects, then these appear on the surface of the component as “positive” defects. This gives rise, for example, to so-called voids: Pores which subsequently require extra filling and hence require additional surface pre-treatment steps for cleaning, grinding, and activation.

If the resin and fibers expand to different extents due to temperature and humidity fluctuations, then the fiber structures – even after painting/lacquering – may be visible on the surface. Fraunhofer IFAM is tackling issues like this in order to be able to produce acceptable paint/lacquer surfaces.

It is advantageous for the production if a component can be removed from a mold already painted/lacquered. Fraunhofer IFAM is therefore working on developing special paints/lacquers which can be directly processed in the mold. This can, for example, be undertaken using a release film into which one or more paint/lacquer layers are integrated. Prior to manufacturing the component, the special films are deep-drawn into the mold. In conjunction with PLATO, the experts of Paint/Lacquer Technology are working to further improve these “in-mold paints/lacquers” and optimize them for applications.

The Paint/Lacquer Technology branch has expanded its extensive know-how for coating carbon fiber composites. This includes the qualification of paint and lacquer systems and also cleaning, pre-treatment, and lacquering processes. The quality of the surface can be analyzed and evaluated for its color, gloss, dust inclusions, run, and many other parameters.

In addition, the functional modification of surfaces with systems such as self-repairing coatings, anti-contamination coatings, anti-icing coatings, anti-erosion coatings, and riblet structures (“sharkskin structures”; Fig. 5) are possible. The latter are particularly interesting due to the aerodynamic benefits for aviation and shipping.

The right joining technique:

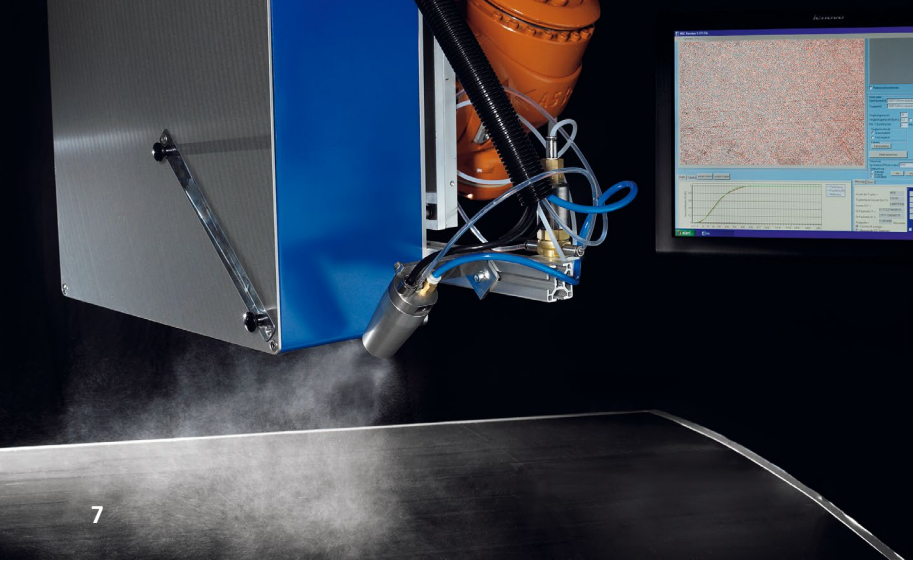
A lot of adhesives, with some bolts

In order to join components made of fiber composite materials to each other for a particular application such that the joints can withstand high loads, one needs an optimized and also economical joining method. This is true for both very small and very large structures: Until the day arrives when “an one-piece aircraft” can be manufactured, wings have to be joined to the fuselage, and the tailfin to the undercarriage – ideally using adhesive bonding technology, which has always been the core competence of Fraunhofer IFAM.

Fiber composite materials are generally joined after surface activation using film adhesives or hot curing adhesives. The adhesive bonding processes are often undertaken with the help of an autoclave in which the joints cure under the influence of pressure and heat (Fig. 6). One of the problems is that the size of the pressure vessel limits the size of the components which can be joined: There are no autoclaves which have the size of aircraft fuselages and it would not be economically viable to construct such large autoclaves. Fraunhofer IFAM is hence developing adhesives for this purpose, which cure at lower temperatures. It is also desirable, for example, to be able to apply

5 Scanning electron micrograph of a riblet-structured coating surface developed by Fraunhofer IFAM.

6 Autoclave for manufacturing fiber reinforced plastics.



an adhesive to long joints with variable thickness – depending on the size of the gap between the individual substrates.

The Adhesive Bonding Technology, amongst others, of the Fraunhofer IFAM is actively tackling these challenges. It is currently investigating, for example, the ideal composition of adhesives for joining fiber composites and is optimizing the flow properties and processing temperature. The experts also develop complete process chains: Taking into account the relevant production environment and the given boundary conditions for the adhesives and components, the necessary personnel, machine, and space requirements are determined.

In addition, adhesive application, namely the actually applying of the adhesive, is a focus of the work. The need for gap size dependent adhesive application and minimum overdosing is being met by a newly developed system. The components and their contours are scanned by a laser scanner and after data transformation the components are virtually assembled on the PC. The varying gap width is measured. Due to the combination of this information and the special robot path programs the adhesive can be finally applied according to need.

A special challenge when joining fiber composites is the bolting of these materials. This is currently common practice in the aircraft manufacturing sector: When the wings and fuselage of an aircraft are joined, the aircraft manufacturers do not yet trust adhesive bonding alone, and also always require bolts. The selection of the correct types of bolts and the drilling of the holes for the bolts are areas where Fraunhofer IFAM is actively engaged. One task is to minimize adverse effects on the particular properties of composite materials due to material damage. The so-called hybrid joining – the combined use adhesive and bolts – integrates advantageously diverse competences within the work of Fraunhofer IFAM.

Know-how for material and process optimization: Adhesion and Interface Research

The aviation industry puts major challenges on adhesive bonding technology for the bonding of load-bearing parts, so-called structural bonding. For safety reasons it must be ensured that the bonded joint remains intact, namely does not suddenly fail. This can be tested using non-destructive test methods. Here one often encounters the problem of “kissing bonds”: these material-fit joints which appear to be bonded perfectly, and yet satisfactory adhesion forces do not develop. The reason for this is a poor connection and poor interaction of the adhesive with the substrates at a molecular level.

Another means of demonstrating production reliability is via process monitoring. The actual bonding process respectively joining process are closely monitored: Is the quality of the surface pre-treatment acceptable? Has the correct amount of the correct adhesive been applied at the correct place? Is the contact pressure acceptable? Have optimum conditions such as temperature and air pressure been observed?

This monitoring can also be very effectively integrated into the production process and is one of the tasks of the Adhesion and Interface Research branch of Fraunhofer IFAM. After the surface pre-treatment and before the application of the adhesive it is determined whether the surface is in an optimal state for being bonded (Fig. 7).

- 7 *Evaluation of the wetting properties of surfaces using the aerosol wetting test developed at Fraunhofer IFAM.*
- 8 *Laser scanning microscopy image of carbon fibers at the surface of a CFRP component manufactured by the resin transfer molding process (RTM).*

The surface characterization – namely analysis of the surface chemistry as well as macro- and microstructures – plays a key role regarding the adhesion of adhesives and coatings. It is hence important, prior to the surface pre-treatment, to acquire fundamental information about the microscopically thin interfacial layer in which the actual adhesion of the adhesive or coating occurs (Fig. 8).

With the help of adhesion and interface research, surface pre-treatments can be analyzed and evaluated – for example the use of release agents, the degree of contamination, and the effects of release agent residues on the strength of the bonded joints. At the microscopic or sub-microscopic levels tests are carried out to investigate the adhesive interactions between the carbon fibers and the matrix resins which are important for the mechanical properties of CFRP materials.

These tests are carried out at Fraunhofer IFAM using state-of-the-art analytical methods and computer-aided simulation methods.

In addition, the evaluation and optimization of concepts for preventing galvanic corrosion when joining CFRPs with light metals, including the required long-term electrical insulation of the materials, is another important task of the adhesion and interface research, especially directed at the aircraft manufacturing industry.

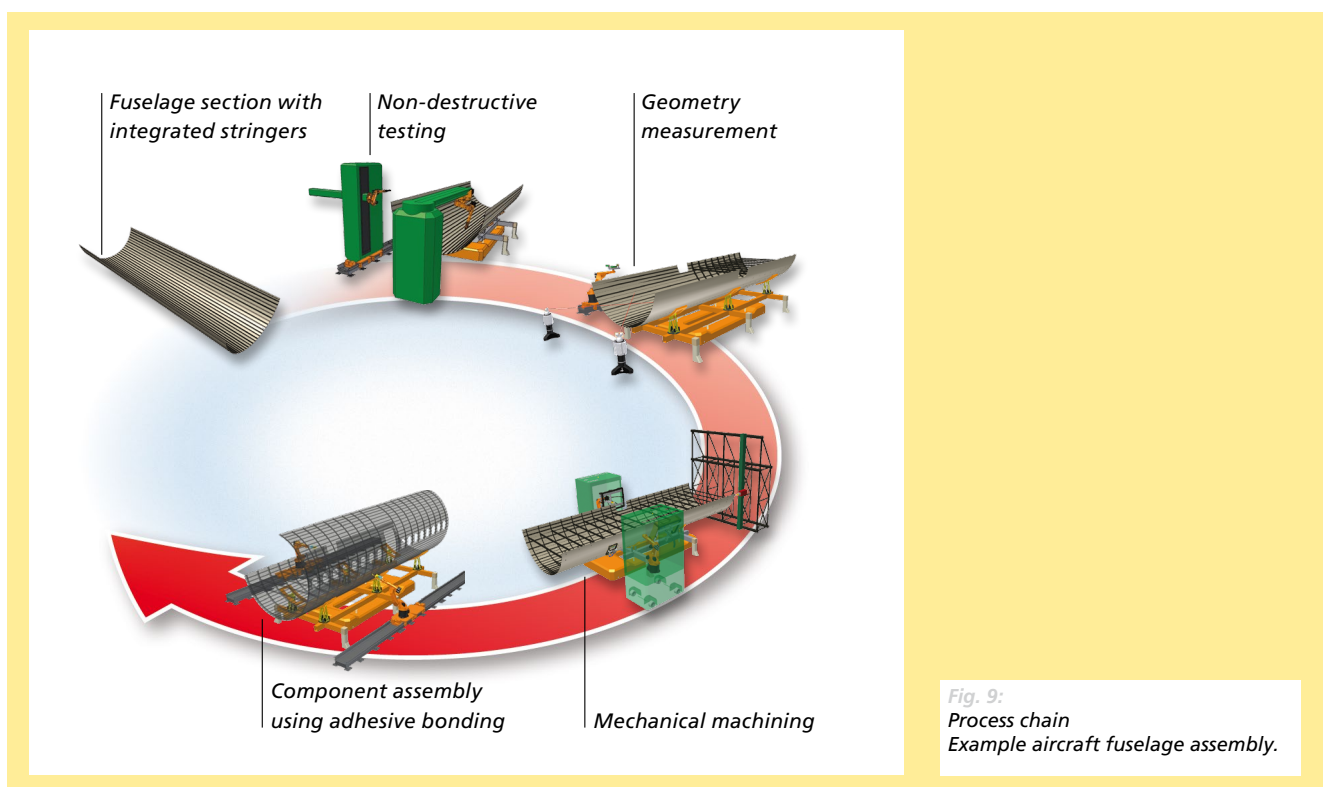


Fig. 9:
Process chain
Example aircraft fuselage assembly.



Joining and assembly – From laboratory scale to 1:1 scale

All the mentioned expertise of Fraunhofer IFAM concerning the manufacture and application of fiber reinforced plastics is also highly relevant for the manufacture of large structures such as aircraft. This area of work is carried out by the Automatisation and Production Technology, which is an established part of the Fraunhofer IFAM based at the Forschungszentrum CFK NORD (Research Center CFRP NORTH) in Stade.

In this 4000 m² facility the scientists of Automatisation and Production Technology develop assembly plants and processes on up to a 1:1 scale for a variety of industries including the aircraft manufacturing industry, the wind energy sector, and the car and commercial vehicle manufacturing industry.

Besides focusing on adhesive bonding, which can also be combined with bolting, another main activity concerns the high-precision machining (drilling, countersinking, edge-milling, and surface-milling) of large structures. An important instrument here is defect prevention by monitoring sensitive process parameters.

Key objectives are to lower the costs and increase the efficiency of plants and processes via automation and via the use of mobile, highly accurate, controllable processing modules that allow extensive product versatility and require no high-duty foundations (Fig. 9).

Workforce training – An important prerequisite

No innovation will achieve a break through and exhausts all the potential of a new technology if it is incorrectly used. This is why the training and further training of the people who work with and use fiber composite materials is very important. Fraunhofer IFAM recognized this already in 1994, when adhesive bonding technology was starting to boom. The Center for Adhesive Bonding Technology of Fraunhofer IFAM is the leading training organization in the area of adhesive bonding technology.

As the processing and joining of fiber composites cannot be separated from adhesive bonding, yet does have its own special features, Fraunhofer IFAM established the Plastics Competence Center. These training courses are becoming increasingly important for the plastic processing industries: The wind turbine construction industry and the shipbuilding, car manufacture, aviation and aerospace sectors require well trained employees. Such trained employees are available thanks to Fraunhofer IFAM: The Plastic Competence Center offers several training courses – Fiber Reinforced Plastic Fabricator, Fiber Reinforced Plastic Specialist and Fiber Reinforced Plastic Remanufacturer.

10 Workforce training: Fiber Reinforced Plastic Fabricator training course at the Plastics Competence Center.

COMPETENCE NETWORK ADHESIVE BONDING TECHNOLOGY AND SURFACES

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Adhesive Bonding Technology

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Production planning; dosing and application technology; automation; hybrid joining; production of prototypes; selection, characterization, qualification of adhesives, sealants and coatings; failure analysis; electrical/optical conductive contacts; adaptive microsystems; dosing ultra small quantities; properties of polymers in thin films; production concepts.

- Microsystem technology and medical technology
- Adhesives and analysis
- Process development and simulation
- Application methods

Plasma Technology and Surfaces – PLATO –

Dr. Ralph Wilken

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Surface modification (cleaning and activation for adhesive bonding, printing, painting/lacquering, etc.) and functional layers (e.g. adhesion promotion, corrosion protection, scratch protection, antimicrobial effect, easy-to-clean layers, release layers, permeation barriers) for 3-D components, bulk products, web materials; plant concepts and pilot plant construction.

- Low pressure plasma technology
- Atmospheric pressure plasma technology
- Plant technology/Plant construction

Adhesives and Polymer Chemistry

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Development and characterization of polymers; nanocomposites; formulation of adhesives, matrix resins, and functional polymers; preapplicable adhesives; conducting adhesives; improvement of the long-term stability; bonding without pre-treatment (polyolefins, light metals, oil-containing sheets with 2-C systems, thermoplastic composites); photocuring; curing at low temperature, but with longer open time; curing on demand; rapid curing; pressure-sensitive adhesives; casting compounds; selection and qualification of adhesives; failure analysis; adhesives based on natural raw materials; peptide-polymer hybrids; bonding in medicine; biofunctionalized and biofunctional surfaces.

- Adhesive formulation
- Composite materials
- Bio-inspired materials

Paint/Lacquer Technology

Dr. Volkmar Stenzel

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Development of functional coatings, e.g. anti-icing paints, anti-fouling systems, dirt-repellant systems, self-repairing protective coatings, coatings with favorable flow properties; formulation optimization; raw material testing; development of guide formulations; characterization and qualification of paint/lacquer systems and raw materials; release of products; color management; optimization of coating plants; qualification of coating plants (pre-treatment, application, drying); failure analysis; application-related method development; accredited Paint/Lacquer Technology Testing Laboratory.

- Development of coating materials and functional coatings
- Application technology and process engineering

Adhesion and Interface Research

Dr. Stefan Dieckhoff

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Surface, interface and film analysis; analysis of adhesion, release and degradation mechanisms; analysis of reactive interactions at



material surfaces; damage analysis; quality assurance via in-line analyses of component surfaces; corresponding development of concepts for adhesive, paint/lacquer and surface applications; corrosion on metals, under coatings and in bonded joints; analysis of anodization layers; electrolytic metal deposition; accredited corrosion testing laboratory; modeling of molecular mechanisms of adhesion and degradation; structure formation at interfaces; concentration and transport processes in adhesives and coatings.

- Surface and nanostructure analysis
- Applied computational chemistry
- Electrochemistry/Corrosion protection
- Quality assurance of surfaces

Material Science and Mechanical Engineering

Dr. Markus Brede

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Testing materials and components; crash and fatigue behavior of bolted and bonded joints; fiber composite components; light-weight and hybrid constructions; design and dimensioning of bonded joints; qualification of mechanical fasteners; optimization of mechanical joining processes; design and dimensioning of bolted joints; accredited Materials Testing Laboratory.

- Structural calculations and numerical simulation
- Mechanical joining technology

Workforce Training and Technology Transfer

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www.kunststoff-in-bremen.de

Training courses for European Adhesive Bonder EAB, European Adhesive Specialist EAS and European Adhesive Engineer EAE with recognized European-wide certification via DVS®/EWF; in-house courses; consultancy; qualification of production processes; studies; health, work safety and the environment; training courses for Fiber Reinforced Plastic Fabricator, Fiber Reinforced Plastic Specialist and Fiber Reinforced Plastic Remanufacturer.

- Center for Adhesive Bonding Technology
- Plastics Competence Center

Automatisation and Production Technology

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Automated assembly of large fiber reinforced plastic (FRP) structures, up to a 1:1 scale; adhesive bonding, combined bonding/bolting; adaptive precision machining; automated measuring and positioning processes; shape and positional correction of flexible large structures in assembly processes.

- Joining technologies
- Precision machining
- Assembly and plant technology
- Measurement technology and robotics

Business Field Development

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- Technology broker
- New research fields

Certification Body of the Federal Railway Authority in Accordance with DIN 6701

Dipl.-Ing. (FH) Frank Stein

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Consultancy, testing and approval of rail vehicle manufacturing companies and their suppliers with regard to their ability to produce adhesive bonds in accordance with the requirements of DIN 6701.

Process Reviews

Dipl.-Ing. Manfred Peschka MBA

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Analysis of development and/or production processes taking into account adhesive bonding aspects and DVS® 3310; processing steps and interfaces; design; product; proof of usage safety; documentation; production environments.

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and Advanced Materials IFAM**

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More information about the areas

- Adhesive Bonding Technology
- Surfaces