Fraunhofer-Gesellschaft
The Fraunhofer-Gesellschaft is the leading independent support body for applied research organizations in Europe. It currently operates more than 80 research establishments, 59 of which are institutes, and employs about 17,000 people at over 40 locations throughout Germany. More than 1.3 billion euros of the annual research budget of 1.6 billion euros are earned from contract research. This work is funded by both industrial companies and the public purse. The results of this research make a key contribution to safeguarding the prominent position of German industry.

Fraunhofer IFAM
– Adhesive Bonding Technology and Surfaces –
The Department of Adhesive Bonding Technology and Surfaces at the Fraunhofer Institute for Manufacturing Technology and Applied Materials Research is the largest independent research group in Europe working in the area of industrial adhesive bonding technology. More than 210 employees carry out industry-oriented R&D activities in the fields of bonding and surface technology, and also plasma technology and paint/lacquer technology. The objective is to supply industry with application-oriented system solutions.

Multifunctional products, lightweight design and miniaturization – achieved via intelligent combination of materials and joining techniques – are opening up new opportunities. The activities range from fundamental research to production and the market introduction of new products. Industrial applications are mainly found in car, rail vehicle, ship and aircraft manufacture, plant construction, energy technology, the packaging sector, textile industry, electronics industry, microsystem engineering, and medical technology.

The work in the area of adhesive bonding technology involves the development and characterization of adhesives, and simulation of bonded, riveted and hybrid joints, as well as the characterization, testing, and qualification of such joints. Planning and automation of industrial adhesive bonding applications are also undertaken. Other key activities are process reviews and providing certified training courses in adhesive bonding technology and fiber composite materials.

The work in the area of surfaces is subdivided into plasma technology and paint/lacquer technology. Customized surface modification – for example surface pretreatment prior to bonding/coating and anti-corrosion coatings – considerably expand the industrial uses of many materials.

The Adhesion and Interface Research work group uses a range of techniques for analyzing surfaces and structures, as well as electrochemistry and molecular modeling, for developing and optimizing bonded joints and coatings.

The Fraunhofer Project Group Joining and Assembly FFM of the Fraunhofer IFAM is carrying out ground-breaking work on large carbon fiber reinforced plastic structures and is able to join, assemble, process, repair, and carry out non-destructive tests on large 1:1 scale CFRP structures.

The Department of Adhesive Bonding Technology and Surfaces is certified according to DIN EN ISO 9001, while the Materials Testing Laboratory and the Corrosion Testing Laboratory are certified according to 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.

www.ifam.fraunhofer.de
A plasma is a highly reactive gas which contains neutral, excited and ionized particles in addition to containing electrons and UV radiation. The nature of the discharge gas determines the surface effect – cleaning, activating, coating.

Benefiting from the advantages

Surfaces are playing an ever more important role in almost all sectors of industry and in everyday life. Both in established production processes and the development of new processes and products, the surfaces of materials often have to be treated to give them additional properties, which enable them to be used in further areas of application.

Surfaces are cleaned and activated so that lacquers, paints and adhesives adhere better to them. Surfaces are also coated, to realize new functions. These wafer-thin layers create properties such as scratch-resistance, resistance to soiling and non-stick surfaces. They can be produced as release layers or barrier layers, or reduce friction or provide protection against corrosion.

Modern technologies allow new additional surface properties to be realized and existing manufacturing processes to be optimized. The customized treatment of surfaces is indeed often necessary before a particular material can be employed.

Individual solutions

Low pressure plasma and atmospheric pressure plasma technologies today allow customized solutions for a wide range of applications. To give but two examples: An anti-corrosion layer produced via plasma polymerization has excellent adhesion, high barrier properties and excellent chemical, mechanical and thermal stability. In the medical sector, catheters can be layered with plasma polymer coatings, which have an antibacterial effect but are not cytotoxic.

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Practice-oriented and customized solutions

The Plasma Technology and Surfaces section at the Fraunhofer IFAM is the right partner for you. Using our in-depth know-how and modern facilities we develop viable, tailored solutions for our customers in the area of surface treatment. We work closely with leading companies in all key sectors of industry.

As a service provider we apply our knowledge in a practice oriented and targeted way – and our customers receive integrated system solutions in which all steps are optimally harmonized with each other. We draw up customized plans for manufacturing processes and plants, specifically directed at the needs and capabilities of our customers.

Our services include consultancy, sample provision, process development, zero-series manufacture and pilot-plant construction. We aim to translate our research work into processes and integrate these into industrial production lines.

Our techniques enable us to produce surfaces which are extra clean or activated and enable us to produce functional layers with a variety of properties such as scratch resistance, barrier effects, corrosion and UV protection, as well as self-cleaning and easy-to-clean properties. These functionalities are already being used by industry.

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Figure page 2: Efficient stripping of gratings by easy-to-clean plasma coating.
Figure top: Transparent scratch protection of plastic surfaces.
Low pressure plasma technology

Low pressure (LP) plasma technology is used to clean, activate and coat surfaces. The processes can be arranged in a flexible yet complex way so that several properties are realized in one process step – for example corrosion protection with extra adhesion. LP plasma technology can be used on all substrates and can be applied to the most complex of geometries. It is suitable for bulk goods, web materials and individual pieces and can be quickly adapted to changing requirements. The substrates are not subjected to thermal or mechanical loads. The process is environmentally friendly and safe.

Example applications of LP plasma technology include:

- the activation of plastics for better adhesion of lacquers,
- the application of release layers for paint/lacquer removal and for the removal of plastic products from molds,
- coatings for elastomers for reducing friction,
- flexible scratch-resistant coatings for displays, windscreens and visors,
- the coating of metals for protection against tarnishing or corrosion and
- antimicrobial, non-cytotoxic coatings for medical products.

The PLATO group has practical expertise in the wide range of applications of this technology. The applications prove their worth on a daily basis in industry.

The Fraunhofer IFAM has a variety of LP plasma plants, from laboratory scale equipment for new development work up to 3 m³ for pilot series. In a vacuum winding chamber, web materials having a width of up to 1 m can be treated at speeds of up to 250 m/min.

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**Atmospheric pressure plasma technology**

Atmospheric pressure (AP) plasma technology, like low pressure plasma technology, can also be used for treating and coating materials, but does not require a vacuum chamber. Consequently, integration of this technology into existing production lines with high processing speeds is possible. Due to novel nozzle technology a spatially restricted plasma is generated which can be very effectively used for localized treatments. The plasma nozzles can be controlled by a robot and can, amongst other things, be used for activating surfaces prior to sealing or bonding and for application of layers for corrosion protection or adhesion promotion.

Example applications of LP plasma technology include:
- activation of plastics prior to adhesive application,
- cleaning and surface activation of large components prior to lacquering/painting,
- anti-corrosion coatings for metal components for sealing flanges,
- deposition of permanent release layers for easy removal of objects from molds and
- surface pretreatment of particles/nanoparticles for improving their dispersion properties.

These processes are being continually improved and expanded.

In addition to various laboratory-scale plasma units, the Fraunhofer IFAM possesses a robot-controlled plant suitable for the treatment of components with complex shapes.

**Excimer technology**

The Fraunhofer IFAM has expertise in excimer technology, which complements the plasma technologies. Excimer lamps emit energy in the vacuum ultraviolet (VUV) region of the spectrum and can be used for photochemical surface modification, at both low pressure and normal pressure. Excimer technology represents a favorable-cost alternative to current pretreatment systems. In combination with standard application methods – such as aerosol application – this technology allows a variety of functional layers to be generated (e.g. release layers, anti-corrosion coatings and easy-to-clean layers).

**Other services offered by the PLATO group**

Such as:
- surface pretreatment using laser and irradiation methods,
- analysis and characterization of surfaces and
- application on plastics

can be found on our website: [www.ifam.fraunhofer.de](http://www.ifam.fraunhofer.de)
COMPETENCE NETWORK FOR 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 conductivity 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

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Surface modification (cleaning and activation for bonding, printing, painting/lacquering) 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; network polymers; formulation of adhesives and functional polymers; chemical and physical analysis; peptide and protein chemistry; peptide-polymer hybrids; bonding in medicine; surfaces functionalized with peptides; marine protein adhesives.
- Synthetic materials
- Protein materials

Paint/Lacquer Technology
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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 (pretreatment, application, drying); failure analysis; application-related method development.
- Development of coating materials
- Application technology and process engineering

Adhesion and Interface Research
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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; 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

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Testing materials and components; crash and fatigue behavior of riveted and bonded compounds; fiber composite components; lightweight and hybrid constructions; design and dimensioning of bonded joints; qualification of mechanical fasteners; optimization of mechanical joining processes; design and dimensioning of riveted joints.
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• Mechanical joining technology

Technology Transfer and Workforce Training
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Training courses for Adhesive Bonder, Adhesive Specialist and European Adhesive Engineer with Europe-wide certification via DVS®-EWF; In-house courses; consultancy; qualification of production processes; studies; health, safety and the environment; training course for Fiber Reinforced Plastic Technician.

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Industrial assembly involving bonding, riveting and combinations thereof; adaptive precision machining; automated measuring and positioning processes; non-destructive tests for large CFRP structures.

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Process Reviews
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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; products; proof of usage safety, documentation; production environments.